Temple University Journal of Orthopaedic Surgery & Sports Medicine

John Lachman, MD

Volume 15 Spring 2021

A John Lachman Society Publication

The John Lachman Society Fund Solicitation

The John Lachman Society is dedicated to supporting and promoting the academic and research activities of students at the Lewis Katz School of Medicine at Temple University and Temple University Hospital Orthopaedic Residents through the John Lachman Orthopaedic Research Fund that since its founding in 2001 has been a 501(C)(3) tax-exempt organization.

These activities include the following:

1) Funds support for medical student and orthopaedic resident research
2) Funds resident expenses for paper/poster presentation at accredited scientific meetings
3) Funds resident attendance at accredited meetings
4) Funds award money at annual resident research day presentations
5) Funds costs for publication and distribution of the *Temple University Journal of Orthopaedic Surgery & Sports Medicine*
6) Funds the accredited medical student summer research program
7) Supplements the Temple Orthopaedic Alumni Society commitment shortfall to send residents to the Orthopaedic board review course
8) Funds current Kenya project

To support these activities, the John Lachman Society is actively soliciting your tax-exempt contributions, which can be made two ways:

Via our new secure website, which is https://lachmanfund.org. Once there, you can make a donation and also view current and past issues of the journal as well as other resident activity.

Or, if you wish to write a check, please make it payable to John Lachman Orthopaedic Research Fund and mail it to our Treasurer: Saqib Rehman, MD, Department of Orthopaedic Surgery, Temple Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

Clearly, these programs greatly enhance the medical student and resident orthopaedic experience! And clearly, your contribution to the program will be greatly appreciated!

Joe Torg, MD Joe Thoder, MD

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Temple University Journal of Orthopaedic Surgery & Sports Medicine

How to Reach Us

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Letter from the Interim Chairman

The Department of Orthopaedic Surgery and Sports Medicine is proud to present this year's edition of the Temple University Journal of Orthopaedic Surgery & Sports Medicine. In accordance with standards set by previous issues, we are pleased to present to you the research efforts of all of the sections of our department. Included are selected articles from our medical student research program, office of clinical trials, attending and resident research projects and the basic science section.

I have the privilege to present this year's journal, dedicated to the man whose namesake professorship I hold, the venerated John W. Lachman, MD. "Latch," as he was affectionately referred to by many, was an exceptional orthopaedic surgeon, teacher and mentor. Dr. Lachman served as chairman and professor of Orthopaedic Surgery at Temple University Hospital from 1956 to 1987 where he dedicated his practice to patient care and resident education. His contributions to our institution are innumerous and his memory and principles live on within the fabric of Temple Orthopaedics. Those of us who are fortunate to have known him and learned from him carry some of what he taught us in everything we do, both professionally and personally. I am privileged to have been mentored by him, and the dedication of this journal is a fitting honor.

I would like to acknowledge the John Lachman Research Foundation for their support of resident education. I would like to express my gratitude to the faculty in making the *"Journal"* possible through their mentoring, clinical contribution and editing efforts. Specifically, Joseph Torg, MD and Saqib Rehman, MD for keeping the process on schedule and the residents on track. I would also like to acknowledge Pekka Mooar, MD and Joanne Donnelly for the great job they have done since this journal's inception in organizing and mentoring the medical students and helping make the IRB a less daunting task. Last but not least, a special thanks to editor-in-chief Dana L. Cruz, MD (PGY5); and associate editors Colin Ackerman, MD (PGY4), Heather Flynn, MD (PGY3), Pat Donaghue, MD (PGY2) and Max McQuade, DO (PGY1).

That being said, I respectfully submit to you Volume 15 of the Temple University Journal of Orthopaedic Surgery & Sports Medicine.

Joseph Thoder, MD
Professor and Interim Chairman
Department of Orthopaedics and Sports Medicine
Lewis Katz School of Medicine at Temple University

Letter from the Editor-in-Chief

I am honored to present the *Temple University Journal of Orthopaedic Surgery & Sports Medicine,* this year dedicated to a great clinician and educator, former chair of the department, John W. Lachman. 2021 marks the 15th volume of the journal and highlights our department's strong commitment to scientific inquiry and patient care. I strongly believe that these contributions from Temple faculty, residents, and medical students exemplify academic excellence.

In addition to the original works from our department, this year we highlight the research efforts of Dr. John Fowler in our Distinguished Alumni Section. After completing medical school at the Lewis Katz School of Medicine at Temple University, Dr. Fowler continued his training as a Temple orthopaedic surgery resident, matriculating in 2012 to begin an impressive career as a hand surgeon. We are proud of his accomplishments and recognize his contributions as a clinician, researcher and teacher.

Beyond the various changes seen within the department and medical school, the world is *very* different since our last publication. In this interim, Philadelphia experienced the closure of Hahnemann Hospital, a safety net institution much like our own. The Philadelphia community, and nation as a whole, was confronted with protests, riots and repeated calls for social justice. And finally, we were forced to respond to a global pandemic, losing countless loved ones and transforming the way we live, learn and practice medicine. In the Temple tradition, despite seemingly insurmountable obstacles, we faced these challenges head on and continue to cultivate a rigorous training environment with a special focus on academics and patient care.

I would like to thank my associate editors, Colin Ackerman, Heather Flynn, Patrick Donaghue and Maximilian McQuade. I would also like to thank the faculty advisors, Joseph Torg and Saqib Rehman, as well as our research coordinators, Joanne Donnelly, Bridget Slattery, and all of our Peer Review Board members. Without all of your collective efforts, the publication of this journal would not be possible. As a graduating chief resident and editor-in-chief, I am proud to be part of the Temple family and look forward to the continued success of the department!

Dana L. Cruz, MD
Editor-in-Chief
Class of 2021

Letter from the Residency Director

I am grateful to again have the opportunity to write an update from the Program Director for our residency. It has been my true privilege to do so for the past 10 years, and it would be a substantial understatement to point out that this year has been quite different than the previous nine. With change occurring all around, even I am surprised at that longevity. As expected, our residents have demonstrated their grit and resiliency over the course of the past year, dealing not only with the challenges of a pandemic and its impact on surgical volume and their clinical education, but also with the changes that arise from turnover in the faculty. In pointing out the turnover, I must express my gratitude to my colleagues who have left for their past efforts in teaching our residents and medical students, and I also maintain my appreciation for my partners who have remained dedicated to our educational mission. Of course, I also am appreciative and proud of each one of our residents.

I am particularly proud of our departing Chief Residents, who have seen change and struggle and have comported themselves admirably throughout. Dana Cruz came to Temple after bouncing back and forth across the country in the course of her education. She will continue her travels in education as she departs Philadelphia for a Hand Surgery fellowship in Arizona. Apparently, summers in Philadelphia have been too cold for her. Alex Johnson seems to have recovered well from a concussion early in his residency that occurred during an ill-conceived battle ball standoff and will be heading to Boulder, Colorado for a Sports Medicine fellowship. He was more excited about the move before finding out that he still needs to pass drug tests while living in the more "permissive environment" of Colorado. Nimit Lad decided that he missed Durham, North Carolina and will be returning to Duke for his Sports Medicine fellowship, where he claims that he is eagerly looking forward to offering Coach K some helpful tips. Finally, Jack Reynolds departing his hometown Philadelphia for Cleveland to do his Hand Surgery fellowship is reminiscent of a famous Ohio native leaving that city for South Beach a few years back, though Jack's announcement may not have been watched by as many people.

J. Milo Sewards, MD

Message from the John Lachman Society

The John Lachman Society was founded in 2001 to honor Dr. Lachman and propagate his principles of integrity, teaching, and excellent patient care. The Society also provides discretionary funds to promote and support the academic mission of the Department, primarily student and resident research. The mechanism to accomplish these goals is through the Society's support of the John Lachman Orthopaedic Research Fund (JLORF), incorporated in Pennsylvania as a non-profit corporation. The Internal Revenue Service has determined that the John Lachman Orthopaedic Research Fund is exempt from federal income tax under 501(C)(3) of the Internal Revenue Code and that contributions to the fund are tax deductible.

It appears appropriate to identify those other potential exogenous sources of support for Temple medical student and Temple hospital orthopaedic resident educational support. These can be divided into two groups: 1) essentially dormant funds and 2) those supporting primarily non-academic activities. The first group, the orthopaedic endowed chairs in the L.I.F.T. program, are not funded and exist in name only, i.e., the Steel chair and the Lachman chair. This program was initiated by the Temple-Shriners' alumni group and is predicated on life insurance policies of the contributing members but is controlled by Temple University. It is my understanding that a "new" insurance company that services the policies has submitted bills to keep them active and that the University is considering "cashing" them in.

Funds in the "active" group are: 1) the Medical Orthopaedic Attending Research and Education Fund, 2) the Orthopaedic Residents' Education Fund, and 3) the Abraham M. Reichman Endowed Orthopaedic Research Fund. To my knowledge, these three funds are not contributing to medical student and/or resident research projects or educational programs.

The second group, consisting of the Temple-Shriners' Alumni and the Thoder Portrait and lecture activity. It is my understanding that the Temple Shriners' Alumni group is no longer actively soliciting funds for their activities, which primarily have involved social events. To be noted, however, they have supported senior residents taking the board review course. With regard to the Thoder Portrait Fund, this was initiated by the medical school.

It is the John Lachman Orthopaedic Research Fund of the John Lachman Society that since its founding in 2001 has represented a dedicated 501(C)(3) tax exempt organization actively supporting both Temple medical student and Temple University Hospital orthopaedic resident education and research. These activities include the following:

1) Seed monies for resident research projects
2) Funds resident expenses for paper/poster/scientific exhibit presentations at accredited meetings
3) Funds resident attendance at accredited scientific meetings
4) Funds award monetary prizes, first, second and third place at annual residents' research day
5) Funds annual publication of *Temple University Journal of Orthopaedic Surgery & Sports Medicine*
6) Funds medical student summer research program
7) Supplements the Alumni Society commitment shortfall to send residents to board review course
8) The JLORF provides financial support for one resident each year to obtain a unique international experience with the African Inland Church (AIC)-CURE International Hospital in Kijabe, Kenya

Those interested in membership in the John Lachman Society should contact the Chairman of the Membership Committee, Milo Sewards, MD, c/o the John Lachman Society, Temple University Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

At the annual meeting of the board of directors of the John Lachman Orthopaedic Research Fund, the following officers were re-elected for a one-year term: President: J. Milo Sewards, MD; Vice President: Eric Lebby, MD; Treasurer: Saqib Rehman, MD; Secretary: Joe Thoder, MD.

The summer medical student research program continues to be a most successful program. This past summer, 15 sophomore medical students participated in the program. In addition to a number of students producing manuscripts suitable for publication in the *Temple University Journal of Orthopaedic Surgery & Sports Medicine (TUJSSM),* it is evident that a major value of this program is that those students have an opportunity to interface with the department in view of the curriculum changes that no longer require students to rotate through orthopaedics. Clearly, this has become a major avenue of acquainting students to the residency program.

In view of the success of the Temple Orthopaedic Summer Research Program, this course has been approved by the curriculum committee and the dean as an elective in the first-year student curriculum to teach students how to conduct a clinical research project based on the model we have developed in our department. The course will cover all aspects of clinical research. Topics that will be covered include: how to develop the research questions, literature review, role of the IRB and responsibilities to protect the data, IRB submission guidelines, and mandatory ethics certification. Clearly, Temple Orthopaedics functions as a trendsetter in medical student education!

Once again, the John Lachman Society published and distributed the *Temple University Journal of Orthopaedic Surgery & Sports Medicine,* Volume 14. Eighteen hundred copies of the *TUJSSM* have been distributed as follows: a) active faculty of the Temple University School of Medicine, b) orthopaedic surgeons who are alumni of Temple University School of Medicine, c) members of the John Lachman Society, d) department chairmen and residency directors of all orthopaedic programs throughout the United States, and e) fellowship directors to all orthopaedic programs throughout the United States.

Academic support for resident travel to meetings January 1, 2020 through December 21, 2020 involved 15 residents who have attended either formal courses or national meetings. The John Lachman Society webpage can be found at www.johnlachmansociety.org. The John Lachman Orthopaedic Research Fund is committed to a $2,500-year expenditure for texts and other educational materials for resident teaching.

Joe Torg, MD

The John Lachman Orthopaedic Research Fund Supports Temple Orthopaedic Surgery Mission to Kenya

In September 2017, Temple Orthopaedics completed the first medical trip to Kenya with one attending physician and one resident. Since then, the trip has continued annually due in large part to the generous support of the Lachman Fund. Of course, the 2020 Covid pandemic did not allow for the trip; however, we plan to resume in 2021. In 2019, two residents, Nimit Lad, MD and Joshua Luginbuhl, MD were in attendance. In addition to providing surgical care to the Kenyan patients, the residents had ample opportunities to learn from their Kenyan colleagues. The following are some thoughts on the experience from Dr. Luginbuhl.

As one might expect, there are many differences between North Philadelphia, Pennsylvania and Kijabe, Kenya. Weather, culture, and food, just to name a few.

The air in Kenya is thin, dry, and crisp — a stark difference to the heavy humidity that frequently coats Southeastern, PA. Kijabe, the small town where CURE Hospital is located, resides on the side of a mountain overlooking the ancient Rift Valley. The sunsets create a kaleidoscope of colors with each one being more memorable than the last.

Culturally, the people of Kijabe are welcoming and friendly. They embraced us with open arms and treated us as if we had known them for years. Each day in the OR, they made us food and made sure we ate first.

This caring and generous attitude permeated throughout the hospital particularly due to the large communal ward where children who underwent surgery or those waiting for surgery reside with their parents. While each family has their own space, caring for the children transcends any physical boundaries. It is not uncommon to see mothers take shifts looking after the many kids, so that each can take time for themselves and rejuvenate. This vastly contrasts the desirable private rooms and individualistic attitudes we see so commonly in the United States.

While being in Kenya felt foreign, new, and exciting, the operating room or “theater” felt like home. The ritual of scrubbing, the dance of gowning and gloving with scrub tech, were exactly the same. The biomechanics of fracture fixation didn’t change just because we were in a different time zone. The goal of orthopaedic surgery, to relieve pain and restore function, is universal.

Although being in the OR felt comfortable, there were also obvious differences. First, the injuries and deformities being addressed are rarely seen in the United States. Clubfoot, which is easily correctable with casting if identified early, is often neglected in countries with poor access to healthcare. Once treatment has been delayed, complex deformity correction is required to realign the foot. Ankle fracture/dislocations, which are typically taken care of expediently in the United States, are unfortunately diagnosed and operated on weeks to months after the injury in Kenya.

Secondly, the implants and sets of instruments available to the surgeon are often incomplete. This necessitates a level of innovation that is not frequently encountered in the United States. Creating something out of nothing, while achieving the goals of the surgery, is challenging but commonplace in the ORs at CURE Hospital.

When we first arrived to Kijabe, the differences were glaring; however, after spending time with patients, nurses, residents, and attendings at CURE Hospital, it became clear that our similarities were more salient. Traveling to Kenya was an incredible opportunity to share the human experience through orthopaedics while reinforcing the fact that musculoskeletal injuries know no race or creed.

Eric Gokcen, MD

Letter from the Office of Clinical Trials

The Office of Clinical Trials and Research Support has been going strong since 2004 when it was established under the direction of Pekka A. Mooar, MD, Joseph S. Torg, MD, and supported by the School of Medicine's Office of Clinical Research Administration. The office continues to fulfill its vision of providing the Department of Orthopaedic Surgery and Sports Medicine with industry-sponsored clinical trials, investigator-initiated and resident research. Additionally, the office helps facilitate research grant applications, and oversees the Orthopaedic Summer Research Program. Joanne Donnelly has served as Program Director and full-time research coordinator since 2004. The office expanded in 2018 with the hiring of Bridget Slattery as a second full-time research coordinator.

The summer research program, now in its 18th year, is geared toward Temple medical students with an interest in orthopaedics. Funding for the program is provided through the federal-work study program and supplemented by the John Lachman Orthopaedic Research Fund. The summer research program will host 17 Temple medical students in 2021.

The eight-week program involves teaching the students the fundamentals of clinical research via a research topic selected by our orthopaedic surgeons and culminates in generating a finished manuscript. There is an orientation by Dr. Susan Fisher, Department of Clinical Sciences Professor and Chair on the "Nuts and Bolts of Statistics for Clinical Research." Jenny Pierce, Temple Reference and Emerging Technologies Librarian, provides the students with basic and advanced research searching tools through PubMed, Ovid, and other search engines as well and Jacob Brintzenhoff who offers guidance in RefWorks for managing citations. Edy Parrilla-Caceres, from the Temple Institutional Review Board, reviews the guidelines pertaining to clinical research. Both Bridget and Joanne are looking forward to another exciting and fruitful year with the students. Due to the COVID-19 pandemic, the program was conducted via Zoom last year; however, we are optimistic that we will be able to conduct the program in person this summer.

In addition to their duties in the Orthopaedic Department, Bridget and Joanne have been working as research coordinators on the Johnson & Johnson coronavirus vaccine clinical trial, "A Randomized, Double-blind, Placebo-controlled Phase 3 Study to Access the Efficacy and Safety of Ad26.COV.S for the Prevention of SARS-CoV-2-mediated COVID-19 in Adults Aged 18 Years and Older (ENSEMBLE)," aiding Dr. Nina Gentile and the Emergency Medicine department staff to recruit and enroll patients as well as assist with data management.

Current Industry-Sponsored Clinical Trials Drug or Device

AESCULAP (Core Study)

A Phase 3, Prospective, Randomized, Partially Blinded Multi-Center Study to Measure the Safety and Efficacy of Novocart® 3D, Compared to Microfracture in the Treatment of Articular Cartilage Defects

Principal Investigator: J. Milo Sewards, MD; Sub-Investigator: Pekka A. Mooar, MD; Sub-Investigator: Vishal Saxena, MD

Open to enrollment — 16 subjects enrolled

AESCULAP (Rescue Study)
Safety and Efficacy of NOVOCART 3D in the Treatment of Articular Cartilage Defects following failure on Microfractur.

Principal Investigator: J. Milo Sewards MD; Pekka Mooar MD; Vishal Saxena MD

Open to enrollment

REGAIN
Regional vs General Anesthesia for Promoting Independence After Hip Fracture Surgery (Large Multi-Center Study)

Principal Investigator: Ellen Hauck, DO; Sub-Investigator: Jon Livelsberger, DO;
Sub-Investigator: Theresa Pazionis, MD, Orthopaedics

Closed to enrollment on March 2021; Goal reached of 1,600 subjects for all sites — 38 subjects enrolled

Novartis (Part A)
A Two Part, Randomized, Placebo-Controlled, Patient and Investigator Blinded, Proof of Concept Study Investigating the Safety, Tolerability, and Preliminary Efficacy of Multiple Intra-Articular LNA043 Injections in Regenerating the Articular Cartilage of the Knee in Patients with Articular Cartilage Lesions (Part A). This phase 2 study will assess the efficacy, safety, and tolerability of multiple intra-articular (i.a.) injections of LNA043 over four weeks, in regenerating the articular surface in patients with cartilage lesions of the knee.

Principal Investigator: Pekka A. Mooar, MD; J. Milo Sewards, MD; Vishal Saxena, MD

3 subjects enrolled

Novartis (Part B)
A Two Part, Randomized, Placebo-Controlled, Patient and Investigator Blinded, Proof of Concept Study Investigating the Safety, Tolerability, and Preliminary Efficacy of Multiple Intra-Articular LNA043 Injections in Regenerating the Articular Cartilage of the Knee in Patients with Articular Cartilage Lesions (Part A). This phase 2 study will assess the efficacy, safety, and tolerability of multiple intra-articular (i.a.) injections of LNA043 over four weeks, in regenerating the articular surface in patients with cartilage lesions of the knee.

Principal Investigator: Pekka A. Mooar, MD; J. Milo Sewards, MD; Vishal Saxena, MD

5 subjects enrolled

Depuy Synthes
Patient Outcomes After a R/AFN Nail Fracture Fixation with a Retrograde Approach

Principal Investigator, Saqib Rehman MD

Comparison of Short Term Clinical Outcomes of Piriformis Fossa and Trochanteric Entry Nailing for Femoral Shaft Fractures

Principal Investigator: Saqib Rehman, MD

NOVEN PHARMACEUTICALS, INC.
A 12-Week, Randomized, Double-blind, Placebo-controlled, Parallel-group Phase 3 Study to Evaluate the Efficacy and Safety of HP-5000 Topical System (Patch) in Subjects with Osteoarthritis Pain of the Knee

Principal Investigator: Pekka Mooar, MD; Michele Noreski, DO; Vishal Saxena, MD

Potential Clinical Trials

Department of Defense (METRC)
Topical Antibiotic Therapy to Reduce Infection After Operative Treatment of Fractures at High Risk for Infection: TOBRA — A Multicenter Randomized Controlled Trial — TOBRA. This study will look to enroll subjects with high energy pilon or tibia plateau fractures treating with either SOC and Local Vancomycin powder or SOC and Local Vancomycin powder and Local Tobramycin powder at definitive closure

Principal Investigator: Saqib Rehman, MD; Sub-Investigator: David Galos, MD

Endo Pharmaceuticals Inc.
Phase II Clinical Trial for Treatment of Adhesive Capsulitis Using Ultrasound Guided Injections

Principal Investigator: J. Milo Sewards, MD; Leslie Barnes, MD

Grant Funded Research

Multimodalwty Prevention of Postoperative Delirium in Geriatric Fracture Patients

Colin Ackerman, MD; Saqib Rehman, MD — OTA Grant $20,000.00 Awarded

A Simple Test to Determine Ability to Drive After Right Lower Extremity Surgery

Dana Cruz, MD; Eric Gokcen, MD – OREF Grant $5,000.00 Awarded

Respectfully,
Joanne M. Donnelly, RC
Bridget Slattery, RC

To support its activities, the John Lachman Society is actively soliciting your tax-exempt contributions, which can be made two ways:

Via our new secure website, which is https://lachmanfund.org. Once there, you can make a donation and also view current and past issues of the journal as well as other resident activity.

Or, if you wish to write a check, please make it payable to John Lachman Orthopaedic Research Fund and mail it to our Treasurer: Saqib Rehman, MD, Department of Orthopaedic Surgery, Temple Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

Clearly, these programs greatly enhance the medical student and resident orthopaedic experience! And clearly, your contribution to the program will be greatly appreciated!

Joe Torg, MD Joe Thoder, MD

John W. Lachman, MD

Dedication

John Lachman, MD

PHILIP ALBURGER, MD

Delivered at the Dedication of the Lachman Auditorium

It is my distinct honor and a great pleasure to discuss John W. Lachman, MD, the man for whom this auditorium is being named. Having your name inscribed on a large structure by a major institution is recognition for men and women who have had great success in life.

Typically, the fruits of their endeavors have endowed them with great material success. Then, because of their philanthropic inclinations, they have made a sizeable contribution to an institution during a major fund drive, the institution in gratitude places their name on an appropriate structure in perpetuity. This model certainly could not have applied to John W. Lachman. On a professional salary at Temple, he never amassed a great fortune. And, to the best of my knowledge, he has not contributed one cent to the construction of this auditorium. Nor has he ever in his life shown any inclination to see his name displayed in prominence publicly. As a matter of fact, if he knew about this naming, I'm sure he would have resisted and suggested that the auditorium be dedicated to someone else, or that others share the honor. He had no interest in notoriety whatsoever. It was contradictory to his dignified reserved, modest, even humble nature. So why is his name on this beautiful auditorium? It would seem that he conformed to another definition of success in life that is not necessarily material. This definition states that the success of a man's life can be measured by the number of people whose lives were favorably influenced by him. By that measure, John Lachman's life can certainly be ranked at the top of this list.

He also achieved his success in a very Conwellian or Temple-like fashion. For those of you who are not familiar with the works of Russell Conwell, the Baptist Preacher who was the founder of Temple University, his quintessential message was contained in his treatise stating that a man does not necessarily have to travel far and wide to find happiness or fortune. Conwell's premise being that there are multiple opportunities right where you are. He stated that there are acres of diamonds (the name of his treaties) in your own backyard, and he delivered it over 5,000 times.

John Lachman was born and raised in the Philadelphia area and found his success not only in his own backyard, but at the very institution that Russell Conwell founded. There, Latch had a 60-year continuous relationship with Temple. He went to undergraduate school at Temple University. He went to medical school at Temple and had his internship and residency at Temple. He joined the orthopedic department at Temple and advanced to be the Chairman of the Department of Orthopaedic Surgery, a position which he occupied for over 20 years at Temple University Hospital. His academic achievements during that time have been well chronicle. He was always a diligent student and was gifted with a brilliant intellect that at least in the world of Orthopaedics, which was his world, frequently made him the preverbal smartest man in the room. He was responsible for the education of over 200 orthopedic surgeons and contributed to the education of thousands of medical students who are now physicians. The present Chair in Orthopaedics has been endowed in his name. His formal portrait hangs in place of honor in this Amphitheater. He has also been memorialized by the formation of the John Lachman Society and the John Lachman Memorial Research Fund. He objected to them being so named until the day he died, insisting that others be included. The John Lachman Society was inspired by Dr. Lachman's principles of excellence in patient care, dedication to teaching and highest standards of medical ethics. The John Lachman Research Fund is dedicated to supporting resident education and teaching. For information and donation of funds, please call (215) 707-3405 and ask for Joe. As a lifelong student of anatomy and skilled diagnostician, Dr. Lachman codified the anterior translation of the tibia on femur in athletic knee injuries as being diagnostic of a torn anterior cruciate ligament. This remains today the most sensitive and accurate physical diagnostic test for acute ACL tears, and is used in the examination of acute knee injuries by doctors, and trainers, etc., in the office and on the athletic fields worldwide. It is universally referred to as the Lachman sign. When Dr. Moore, Dr. Lachman's predecessor, was 65 years of age, the requirement at Temple was that he had to retire as Chief. He could continue to operate but could no longer be Chairman of the department. A search committee was formed but Latch stated he had no desire to be the Chairman. Dr. Parkinson urged him to submit his name and at least be a consideration for Interim Chairman. In this role, he did so well that he was permanently appointed. He was a wonderful chief, and gave credence to the saying that sometimes the man who is best for the job is the one who doesn't want it. He treated his chairmanship not as an imperious autocratic

dictator, the style of his predecessor, but as the steward of a sacred trust. He never made a decision based on a self-serving motive or for personal ambition, but always did what was in the best interest of the department at large. He frequently said, "you can get an awful lot accomplished if you don't care who gets the credit."

Once when I was a young staff man, I was in his company at the Annual Meeting of the American Academy of Orthopaedic Surgeons. While walking the exhibit floor, we encountered the Chairman of another orthopedic department in Philadelphia. A third Senior Orthopaedic surgeon joined the conversation and spilled some jellybeans which he was eating onto the floor. He immediately bent down to start picking up the beans. I bent down to help him and as Latch bent over to help, the other Chairman, beaming with self-importance, grabbed Latch's sleeve and attempted to pull him to a straight posture saying "John they will take care of that, RHIP."

Latch pulled his shoulder away and helped to retrieve the remaining candy. As we walked away, I asked Latch what does 'RHIP' mean and he grumbled, "rank has its privileges. I loathe that saying." He never thought he was more important than someone else. He thought that physicians were there to serve the patients, and the administration was there to facilitate the ability to accomplish that goal. The hierarchy was not the other way around. He was fiercely loyal to all members of his department. If anyone in the department had a problem with administration or some other force in the hospital and Latch thought there was an injustice being done, the central vein would start pulsating, and he would adopt the cause as his own. His involvement would become immediate and formidable. When he thought that Janet Stellini, our office manager for many years, had merited a raise and administration refused to accommodate the request, frustrated with due process, he stormed into the administrator's office and informed him that unless Janet got her just deserts, he would ask a number of his total hip patients to pay him directly and he would personally pay Janet with the proceeds. Janet got her raise. He reduced his own compensation on several occasions so that other members of the department could get more. As one of his long-term colleague at Temple, after he heard of Latch's death said with great admiration, "I never saw anyone in my 60 years at this medical school and hospital who engendered so much respect and loyalty from his entire department. Not just the medical staff, but everyone." Loyalty begets loyalty.

His first principle of clinical practice was not *premum non nocere.* First of all, do no harm, but beneficence, that is, providing what is most appropriate and best for each patient. He was a thoughtful, careful and meticulous surgeon and consummate clinician with renowned expertise in his field. However, he provided his patients with more than just technological procedures and medications. He also provided understanding and compassion. When they talked to Dr. Lachman, he was not distracted or thinking about something else. They knew that they had his undivided attention. They knew that he cared not just cared for them, but about them as individuals. Latch practiced in a way that did not neglect the art of medicine in pursuit of the science. Realizing that it was often the art that was the most beneficial for his patients, and he always did what was in their best interest. His patients were most appreciative and the office was always receiving gifts and tokens of gratitude (especially during Christmas time), and other holidays as well (including lots of chopped liver on Yom Kippur, which fortunately he shared with the rest of us). He didn't have a protocol and he didn't care about making money or enhancing his reputation. He eschewed fame and notoriety and was the antithesis of the stereotypical, arrogant, egomaniacal surgeon. Ostentation was repugnant to him, and although he dressed very nicely and conservatively, he would never drive a Mercedes or other fancy car saying "it would be inappropriate to appear to be making a lot of money at the expense of sick people." He had a very sensitive social conscience. On more than one occasion, at the end of day, I've seen him approach a clinic patient seating alone in the clinic that had missed their transportation home and offer them a ride. He also cared deeply about his students and residents and teaching them to be physicians. The guiding principle of his teaching style was also patient care. There was no compromise in his demand for excellence and attention to detail. There was no escape from accountability. He was the consummate teacher, mentor and role model. He was the anti-Charles Barkley. Charles says "he is not a role model," by Latch's standard. Charles is a role model, just not a very good one. Latch thought that every person had a sphere of influence and that every act they performed had an influence on that sphere for better or worse. He consciously attempted to be sure that what he did was for the better. He taught not by correcting or admonishing but by example. So those of us who worked with him on a daily basis as students and residents, had his unparalleled level of excellence and devotion by which to gauge our own performance and we still do. Lucky us!

He was esteemed Chairman, Professor and teacher, but beyond that, he had many personal characteristics of which some of us would like to have even a few. He was kind, thoughtful, understanding, and nonjudgmental, willing to listen, free of ego, professionally accomplished, he gave willingly and happily to all those who crossed his path. And that is why his name is on this auditorium. Although he may

have protested the naming, I know nothing would have made him happier than to know that his name is on an auditorium dedicated to the teaching training of young physicians. And,that it was the respect, admiration, and gratitude of so many of his friends and colleagues that made it possible. And in that sense, his name is on this auditorium because of you.

John W. Lachman, AB, MD, FACS

It is eight o'clock Saturday morning, the subject is fundamental Orthopaedics. The lecturer loves his subject, relishes teaching it, and knows it as well as he knows himself. He tells the class, "Stop writing: look up here." He throws his coat off and rolls up his sleeves to show the mechanics of the Colles' fracture; later, he removes his shoes to demonstrate varus and valgus at the ankle. At the bedside or in the lecture hall, his teaching always conveys the excitement that he feels for his specialty and practice of medicine. It is with a real sense of appreciation, therefore, that the class of 1966 dedicates its yearbook to this outstanding teacher and physician — Dr. John W. Lachman.

To support its activities, the John Lachman Society is actively soliciting your tax-exempt contributions, which can be made two ways:

Via our new secure website, which is https://lachmanfund.org. Once there, you can make a donation and also view current and past issues of the journal as well as other resident activity.

Or, if you wish to write a check, please make it payable to John Lachman Orthopaedic Research Fund and mail it to our Treasurer: Saqib Rehman, MD, Department of Orthopaedic Surgery, Temple Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

Clearly, these programs greatly enhance the medical student and resident orthopaedic experience! And clearly, your contribution to the program will be greatly appreciated!

Joe Torg, MD Joe Thoder, MD

John W. Lachman, MD
1919–2007

Delivered as a eulogy for Dr. Lachman on October 18, 2007 at Villanova University, St. Davids, PA

John W. Lachman, MD was the distinguished Professor of Orthopaedic Surgery at Temple University School of Medicine and Chairman of the Department of Orthopaedic Surgery for more than 30 years. During that time, he was responsible for the education of over 200 orthopaedic surgeons and contributed to the education of thousands of medical students who are now physicians. He has already been memorialized professionally in many ways. His dedicated portrait hangs in a place of honor in the medical school. The Chair in Orthopaedics has been endowed in his name. He has been honored with the construction of the auditorium bearing his name in Temple's new $150,000,000 medical school completed in 2009. He is also memorialized by the John Lachman Society, inspired by his principles of excellence in patient care, dedication to teaching, and the highest standards of medical ethics. His name is universally recognized in orthopaedics around the world because of his innovation of the most reliable physical diagnostic maneuver for determining the presence of a torn anterior cruciate ligament. Yes, every time we see a team physician or trainer rush to the aid of a fallen athlete with a knee injury, we can consider it a tribute to Dr. Lachman since we can be sure that they are employing the maneuver which bares his name, the "Lachman Sign."

The facts and comportment of his life reveal some of the characteristics that made him so exceptional. He was a diligent student blessed with a brilliant intellect. This became evident early on when he skipped third grade and finished grammar school early. As the top student in his high school's graduating class, he won a scholarship to Temple University. It was the Depression and times were tough, so he always appreciated the opportunity that Temple had given him to continue his education. Following college, he matriculated at Temple University School of Medicine, which he completed in three years and where he was again first in his class. There he met fellow student and life long friend, John Kolmer. A medical school professor of theirs whose name I don't know, but only the fact that they referred to him as "shifting dullness," continually irritated John by referring to him as Latchman rather than Lachman. Dr. Kolmer undoubtedly sensing a weak spot, immediately dubbed him "Latch" and it stuck. Here began a life long friendship. The Kolmers got a Godfather for the ages and Latch got another wonderful family to be a part of. For even though he never married, I considered Latch to be among the finest family man I've ever met. He was devoted to the Lachman families and all their children, and was also a surrogate member of the families, of many friends, former residents, students and patients. He may have been too busy to go to all of their cocktail parties, but if any of them had family members that were in trouble, or had any sort of problems, Latch would always be there to comfort and help. By the measure of the saying a "friend in need is a friend indeed," Latch was the best friend you could ever have.

His family and friends, however, were not the only beneficiaries of his extraordinary thoughtfulness and generosity. Latch seemed to make time for everybody, and had an inclination to help anyone in distress. If there was a patient left in the clinic at the end of the day without a ride home, Latch would drive him there himself. I know he once gave $2,000 to one of our trainers who wanted to go to physical therapy school, but could not afford it. Latch said, "I want him to be able to get his education." He gave money to a young caddy that was having difficulty getting to school and work because his car broke down. He gave financial assistance to his former maid when her family was in difficulty. He reduced his own salary so some of his staff could get raises. He is the only man I know who actually paid sticker price for a car because he liked the salesman. He gave of his time and resources routinely in many ways to those without the financial, social or political capital, to ever be able to repay him. He never wanted recognition. Among his peers, students, family and friends, he is universally respected as one of the finest gentleman that they

have ever encountered. But among all the benefactors of his virtues, the most fortunate may have been those of us who were nurtured by him as orthopaedic surgeons. To know him as he was, as a physician, the profession to which he devoted his life, was a stroke of extraordinary good fortune. He was the consummate clinician and a meticulous surgeon who seemed to make a personal connection with almost every patient. I was once treating a very urbane influential patient of Dr. Lachman's in his absence who was extolling Latch's praises, so I asked him what he thought made Latch so special? I expected him to mention Latch's extraordinary clinical acumen, but he replied "his humanity." When Latch injected a patient's knee, the beneficial effects lasted at least three months. When I, in his absence, would do the same to the same patient in exactly the manner that he taught us, they would return in three weeks to have it done properly by Dr. Lachman.

Talk about having presence. His patients loved him, and medically, it was as if he were a walking placebo effect. In addition to patient care, he had a passion for teaching, sharing his wisdom and knowledge with his students and residents. He was a true mentor and treated every resident as one of his sons. He tended to be extremely tolerant and forgiving of all sorts of our individual failings and idiosyncrasies. However, in matters of patient care and learning to be a skilled and gentle surgeon, he was an unrelenting task master in his demand for excellence and attention to detail. There was no escape from accountability. "It didn't just break." The aphorism went, "the road to failure is paved with blocks of sorries." If you made a mistake and said you were sorry, he would reply, "that makes no difference to the patient." You have to be more thoroughly prepared. If a resident failed to go to the emergency room to see a patient in a timely fashion, and the "man" as he was known found out about it, he might say something like, "Ed, I realize you were tired, but please if you ever find yourself in a situation where you can't make it to care for one of our patients, you must call me and not deny me the opportunity of coming in and caring for them properly myself." The problem with this type of scenario was that you knew that he meant it. This was not some sloganeer. This was not a detached administrator expositing a principal of patient care from a manual. This was a totally involved dedicated leader who never asked you to do anything he wouldn't do himself. He taught not by pontificating or admonishing, but by example. He simply expected us to meet the same standards to which he held himself, and he never had a self-serving motive or personal ambition. The single premise was to be totally responsible for all aspects of patient care. Consequently, he spoke with the commanding moral imperative of the only true authority, the authority to serve.

What motivates a man such as this? He certainly wasn't motivated by money. He cared nothing for fame or popularity. I think it might have something to do with the response I heard him give to an 85-year-old woman at the Waterford. She knew that he was a daily communicant and was never without his rosary. She said, "John, you are truly a holy man." He responded, "I'm not holy but I am trying to be." He was an ideal role model having led an impeccable life both professionally and personally. All of us who have studied under him, stand in awe of him and his level of excellence. We share a fraternal bond, for only having been taught by him could you possibly realize how much he cared for each and everyone one of us. We are in a sense "Latched" together. His departure leaves a huge void, for we know that we will not see another one like him come along in our life times. So it's time to see if the mentoring worked and we are left the daunting prospect of trying to emulate him so that his principals can endure. When I think of Latch, I'm filled with a great sense of gratitude to him for all he did for us, and to the good Lord for allowing us to have him for so many wonderful years. May he rest in peace.

Philip Alburger, MD

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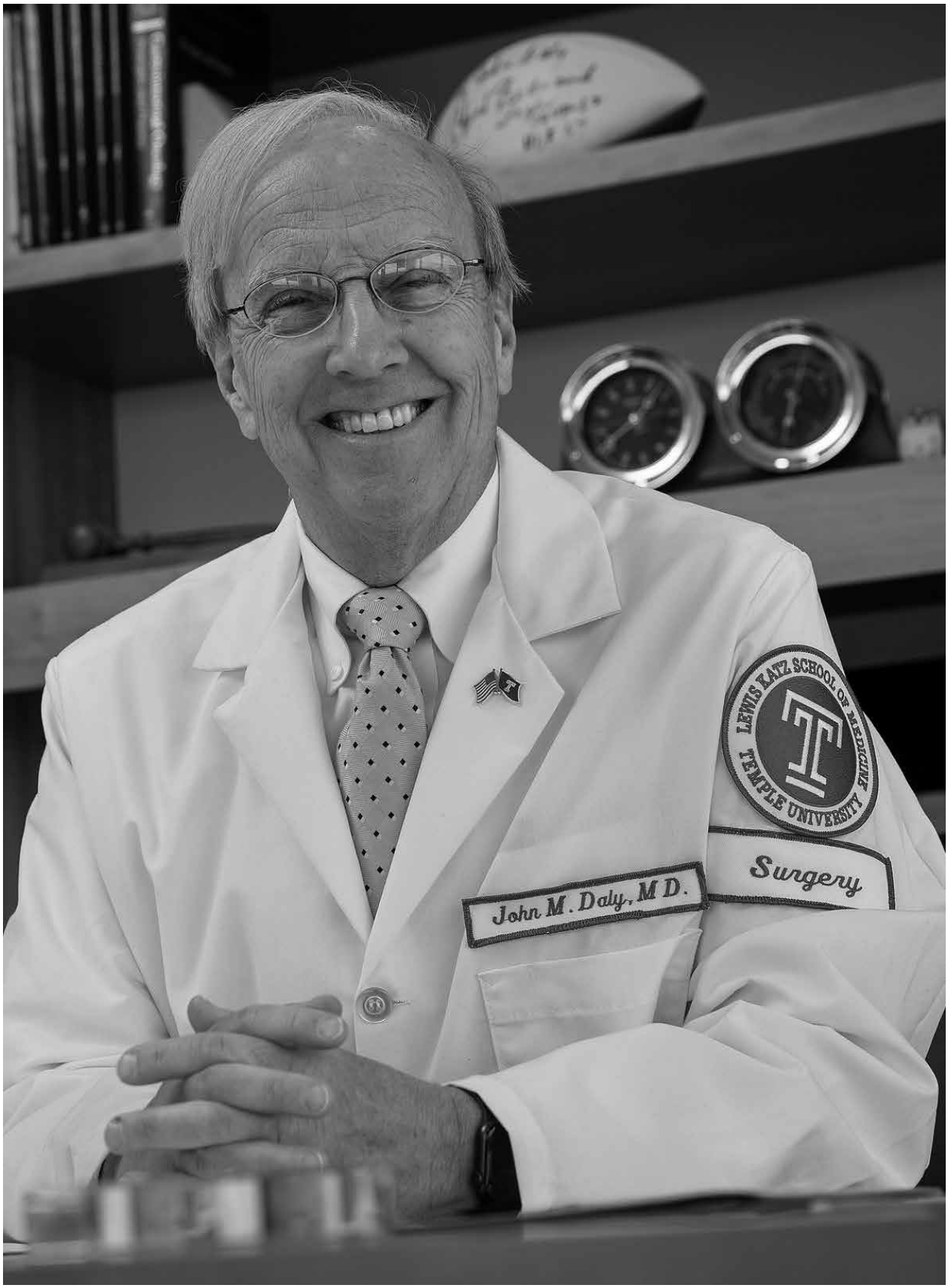

John M. Daly, MD
Dean of Temple University School of Medicine 2002–2011

In Remembrance

John Michael Daly, MD

JOSEPH TORG, MD

As suggested by Joe Thoder, Department Chair, and unanimously and enthusiastically agreed upon by the editorial board, this volume of the *Temple University Journal* of *Orthopaedic Surgery & Sports Medicine* is dedicated to John M. Daly, Dean of the Medical School from 2002 to 2011. And what a dean he was: surgeon extraordinaire, internationally renowned academic animal, leader of men, visionary and role model for the ages. Such platitudes clearly describe the man but first let us examine his short comings.

I have known John Daly for the past 38 years. Our first encounter occurred when he was a medical student at Temple on an orthopedic rotation and I was a young faculty member. As a student, he appeared capable, enthusiastic, and destined for a career as an orthopedic surgeon. But as we all know, he rejected or was rejected by orthopedics and pursued a general surgery residency. What happened? Was he not physically capable of managing large bone and joint problems? Was he too intellectually challenged to handle the concepts of orthopedic principles and practice? Did he lack the eye-hand coordination and cognitive skills to deal with the arthroscope and other advanced orthopedic devices?

The house that Daly built

John Daly, a general surgeon! Such a disappointment! But he did recover as an itinerant surgeon at the University of Texas School of Medicine, Cornell University Medical College, the Weill Medical College of Cornell University, and the University of Pennsylvania, where our paths crossed once again.

And let me share another Daly vignette that occurred when we were both on the staff at Penn back in the 80s. While vacationing at the Jersey shore, I was asked by a friend to see a patient who had been admitted to a local hospital and was scheduled for a "diagnostic laparotomy" because of what was undiagnosed abdominal pain. Having spent the first year of my orthopedic residency at Temple on general surgery and being somewhat vaguely familiar with inter-abdominal problems, opening the belly without a diagnosis just didn't seem cool. So I called my good friend John Daly, explained my concern and arrangements were made to transfer the patient to Penn. And my good friend John Daly then, on the basis of his extraordinary clinical acumen and experience, diagnosed acute mumps pancreatitis, initiated appropriate conservative, non-surgical management that resulted in a complete recovery without sequela. What made the experience more meaningful was that surgical intervention would have most certainly resulted in disaster. And my good friend John Daly — what a guy — clinician, diagnostician, academician — the whole enchilada.

But let us examine John Daly in a more serious vein. I can attest to the fact that he is a man of faith, has been a committed husband and father, a most supportive friend of Temple Orthopaedics and the School of Medicine and a great a humanitarian. With an unassuming demeanor, he maintains a low profile, avoids rhetorical bombast and self promotion, and is modest almost to a fault.

And did he recover as a general surgeon! During his travels, he produced 250 publications in peer review journals, amassed a total of $2,831,000 as principal investigator in 20 research grants, and was awarded honorary doctorate degrees from both the University of Glasgow and the University of Dublin — a classic example of Irish cohesiveness.

But let's talk about his really important contributions. John Daly's tenure as Dean of the Medical School was initiated by the threat of the loss of the academic accreditation of the medical school. And with diligence and foresight, he initiated a transformital program that involved the academic curriculum, faculty acquisition and, of course, the design and construction of the new Medical Education and Research Building, the signature accomplishment of a magnificent career.

Reprinted from the *Temple University Journal of Orthopaedic Surgery & Sports Medicine,* Spring 2013.

In Remembrance

William G. DeLong, Jr., MD (1948–2020)

Saqib Rehman, MD, MBA

William G. DeLong, Jr., MD, passed away on Friday, March 13, 2020, unexpectedly from a heart attack at his home. Dr. DeLong was a Professor of Orthopaedic Surgery and Sports Medicine and Professor of Anatomy and Cell Biology at the Lewis Katz School of Medicine at Temple University. He was also the Network Chairman of Orthopaedic Surgery at St. Luke's Health Network in Bethlehem, PA.

Dr. DeLong was a native of North Philadelphia and obtained both his undergraduate and medical degrees from Temple University (in Chemical Engineering), graduating from the School of Medicine in 1978. He was then recruited to Penn for his residency training, and thereafter teamed up with fellow Penn resident Christopher Born for a partnership that would last for 20 years. From Cooper, then back to Penn, he returned to Temple in 2003 as a full-time member of the orthopaedic department. During his tenure at Penn, he had helped to establish the trauma program at St. Luke's. Eventually, he was recruited to St. Luke's to chair their orthopaedic program and in 2009, started a residency program. He continued to help with trauma rounds at Temple on Fridays for several years and Temple residents continued to learn from his bedside teaching. His humor, energy level, and commitment are remembered to this day by his former trainees.

Dr. DeLong trained countless surgeons and was a genuine leader whose most recent position as Chairman at St. Luke's oversaw the rapid growth and development of a community program into a large network of academic specialists. He served many leadership roles at Cooper University Hospital, University of Pennsylvania Health System, and Temple University Hospital. He was also a team doctor for the Philadelphia Flyers and several other professional, collegiate, and youth sports teams. Bill was also well-known for his "boots on the ground" humanitarian efforts during Hurricane Katrina and the Haiti Earthquake and his leadership as Chairman of the Humanitarian Committee of the OTA. He was a member of the Trauma Critical Care Team of the Dept. of Homeland Security for many years. He was also active as a consultant to the numerous community organizations in his hometown of Haddonfield, NJ.

Always leading by example, he continued to take overnight trauma call responsibilities and maintained full surgical and clinic schedules up until his passing. His energy level, fearlessness, and commitment to excellence set a gold standard for others to follow. He never turned a patient away, never said no to a colleague in need, and generously mentored countless young surgeons. His contributions continue to benefit patients and doctors around the world. He has been recognized with awards including Best Doctors in America, Top Physician in multiple publications, as well as teaching and research awards. A sought-after educator, he was a steady presence as a lecturer and chairman at national and regional meetings and courses. He has also written numerous book chapters and scientific publications.

On a personal note, Bill was a true mentor to me since 2003. He gave me the opportunity to train with him and Chris Born as an AO trauma fellow and gave me my first job, which I still have, as a faculty member at Temple University. Along the way, he helped my career trajectory immensely by opening up opportunities for research, committee and leadership positions, and humanitarian efforts in multiple organizations. He also provided me with advice on both professional and life decisions up until the time of his passing. I will forever be indebted to his mentorship and friendship and will miss him dearly.

In Remembrance

The Demise of Hahnemann University Hospital: A Cautionary Tale with Far-Reaching Impact

MARTIN J. HERMAN, MD; NORMAN A. JOHANSON, MD

Introduction

The closure of Hahnemann University Hospital (HUH) in 2019 was a cataclysmic event that reverberated throughout the Philadelphia region and the entire United States. While the causes of its ultimate demise are myriad and blame for its failure continues to be assigned, one truth is clear: the impact of the closure of HUH will be felt by the community served by the hospital, and the many trainees who passed through its wards and operating rooms, for years to come. For those of us who are dedicated to Orthopedic Surgical resident education, the loss of the HUH/Drexel University College of Medicine (DUCOM) Orthopedic Surgery Residency Program was especially personal and heart-breaking. The demise of HUH should serve as a wake-up call to the greater community of physicians who are dedicated to high-quality patient care for all and to education of the future generation of physicians.

Brief History of HUH

Founded in 1848 as the Homeopathic Medical College of Pennsylvania, the institution was the first and only homeopathic medical college in the United States. Hahnemann University Hospital (HUH), at its iconic location on North Broad Street, opened in 1928. The school's progressive beginnings evolved with the times, utilizing a more traditional model of medical education for trainees of all levels by the mid-20th century and providing quality care to countless patients in the Philadelphia region at HUH. In 1998, Drexel University first assumed operational control of the remnants of the Allegheny Health, Education, and Research Foundation (AHERF), which had combined Hahnemann University College of Medicine and the Medical College of Pennsylvania (MCP) in 1995. AHERF would later become the largest not-for-profit organization to declare bankruptcy in U.S. history. In 2002, MCP-Hahnemann became Drexel University College of Medicine (DUCOM), continuing the tradition of outstanding medical education. The operations of the AHERF-owned hospitals, including HUH and St. Christopher's Hospital for Children (SCHC), were taken over by Tenet Healthcare Corporation in 1998, a Dallas-based national for-profit hospital system with over 100 hospitals. During the next 20 years, HUH experienced chronic instability related to inconsistent direction, institutional financial challenges, and the rapidly changing landscape of healthcare regionally and nationally. In January 2018, the institution's fate was sealed when leadership formed the American Academic Health System (AAHS), purchasing HUH and SCHC. Two years later, AAHS declared bankruptcy, closing HUH and ultimately selling SCHC to Tower Health, in partnership with the Drexel University College of Medicine. The storied and tumultuous 171 year-long history of (HUH) ended abruptly on September 6, 2019, when its doors closed for good.

Impact on the Community

HUH has been an important safety-net hospital in the Philadelphia region for nearly its entire existence, providing state-of-the-art care to all patients regardless of their ability to pay. In 2017, Hahnemann had over 17,000 hospital admissions and 53,000 emergency department visits — with over 80% of patients having governmental insurance or no insurance. Other regional institutions, notably Thomas Jefferson University, Temple University and Albert Einstein University Hospitals, were abruptly strained by the influx but ultimately were able to accommodate many of these patients. The closure of HUH's Level One Trauma Center was equally disruptive for the community and symbolic of the abandonment that the neediest individuals in our region experienced.

The impact on the community extended beyond access to care. At the time of closure, HUH employed over 2,500 people in a wide variety of health care and hospital support positions including nurses and advanced care practitioners, medical assistants, technicians, and environmental services staff. Over 200 employed physicians were released with the relocation and closure of hospital-based clinics and medical practices, forcing many patients to leave their long-standing medical homes for routine and specialty care. Countless others, from vendors to local small businesses, were also profoundly negatively affected by the HUH closure.

Impact on Medical Education

From the perspective of graduate medical education, the demise of HUH was one of the most catastrophic failures in the history of the ACGME. A total of 583 residents and fellows became "orphan residents" essentially overnight. The Chief Academic Officer of HUH at the time of closure, William Boyer, described the situation as "disastrous, chaotic, and dynamic." Mr. Boyer, with no specific guidance from the ACGME or DUCOM, and minimal resources, was charged

with finding residency slots for these young physicians over the course of 45 days. The situation was further complicated by the legal proceedings surrounding the hospital bankruptcy, a malpractice tail coverage dispute, and the simultaneous closure of a 500-bed hospital. Most of the residency slots were redistributed within the Philadelphia area's three largest health systems, i.e., Thomas Jefferson University, Temple University, and the University of Pennsylvania. Miraculously, nearly all the resident physicians were able to continue training without disruption or extension of their residency tenure. Of the 20 "orphaned" Orthopedic Surgery residents, only seven were placed in programs outside of the region. For DUCOM and other regional medical students, nursing students and other professional school students, an important training ground with complex pathology and supportive faculty was lost forever.

Impact of HUH/DUCOM Orthopedic Surgery Residency Dissolution

The HUH Orthopedic Surgery Residency Program began training orthopedic surgeons in the late 1940s, with an accredited training program established in 1972. In 1995, the HUH residency was merged with the MCP Orthopedic Surgery Residency when the institutions were merged under AHERF. The resulting four-person/year program was formally renamed HUH/DUCOM Orthopedic Surgery Residency in 2002 until its dissolution after the HUH closure in 2019. Under the leadership of its chairs in the modern era, Arnold Berman, Joseph Torg, and Norman Johanson, more than 150 orthopedic surgeons have graduated from the program, practicing in nearly all 50 states in every sub-specialty in Orthopedic Surgery.

According to Johanson, DUCOM Professor of Orthopedic Surgery and Department Chair from 2000 until its closure, the program's focus was developing outstanding and compassionate orthopedic surgeons who were dedicated to caring for the most challenging patients. He and the HUH Orthopedic Surgery faculty established a culture that can be best summarized as, "What is good for the resident experience is good for patient care." HUH's foibles and its fiscal and administrative challenges helped to create a unique camaraderie among the residents and faculty that few programs matched. The program naturally attracted a diverse group, including female and under-represented minority graduates. A mutual respect and affection emerged that was exceptional. Despite the challenges posed by both the patients and the institution, high-quality patient care in Trauma, Joint Reconstruction, Spine, and Sports Medicine was the hallmark of the department, regardless of patient socio-economic status. Abington Memorial Hospital became an important community-based training site in 2004, rounding out the outstanding adult orthopedic surgical experience. The SCHC faculty, equally dedicated to care of Pediatric Orthopedic patients, further strengthened the academic and educational value for the HUH residents. With the dissolution of the program, the Philadelphia Orthopedic community lost a valuable asset.

A Cautionary Tale

The lessons learned from the demise of HUH are still being determined and presented our national academic medical community with many more questions than answers. Those who went through it continue to reflect on its meaning and significance. It was existential and life-changing in many ways. Those that viewed it from a distance with a degree of shock should continue to consider it as a cautionary tale with implications that reach throughout the intertwining disciplines of patient care, education, and research. What must a medical student see and do before graduation? What does resident competency mean and how does that achievement happen in the setting of more rigidly defined educational goals and restricted clinical opportunities? In a financially-stressed hospital environment, with more poverty in sicker patients, there is a natural need for everyone to "put their hands to the plow." If done with proper teams formed to meet the need, and the supervision provided by dedicated and experienced providers, the result can be educationally rich. Nevertheless, what is the cost and who will assume responsibility for it? Perhaps a closer look at "programs at risk" would provide some data that would lead to a re-formatting of medical education and a realignment of priorities. Consider the paradigm of needing to go far away to observe medical care in underserved regions. This experience may be nearer to you than expected.

Moving Beyond the Closure of HUH

The demise of HUH, while devastating in many ways, may also be viewed as a wake-up call for all stakeholders in academic medical education, as this experience taught several hard lessons:

1. Safety-net hospitals can fail, even when the community believes that this is not possible. City, state, and national government representatives, as well as insurers, must take a more active role in protecting these institutions for the sake of our most vulnerable citizens.

2. In our current system of Graduate Medical Education, residents are vulnerable to disruption of training when oversight of institutions, especially fiscal oversight, is inadequate. This oversight is especially important when hospital systems, and in particular those run by for-profit companies and private equity investors, view GME more as a revenue stream than a sacred obligation to the trainees. The ACGME must consider improvements in oversight and "disaster planning" to protect residents and fellows.

3. The voice of physician leaders can get lost, or ignored, in the day-to-day running of academic hospital systems. It is clear now that academic physician leaders must raise their voices and be constructively critical of hospital owners and administrators, while offering to work collaboratively with them to achieve the goals of compassionate patient care and outstanding medical education.

Distinguished Alumni Paper

The Use of Ultrasound in Carpal Tunnel Syndrome

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A syndrome is a constellation of signs and symptoms. One challenge with syndromes is deciding what signs and symptoms and in which combination result in a positive diagnosis. Carpal tunnel syndrome (CTS) is a prime example of this challenge as reasonable and well-meaning physicians can disagree over the ideal diagnostic criteria based on the history and physical examination. If a patient has paresthesias in the median nerve distribution but all provocative maneuvers are negative, does this patient have CTS? What if the patient reports the entire hand is numb rather than the median nerve distribution? In these cases, it would be desirable to have a diagnostic test that was able to accurately and reliably discriminate between those who have the syndrome and those that do not. The ideal test would be readily available, comfortable for patients, efficient, inexpensive and add prognostic value and/or guide treatment.

Electrodiagnostic testing (EDX), a combination of nerve conduction studies and electromyography, has historically been the diagnostic test of choice for CTS. Demino and Fowler performed a systematic review and found the specificity of nerve conductions studies to exceed 93% when using distal sensory latency and distal motor latency in isolation.[1] Tests with high specificity are considered strong confirmatory tests as this limits the number of false positives, thereby avoiding exposing subjects to treatment who do not actually have the disease. A major issue when interpreting the literature is the variability in the cut-off values used for positive diagnosis and that electrophysiologists do not use the tests in isolation. The American Association for Neuromuscular and Electrodiagnostic Medicine (AANEM) recommends the use of a number of different tests for a complete electrodiagnostic evaluation.[2] When conducting 10 different measurements, if only one is positive, one must consider whether or not that should count as a positive test for CTS? The use of so many different measurements within EDX results in a lower specificity and a higher sensitivity and as the number of measurements increases, the chance that one will be randomly positive also increases. This leads to a higher rate of false positives. Atroshi[3] and Witt[4] independently noted a high rate of false positive electrodiagnostic exams based on clinical examination. Fowler and colleagues found that EDX was positive in 43% of patients without any clinical signs of CTS.[5] Chen et al. noted that despite over 1,000 articles regarding EDX and median nerve motor and sensory latencies, only one study was of high enough quality to be included in their systematic review.[6] In addition, the cut-off values from this study are generally higher than used in my local laboratories, making the generalizability of EDX results difficult at best. These findings suggest that EDX may not be the best test for CTS and that alternative diagnostic testing should be explored.

Peripheral nerve compression results in nerve swelling proximal and distal to the site of compression. This nerve swelling can be measured using magnetic resonance imaging (MRI) and/or musculoskeletal ultrasound (US). Buchberger et al.[7] compared MRI and US cross-sectional area (CSA) of the median nerve at the carpal tunnel inlet in 20 wrists with clinical and EDX confirmed CTS to 28 wrists without clinical CTS. The CSA of the median nerve in subjects with CTS was 8.1 mm^2 in wrists without CTS and 14.5 mm^2 in wrists with CTS, $P < 0.01$. There was no difference in the CSA between MRI and US measurements. This study served as a proof of concept that median nerve CSA correlated with CTS and could be measured with cross-sectional imaging. Nakamichi and colleagues used US to measure the CSA of the median nerve in 414 wrists with CTS and 408 wrists without CTS.[8, 9] The results confirmed the work of Buchberger, finding that the mean CSA at the carpal tunnel inlet was 14.4 mm^2 in patients with CTS and 9.6 mm^2 in patients without CTS $< P < 0.001$. The authors noted that a CSA > 12 mm^2 resulted in a specificity of 97%.

Fowler and colleagues performed a systematic review to determine the sensitivity and specificity of ultrasound for diagnosis of carpal tunnel syndrome.[10] This study found that the sensitivity and specificity of ultrasound was 77% and 93%, respectively, when using clinical diagnosis as the reference standard. Our group then performed a cost-effectiveness analysis using ultrasound as a first-line test in patients with a clinical diagnosis of carpal tunnel syndrome.[11] If the ultrasound was discordant with clinical findings, electrodiagnostic testing was performed. Despite the study assuming the electrodiagnostic testing was a perfect test for carpal tunnel syndrome (which we know is not true in a real-world scenario), the cost-effectiveness analysis showed that using ultrasound as a first-line test for carpal tunnel syndrome was a more cost-effective strategy than using electrodiagnostic testing as the sole test. This also did not take into account the fact that most surgeons performing ultrasound at the point of service for diagnosis of carpal tunnel syndrome do not bill for that service, myself included.

Our group recognized that the use of electrodiagnostic testing as the reference standard was imperfect and deter-

mined that the use of a validated diagnostic tool, CTS-6, was a better strategy.[12] The CTS-6 diagnostic tool predicts the probability of diagnosis of carpal tunnel syndrome with subjects having a score of greater than or equal to 12 translating to a probability of 80% for diagnosis of carpal tunnel syndrome by an expert panel. A total of 85 consecutive patients with a clinical suspicion of carpal tunnel syndrome underwent electrodiagnostic testing, ultrasound examination, and completion of the CTS-6 diagnostic tool. Ultrasound and electrodiagnostic testing both had a sensitivity of 89%; however, ultrasound had a specificity of 90% compared to a specificity of 80% for electrodiagnostic testing. A higher specificity is preferred for confirmatory tests, indicating that ultrasound was preferred over electrodiagnostic testing when using CTS-6 as the reference standard.

The baseline cross-sectional area of the median nerve is an essential piece of information when attempting to determine cut-off values for carpal tunnel syndrome. One would assume that an NFL offensive lineman would have a larger nerve at baseline than a ballerina. However, the difference between those groups was not as large as one might think. A total of 349 wrists were prospectively examined and the mean cross-sectional area in subjects without evidence of carpal tunnel syndrome was 6.9 mm^2 with a standard deviation of 2 mm^2.[13] There was little variation based on gender or body mass index. A cut-off value of 10 mm^2 was confirmed as the most accurate cut-off value in this population.

With the understanding that there is not a perfect reference standard for carpal tunnel syndrome, latent class analysis was utilized to compared ultrasound and electrodiagnostic testing. Latent class analysis is a statistical technique that analyzes the associations between tests to determine diagnostic accuracy in cases where there is no universally-accepted references standard. In this study, 85 consecutive patients underwent ultrasound, electrodiagnostic testing, and the CTS-6 evaluation.[14] Latent class analysis determined that the sensitivity of ultrasound and electrodiagnostic testing was 91% and 91%, respectively. The specificity of ultrasound and electrodiagnostic testing was 94% and 83%, respectively. The latent class analysis was repeated in a separate patient population, this time comparing six different diagnostic tests.[15] This new latent class analysis found the sensitivity of ultrasound and electrodiagnostic testing was 89% and 97%, respectively. The specificity of ultrasound and electrodiagnostic testing was 72% and 40%, respectively. A common theme has emerged: the specificity of ultrasound is greater than electrodiagnostic testing. A high specificity is preferred for a confirmatory test to prevent false-positives, thereby preventing unnecessary treatment. Electrodiagnostic testing has utilized increasingly lower cut-off values and relative latencies to increase the sensitivity of the test at the expense of specificity.

Despite evidence that electrodiagnostic testing does not correlate strongly with patient-reported outcomes of symptoms and function, anecdotally, many surgeons order electrodiagnostic studies to grade the severity of carpal tunnel syndrome. A cohort of 87 wrists in 52 subjects was prospectively evaluated and the study determined that there was fair correlation between ultrasound cross sectional area and distal motor and/or distal sensory latency (i.e., as distal motor and/or distal sensory latency increase, median nerve cross-sectional area increases as well).[16] Panagopolous et al. retrospectively reviewed 215 subjects with suspected CTS and found a weak correlation between two-point discrimination and both US and nerve conduction studies.[17] However, an abnormal US CSA had a higher positive predictive value than nerve conduction studies for abnormal two-point discrimination. It is likely that ultrasound and electrodiagnostic studies are measuring two distinct aspects of median nerve dysfunction and that is why there is not a perfect correlation between the two tests. Our group did note that increasing severity of carpal tunnel syndrome as graded by electrodiagnostic studies did predict time to recovery of symptoms.[18] Therefore, correlation of ultrasound and electrodiagnostic studies could be important from the standpoint of prognosis. In a separate study, 274 patients underwent ultrasound and electrodiagnostic study evaluation for carpal tunnel syndrome. A cross-sectional area of the median nerve of 12 mm^2 was found to correlate with no response to either distal motor or distal sensory latency on electrodiagnostic studies.[19] Based on the results of this study, if the physician would prefer to use a diagnostic test to grade severity of carpal tunnel syndrome, a cross-sectional area of the median nerve at the carpal tunnel inlet of greater than 12 mm^2 could be used in lieu of electrodiagnostic studies to grade carpal tunnel syndrome as severe.

Anecdotally, a significant portion of patients in our practice are referred for consultation based on positive electrodiagnostic studies despite lack of clinical signs and symptoms of carpal tunnel syndrome Our group identified 40 patients with a CTS-6 of zero, indicating a probability approaching zero of having carpal tunnel syndrome.[5] In this cohort, 43% of subjects had positive electrodiagnostic studies compared to only 23% of patients with positive ultrasound findings. In addition, there were only two patients with a false-positive ultrasound who did not also have positive electrodiagnostic testing. This would have potentially saved nine of 11 patients from undergoing carpal tunnel release for a wrong diagnosis.

Despite increasing evidence that ultrasound is a viable tool for the diagnosis of carpal tunnel syndrome, there remains a lack of utilization by upper extremity surgeons. A surgery of the members of the ASSH found that 43% of respondents had an ultrasound machine available in their office, but only 8% of respondents utilized ultrasound for diagnoses of carpal tunnel syndrome.[20] Part of this lack of utilization may be attributed to the understanding that a confirmatory test is not "necessary" for diagnosis of carpal tunnel syndrome. Recent AAOS guidelines reported that there is moderate evidence that diagnostic questionnaires and/or

electrodiagnostic studies can aid in the diagnosis of carpal tunnel syndrome. D'Auria and colleagues found that hand fellowship trained orthopaedic surgeons were able to predict the results of nerve conduction studies in 86% of cases and a more experienced surgeon had an accuracy of 90%.[21]

Some have called into question the ability of ultrasound to accurately and reliably measure the cross-sectional area of the median nerve. Buchberger et al. found that ultrasound and MRI produced similar measurements for the cross-sectional area of the median nerve at the wrist in 1992.[7] Using contemporary MRI technology with a 3T magnet, our group demonstrated that ultrasound and MRI measurements of the median nerve had a near perfect correlation.[22] In addition, our group demonstrated that a simple teaching session resulted in inexperienced examiners measuring the correct structure (median nerve) in 93% of cases and within 1 mm^2 of an experienced examiner.[23] Finally, the ultrasound cross-sectional area measurements of 22 wrists were obtained by an inexperienced examiner, moderately experienced examiner, and expert examiner. The correlation between these measurements overall was deemed moderate; however, individual inter-rater correlations were strong.[24]

Ultrasound may also be useful to track nerve recovery after surgical intervention. Smith et al. followed 77 patients who underwent carpal tunnel release and found that the median nerve cross-sectional area improved (decreased), particularly in patients who had undergone endoscopic carpal tunnel release, and that this improvement in CSA correlated with improvements in the Boston Carpal Tunnel Questionnaire score.[25] The results of this study are promising and may suggest a role for the use of US to confirm improvement in nerve morphology after treatment.

There is a growing body of literature that US is an accurate diagnostic test for CTS that compares favorably to EDX. US can offer significant efficiency benefits when placed in the hands of the treating surgeon and also provide cost-savings over referral for EDX. Future research in our group is being directed towards decreasing the number of false positives and false negatives of ultrasound and in determining prognosis based on ultrasound findings.

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Resident Research Day 2020

The New Era of Nicotine: Better for Patients?

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Introduction: According to the Centers for Disease Control and Prevention, smoking is the leading cause of preventable death worldwide. With the advent of new smoking devices such as "e-cigarettes," "vapes," and "mods," this problem continues to worsen as many people consider these alternatives "healthier" and having little to no adverse effects. This notion is perpetuated by the novel nature of these devices as well as their ability to market over the internet, a platform which prohibits the advertisement of cigarettes. Furthermore, unbeknownst to many, these smoking alternatives contain similar chemicals to those found in cigarettes, namely anti-freeze, formaldehyde, nicotine, and tobacco. At present, smoking is known to cause cancer, heart disease, stroke, lung disease, diabetes, and chronic obstructive pulmonary disease, yet it also has known adverse effects within the realm of orthopaedics. Fracture healing, wound complications, and infections are all seen at higher rates in smokers as compared to nonsmokers. The aim of this study was to determine the prevalence of smoking alternative usage, to compare the perception of the impact of cigarette smoking versus smoking alternatives in regard to the impairment of bone fracture healing, and to assess willingness to quit smoking altogether if aware of the orthopaedic implications of nicotine.

Methods: A multiple-choice survey was randomly distributed to 231 patients, 18 years and older, who sustained an extremity fracture. All surveys were administered in an outpatient orthopaedic surgery clinic at a Level 1 urban trauma center.

Results: Of the respondents, 55.3% were male and 46.8% African American with a mean age of 46 years old. Use of either cigarettes or e-cigarettes represented 41.1% of respondents with 78.9% being daily consumers. When asked if patients felt cigarettes impaired fracture healing, 30.3% of nonsmokers compared to 19.2% of smokers answered "definitely." For the same question but concerning cigarettes, 22.7% of nonsmokers and 15.2% of smokers answered "definitely." A larger portion of smokers (36.4% compared to 25.3%) answered that they felt e-cigarettes rather than traditional cigarettes affected bone fracture healing. Amongst smokers, 88.9% responded that they would be interested in cessation if told nicotine impaired fracture healing.

Discussion and Conclusion: This survey of orthopaedic patients identified a substantial discrepancy between the perceived harms of traditional cigarette versus e-cigarette usage. Therefore, these results may guide clinicians in further research as to the most effective methods of patient education regarding the effects of smoking, whether it be traditional or alternative use, on fracture healing.

Cost of Operative Fixation of Ankle Fractures: Comparing Orthopaedics and Podiatry

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Introduction: Despite the increasing emphasis on value-based medical care in the United States, there are few cost-utility analyses focused on the treatment of ankle fractures. With an incidence of 168.7/100,000/year, ankle fractures are a common injury amongst the general population and an economic burden on the health care system. The cost of managing an ankle fracture both operatively and non-operatively is estimated to be between $1,908 and $19,555. Ankle fractures pose a unique situation as both podiatrists and orthopaedic foot and ankle surgeons are licensed to treat them. Despite this unique duality in potential management teams, there is currently a deficit in literature that examines the cost effectiveness of integrating both an orthopaedic surgery foot and ankle service and a podiatry team into clinical triage and subsequent surgical management of ankle fractures. The goal of this study is to determine if it is more cost effective for an orthopaedic surgeon or podiatrist to manage patients with ankle fractures.

Methods: Data was obtained over a one-year period at an academic level 1 trauma center. A total of 34 patients were treated for ankle fractures between July 2017 and June 2018. An indirect cost analysis was performed by analyzing the time spent in the operating room in procedure minutes (PR) and room minutes (RM) by both orthopaedic surgeons and podiatrists. The procedures performed by both the orthopaedic teams and podiatry teams were standardized using CPT codes. A statistical analysis was performed on the indirect cost data using a two-sample t test with equal variances. After organizing the data into "orthopaedic surgery" and "podiatry" categories depending on the provider seen, each variable was analyzed, including room minutes and procedure time.

Results: Twenty-five patients were managed by an orthopaedic surgery team and nine patients were managed by a podiatry service. For CPT code 27792 (Fracture and/or Dislocation Procedures on the Leg (Tibia and Fibula) and Ankle Joint), the average time in the room was 114 minutes for orthopaedic surgery and 140 minutes for podiatry (p =

0.007). The average procedure time was 70 minutes and 86 minutes for orthopaedics and podiatry, respectively (p = 0.30).

Conclusions: Orthopaedic surgeons and podiatrists are both licensed to treat ankle fractures. Previous studies have shown that a risk factor for increased total post discharge costs included treatment by podiatry services. Furthermore, ankle fracture fixation performed by podiatrists was associated with higher malunion/nonunion rates amongst all types of ankle fractures, therefore requiring prolonged treatment. In this study, we demonstrate that the amount of OR time, an indirect measure of cost, needed to treat an ankle fracture was less for the orthopaedic surgery service.

Gender and Racial Bias in Letters of Recommendation for Orthopedic Surgery Residency Positions

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Background: Orthopedic surgery continues to be a male and Caucasian dominated specialty. Although this has begun to change in recent years, females and minorities remain underrepresented in residency positions. While it is true that the largest demographic of the overall applicant pool for first year residency positions remains male and Caucasian, it is possible that there are biases within the recruitment process that increase the challenges faced by females and minorities wishing to enter the field. Letters of recommendation are one facet of the application process that could contain such bias. To our knowledge, in contrast to other fields such as urology and emergency medicine, studies that attempt to objectively analyze letters of recommendation for evidence of bias in orthopedic surgery are lacking. The primary purpose of this study was to retrospectively analyze all letters of recommendation received as part of the application process for first year residency positions at one ACGME accredited orthopedic residency program for the presence of bias. The secondary purpose was to determine if the presence of bias was influenced by the gender of the letter writer.

Methods: This was an Institutional Review Board (IRB) approved study. All letters of recommendation received in the years 2016 and 2018 were identified and analyzed using the Linguistics Inquiry and Word Count (LIWC) 2015 software. This software uses prior published linguistic algorithms to calculate quantitative values between 0 and 100 for subjective qualities such as positive emotions and negative emotions and composite summary variables such as analytic, clout, authenticity, and emotional tone within a body of text. Independent variables in our analysis were applicant gender (male or female) and applicant race (Asian, Caucasian, or Other). Dependent variables included the aforementioned subjective qualities and composite variables. Separate analyses were completed for male letter writers and female letter writers. Standardized letters of recommendation that did not contain a narrative portion, letters from international applicants, and ones that were a part of an incomplete application were excluded from analysis. Groups were compared using nonparametric tests, i.e., Wilcoxon for two groups and Kruskal-Wallis for three groups.

Results: A total of 5,858 letters of recommendation from 1,678 applicants were available for analysis. Of these, 5,462 letters of recommendation from 1,551 applicants were included in the final analysis (893 for female applicants, 4,569 for male applicants, 3,307 for Caucasian applicants, 858 for Asian applicants, and 1,297 for other races). 5,059 letters were written by male faculty and 403 by female faculty. Female and Asian applicants' letters were more likely to be longer in length ($p < 0.001$; median words F vs. M 310 vs. 293). Male applicants' letters were slightly more likely to have negative emotions ($p = 0.05$). When the letter writer was male, Asian applicants' letters were more likely to convey analytic and authentic qualities ($p = 0.013$ and 0.016). Other variables were similar between such groups, although there was a trend towards statistical significance of male applicants' letters containing more authentic qualities ($p = 0.059$).

Discussion and Conclusion: Our study shows that letters of recommendation for orthopedic surgery residency positions are likely to contain some degree of bias. Faculty should ensure that they remain objective when analyzing the candidacy of future residents. Strengths of this study include its large sample size, utilization of software that is built on validated linguistic algorithms, and large inclusion criteria. Weaknesses include its retrospective nature, inclusion of only applicants to our institution, and inability to further divide races due to a low sample size of African American and Hispanic applicants. Further studies are required to fully characterize the degree and magnitude of bias in letters of recommendation and whether the findings of our study are significant enough to contribute to the difference in socioeconomic demographics between orthopedic residents and society at large.

Causes for Early Readmission in AIS Surgery

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Introduction: With increased attention on readmission, identifying risk factors associated with readmission may allow us to reduce the incidence.

Methods: We retrospectively reviewed a large dataset of prospectively collected AIS patients and divided patients into readmission <90 days and >90 days. Univariate analysis was performed and factors found to be $p < 0.10$ met criteria

for entry into multivariate regression models. Separate models were created for <90 readmit (RA) vs. no readmit (NO) and >90 readmit (RA) vs. NO.

Results: 2,049 patients were included of which 1,957 (95.5%) were not readmitted. Twenty-seven were readmitted within 90 days (1.3%) and 65 were readmitted after 90 days (3.2%). Mean time to RA was 25.6 ± 17.6 days in the early group and 957.0 ± 642.3 days in the late group. The common reasons for RA were wound infections (33%), GI complications (30%), and instrumentation-related (15%). GI causes for RA included GI upset (N = 3), SMA syndrome (N = 3), two undescribed GI issues and were re-admitted 13.9 ± 4.2 days after surgery. Infection (23%) and instrumentation issues (22%) were the most common reasons for late RA. Lower pre-op SRS pain scores were consistently significant in both early and late readmission cohorts.

Discussion and Conclusion: We reviewed risk factors associated with readmission in AIS patients from a large registry. GI complications were one of the most common reasons for early readmission (RA), representing a third of cases. Patients were readmitted an average of two weeks post-op due to SMA syndrome and GI upset. Overall, a low pre-op SRS pain score was most consistently associated with readmission risk. The readmission rate at two years for AIS patients was 4.5% with GI complications as a common reason within 90 days. The only consistent predictive factor for readmission was a low pre-op SRS pain score.

Variable Force Distribution in the Femur During Broaching Through a Direct Anterior Approach

Andrew S. Porter, Jason Brustein, Kurosh Darvish, Andrew M. Star, Danielle Y. Ponzio

Introduction: The direct anterior approach (DAA) has gained popularity as a true internervous and intermuscular approach because of the potential for less soft tissue insult, faster functional recovery, and reduced dislocation rates. However, a concern with the DAA is an associated technical learning curve with a difficult exposure accompanied by potential complications such as femoral fracture or femoral loosening. Previous retrospective analysis of these fractures found that the majority of fractures affected right-sided hips. This study evaluates mechanical force ratios transmitted by the surgeon to the bone while broaching for a right-sided hip compared to a left-sided hip via the DAA.

Methods: An experimental construct was adapted from a previous study by Greenhill et al. in which a 179-g size 10 broach was rigidly secured inside a hand-crafted metal casing with the distal tip resting on a 6-axis load cell. This construct was positioned to simulate the standard broaching position during the DAA. Forces were measured from 12 surgeons of varying experience levels, as well as the automated Kincise impactor, while broaching right vs. left hips, straight vs. offset broach handles, and Actis vs. Trilock broaches.

Results: In this experimental model, it was shown that straight broach handles transmit greater force, both on and off axis, when compared with offset broach handles. On average, residents were found to transmit more force, again both on and off axis, when compared to attendings. Most significantly, it was found that in left hips, the moment — or twisting force applied to the broach — remained relatively constant with increasing force, whereas in right hips, the moment increased with greater broaching force.

Discussion: The increase in moment seen in right hips when compared to left hips may help to explain the higher incidence of right-sided fractures during the DAA. In addition, this study has reaffirmed that greater forces are seen when using a straight compared to an offset broach handle, but in an anatomical model. There was also shown to be a clear difference in force transmission from attendings to residents. The strengths of this study are the anatomical position of the construct, the large number of surgeons tested, and the numerous variables compared. Limitations are obviously that this is still an experimental model, as well as the fact that the all-metal construct is unable to imitate to physical properties of cortical bone. Moving forward, there is the possibility that this model may be used as a training tool.

Prospective Follow-Up of Anterior Vertebral Body Tethering for Idiopathic Scoliosis: Interim Results from an FDA IDE Study

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Introduction: Anterior vertebral body tethering (AVBT) has emerged as a novel treatment option for patients with idiopathic scoliosis. We present the results from the first FDA IDE study on AVBT.

Methods: In this prospective review of a retrospective dataset, eligible patients underwent AVBT at a single center from August 2011 to July 2015. Inclusion criteria included skeletally immature patients with Lenke 1A or B curves between 30 and 65°. Clinical and radiographic parameters were collected until completion of the study (>18 years of age) contradicts average 17.1 ± 1.4 years of age at last visit, with the latter measured by an independent reviewer.

Results: Fifty-seven patients (49 girls, eight boys) were enrolled in the study with mean age of 12.4 ± 1.3 years (range 10.1–15.0). Patients underwent a mean number of 7.5

± 0.6 levels tethered with a mean operative time of 223 ± 79 minutes and estimated blood loss of 106 ± 86 ml. Follow-up averaged 55.2 ± 12.5 months with mean Risser sign at follow-up of 4.2 ± 0.9. The average preoperative main thoracic Cobb angle of 40.4 ± 6.8° corrected to 19.3 ± 8.4° at first erect. At most recent follow-up, the Cobb angle further improved to 18.7 ± 13.4°. In the sagittal plane, T5-12 kyphosis measured 15.5 ± 10.0 pre-op, 17.0 ± 10.1 post-op, and 19.6 ± 12.7 at most recent follow-up. Eighty percent of patients had curves <30° at most recent follow-up. Pulmonary function remained stable. Most recent SRS scores averaged 4.5 ± 0.4 and self-image scores averaged 4.4 ± 0.6. No major neurologic or pulmonary complications occurred. Revision surgery occurred in 7/57 patients (12.3%): five for overcorrection and two for adding on.

Discussion and Conclusion: AVBT is a promising technique that has emerged as a treatment option for patients with immature idiopathic scoliosis. We present the results from the first FDA approved IDE study on AVBT. The findings affirm the safety and efficacy of this technique and suggest opportunities for improvement particularly with respect to reoperation rates.

Risk Stratification Algorithm for Orthopaedic Trauma Patients at Risk for Fat Embolism Syndrome

Andrew Lowery, Vineet Naran, Robert Ames, Theresa Pazionis

Background: Fat embolism syndrome is commonly reported in the setting of long bone fractures (typically the femur or tibia) and fractures of the pelvis. The true etiology and pathogenesis are unclear. FES can lead to dangerous clinical sequelae with pulmonary, neurologic, and/or dermatologic manifestations. The object of our research is to identify clinical characteristics and/or medical comorbidities that may place orthopaedic trauma patients at higher risk of developing FES. A secondary goal is the design of a clinical algorithm for prediction of symptomatic FES.

Methods: We reviewed the electronic medical record of all orthopaedic trauma patients with a diagnosis of FES between the ages of 18–89 who presented to our institution between January 15th, 2015 and November 15th, 2019. A 3:1 matched pair analysis was performed between patients who carried a diagnosis of FES and those with similar age, gender, and fracture type. Exclusion criteria included patients younger than 18, older than 89, pregnant women and prisoners.

Results: Eighteen patients with FES who met inclusion criteria were identified. Mean age was 41.16 (20.97). Mean BMI was 27.80 (5.99). 55.60% of patients had prior smoking/tobacco use history, 27.80% of patients carried a history of diabetes mellitus, 22.2% of patients had chronic inflammatory conditions, 5.60% of patients had history of DVT/PE and 5.60% had a history of TIA/stroke. Fifteen patients (83.30%) sustained a femur fractures, six patients (33.33%) sustained tibia/fibula fractures, three patients (16.70%) had pelvic fractures, and two (11.10%) patients had humerus fractures. 15.78% of fractures were open, two of which were femur fractures, and one humerus fracture. 100% of the patients had respiratory symptoms, neurologic symptoms in 61.1%, thrombocytopenia in 50.00%, fever in 38.90%, hypotension in 38.90%, coagulopathy in 33.30%, right heart failure in 16.70%, and shock in 5.60%. The following differences were noted between the FES and control groups: FES patients had higher pre-morbid rates of DM (27.8% vs. 18.5%), CAD/PAD (16.7% vs 7.4%), DVT/PE (5.6% vs. 1.9%), TIA/stroke (5.6% vs 3.7%). While they had similar rates of smoking/tobacco use (51.9% vs 55.6%) and similar mean BMI (27.8 vs. 27.3), further statistical analysis is currently pending.

Conclusion: The clinical and laboratory findings in our data were often consistent with previously reported FES diagnostic criteria. A number of pre-morbid differences existed between the groups at baseline. We plan on expanding our dataset to more closely investigate the true incidence of FES at our institution, as well as trends in vital signs, renal function and inflammatory markers. We anticipate that after further data mining and statistical analysis, we will be able to determine risk factors that predispose patients to development of FES, as well as develop a risk assessment algorithm to help clinicians manage this difficult clinical scenario.

Pediatric Train Injuries: The New Urban Lawnmower

Dayna Phillips, Arianna Trionfo, Alexandre Arkader, Martin Herman

Background: Pediatric train injuries are rare, but potentially devastating injuries. The literature on train-related accidents is limited and primarily focuses on injuries occurring in the adult population. Despite current prevention and safety strategies, these injuries have remained relatively consistent over the past decade. The patterns of injury reported have varied depending upon the patient population and clinical setting.

The objective of this study is to report the patient demographics, mechanisms and patterns of injury, required interventions and morbidity caused by train-related injury in children at two level I pediatric trauma centers over an approximate 20-year period.

Methods: Retrospective chart review of all patients presenting to two Level I trauma centers (Children's Hospital of Philadelphia and St. Christopher's Hospital for Children) from 1/1/2000 to 8/30/2017 who sustained train versus

pedestrian injuries. Patients included in the study were males and females age 0–18 at the time of clinical presentation as well as in whom sufficient data could be collected. Individuals who were deceased upon arrival and involved in automobile versus train accidents were excluded from the study.

Results: A total of 13 cases were identified (three female and 10 male) with zero deaths. Average age was 12 years upon presentation (14 years for females and 12.3 years for males; age range from 8–17). The majority of injuries (six out of 10 with known injury location) occurred in South/Southwest Philadelphia. The injury was determined to have occurred while the child was walking/jumping on the train tracks in eight cases (two females and six males). The remainder were secondary to jumping onto train cars (three) and among other reasons (two). When assessing return to OR, eight cases required multiple visits to the operating room prior to definitive treatment. These cases primarily were revision amputation cases, repeat irrigation and debridements, or for definitive fixation. A single case required revision of their amputation to a level proximal to the level they presented with. A total of 12 cases presented with orthopedic-related injuries with four of the cases being amputations involving the upper and lower extremity.

Discussion and Conclusion: A majority of the pediatric patients who sustain train-related injuries typically sustain musculoskeletal injuries, primarily involving the pelvis or the lower extremity. These injuries not only require multiple operating room visits, but also require the involvement of multiple surgical sub-specialties due to the complexity of these injuries. The results of this study bring light to the need for further improvement in limiting access to railroad areas and the incorporation of railroad safety initiatives/programs into schools.

Dorsal Hand Infection Admission Risk Factors

Colin MacElroy Vroome

Background: Hand cellulitis lies on a spectrum of hand infections involving the dorsal aspect of the hand. These range from simple cellulitis to superficial and deep abscesses, as well as septic arthritis. First line treatment for cellulitis is typically a trial of oral (PO) antibiotics but the risk factors for failure of outpatient management have not been well identified. It is commonly described that delayed treatment of hand infections can result in stiffness and contractures so it would be of benefit to identify patients at risk for failure of PO therapy to expedite their proper treatment with admission and intravenous (IV) antibiotics.

Methods: A survey was created and distributed to attending and resident orthopedic surgeons to evaluate potential risk factors for failure of PO antibiotics in treatment of dorsal hand cellulitis. Risk factors assessed included patient compliance, diabetes, history of MRSA infection, intravenous drug use (IVDU), fever or elevated WBC on presentation, and size and location of the cellulitis as well as presence or absence of stiffness. Each of these were rated from one to five with one representing a non-factor and five representing a factor which is sufficient reason alone to admit a patient with dorsal hand cellulitis. A superficial abscess amendable to bedside decompression was assessed as a final risk factor for admission. Attending and resident surveys were separated and then, within each group, the rating for each risk factor were averaged to determine the highest rating risk factors with a score of five representing unanimous agreement that a patient with that factor should be admitted for antibiotics based on the presence of that factor alone.

Results: There were 12 and 15 returned surveys out of potential 16 faculty and 21 orthopedic residents, respectively. Highest scoring risk factors rated by faculty were failed PO therapy (4.75), fever or WBC count (4), diabetes (3.92), cellulitis extending to a joint with decreased motion (3.5), patient compliance (3.33), and IVDU (3.08). Highest scoring risk factors rated by orthopedic residents were failed PO therapy (4.73), diabetes (4), fever or WBC (3.93), cellulitis extending to a joint with decreased motion (3.73), MRSA history (3.73), compliance (3.6), contained cellulitis with joint stiffness (3.47).

Discussion and Conclusion: Orthopedic surgery faculty and residents ranked risk factors for hand cellulitis requiring hospital admission to be similar. Both ranked failure of PO antibiotics highest. Both also ranked fever or elevated WBC and diabetes in the top three risk factors. Other risk factors may contribute and have a cumulative effect which is supported by the finding that no factors were rated unanimously as nonfactors (average score of one). All patients presenting with dorsal hand cellulitis and infections should continue to be evaluated on an independent basis but these findings may help identify patients at risk for failure of oral antibiotic therapy in treatment of dorsal hand cellulitis.

Repeat Drainage of Upper Extremity Infections: Do Repeat Cultures Change Antibiotic Treatment Regimens?

Jeffrey Wera, Bradley Wiekrykas,
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Background: Polymicrobial infections and changing resistance patterns have made treating upper extremity infections difficult. Isolation of flora is essential to direct appropriate treatment. Some infections require multiple procedures. We sought to determine if repeat culture at time of repeat drainage changes treatment.

Methods: We queried our institutional coding database to identify patients admitted between October 2010 to August 2015 with an ICD-9 code associated with upper extremity

infections. Patients were included if they had an upper extremity infection that required more than one procedure for drainage, and if repeat cultures were obtained. Data was grouped "same" if no new organisms resulted nor changes to sensitivities. Data grouped "different" was subdivided into "change" or "no change" depending on resultant organisms and sensitivities.

Results: One hundred eighty-three patients were included. Repeat culture resulted in antibiotic changes in 13 patients. Patients with HCV were more likely to require antibiotic change ($p = 0.005$). Those with HIV approached statistical significance ($p = 0.13$). Patients with history of IVDA did not result in significant changes to treatment ($p = 0.23$).

Discussion and Conclusion: Repeat culture data resulted in a change in antibiotic regimen in 7.1% of patients (13/183). Patients without risk factors of HCV and HIV may not warrant repeat culture at time of repeat drainage.

Resident Research Day 2021

Factors Predicting Increased Length of Stay in Patients with Drainable Upper Extremity Abscesses

Evan Jacquez, Etka Kurucan,
Hesham Abdelfattah, Mark Solarz

Hypothesis: Intravenous drug use (IVDU) is associated with longer hospitalizations for patients who undergo irrigation and debridement for the treatment of upper extremity abscesses.

Methods: This is a retrospective review of patients admitted to a single urban teaching hospital for upper extremity abscesses who underwent either bedside or operative irrigation and debridement between 2016 and 2019. Patient characteristics from a preexisting and deidentified database were analyzed over the course of this study. IVDU and non-IVDU patients were compared. In addition, we compared patient characteristics by categorizing length of stay (LOS) into three equally-sized groups (<3 days, 3–4 days, >4 days). Chi-square and t-tests were used to compare categorical and continuous variables between groups, respectively. Analysis of variance model was used in the comparison of continuous variables between the three LOS groups. A multivariable regression analysis was also performed for the continuous variable LOS. Statistical significance was set at $p < 0.05$. All calculations were performed using Stata 13.1 (StataCorp, College Station, TX).

Results: Three hundred fifteen patients met inclusion criteria. Mean length of stay for all patients was 5.1 days. IVDU patients were admitted for 5.5 days versus 4.6 days for non-IVDU patients ($p = 0.21$). Statistically significant differences were found in the lengths of stay of IVDU patients, with 39.1% of these patients having hospital stays >4 days as opposed to 34.6% in the 3–4 day group and 26.3% in the <3 day group ($p = 0.01$). Hepatitis C ($p < 0.01$) and diabetes mellitus ($p = 0.04$) were associated with increased lengths of stay in the categorical analysis. Elevated erythrocyte sedimentation rate at the time of admission was also found to be associated with longer hospital stays ($p = 0.03$). On multivariable analysis, hepatitis C and diabetes mellitus were associated with increased length of stay ($p = 0.01$ and $p < 0.01$, respectively).

Summary Points:

- Patients engaging in intravenous drug use were hospitalized for an average of 5.5 days, with a significant proportion experiencing stays >4 days.
- Hepatitis C infection and diabetes mellitus are associated with increased length of stay, as are elevated inflammatory markers on admission.
- Further studies investigating the specific causes of increased LOS in IVDU patients with upper extremity abscesses may benefit the multidisciplinary treatment team to direct resources appropriately.

Acute Management of Open Long Bone Fractures

Jared Colon, Conor Mooney, Saqib Rehman

Introduction: Acute management of open fractures seeks to promote bone and wound healing through a series of important interventions; however, lack of standardization regarding these interventions can lead to increased complication rates. This paper seeks to update the previous recommendations for management of these injuries put forth by our institution using the best available evidence.

Methods: A literature review was conducted to find the best available literature using the MEDLINE database, focusing on recent literature regarding prophylactic antibiotic administration, local antibiotic delivery, time to debridement, and irrigation techniques published since the prior implementation of the most recent institutional guidelines.

Results: A computerized search yielded a total of 130 articles, of which 61 met criteria for review. The final total was then subdivided based on topic: prophylactic antibiotic administration (n = 10), local antibiotic delivery (n = 8), time to debridement (n = 6), and irrigation techniques (n = 4). The remaining 24 articles dealt with multiple subjects or were comprehensive review articles which were included for analysis.

Conclusions: Recommendations were updated based on a review of clinical studies on open fracture management. Prophylactic antibiotic recommendations, including coverage of choice and duration of administration, were adapted from the guidelines proposed by the Eastern Association for the Surgery of Trauma workgroup and remained consistent with prior guidelines. In addition, the use of local antibiotic delivery techniques may prove beneficial as an adjunct to systemic prophylactic antibiotic therapy in the management of severe open fractures and in patient populations where prolonged antibiotic therapy is otherwise indicated, however, not routinely recommended. Debridement and irrigation should occur emergently, but only if resources are available. A low-pressure (<2 pounds-per-square-inch) lavage system using a sterile saline solution, with increased volumes for more severe fractures, is recommended prior to fracture fixation to reduce the bacterial load.

Acute Management of Gunshot Fractures

Jared Colon, Saqib Rehman

Introduction: Gunshot injuries represent a significant portion of healthcare treatment in the United States, with orthopaedic intervention often required due to complications such as fractures, compartment syndrome, nerve injuries, and soft tissue defects. Despite the frequency of these injuries, a consensus regarding definitive management continues to be lacking. This paper proposes guidelines for treatment at our institution using the best available data regarding antibiotic therapy and debridement practices.

Methods: A computerized literature search was performed using the MEDLINE database, including terms such as "gunshot wounds," "fractures," and "antibiotics." Articles investigating antibiotic and debridement practices in gunshot injuries in the adult population were included for review, and articles involving pediatric populations, articles published in languages other than English, and those which did not have clearly-defined infection and complication rates were excluded for review.

Results: Ultimately, 36 articles met criteria and were chosen for review. These articles were then subdivided by topic, namely recommendations for antibiotic therapy, debridement practices, and management of low-velocity and pelvic fractures.

Conclusions: Based on the articles reviewed, recommendations were developed regarding management of these injuries. Antibiotic prophylaxis should be given for low-velocity gunshot fractures using an intravenous first generation cephalosporin in the emergency department followed by seven days of an oral first generation cephalosporin if the patient is stable for discharge. If the fracture is operative, standard perioperative antibiotics should be given. Superficial bedside irrigation and debridement should be performed as appropriate prior to reduction/splinting. High-velocity gunshot injuries should receive antibiotic prophylaxis as outlined in the institutional open fracture protocol using the Gustilo-Anderson classification. Extensive emergent operative debridement should be performed in cases where there is significant soft tissue injury, in conjunction with delayed wound closure and a "second-look" prior to definitive fixation. Irrigation and debridement should be performed for all intra-articular injuries with retained missiles. All pelvic gunshot fractures should receive 72 hours of prophylactic antibiotics using a first generation cephalosporin and metronidazole. Surgical management of these injuries is reserved for those with pelvic instability requiring operative stabilization.

Just Do Your Best to Stay Off It: A Look at the Ability of Orthopaedic Trauma Patients to Comply with Non-Weightbearing Instructions

Heather Flynn, Britt Hankins, D'Andrew Gursey, Frederick Ramsey, Saqib Rehman

Introduction: The purpose of this study was to examine the self-reported rates of noncompliance with strict non-weightbearing (NWB) instructions in a population of orthopaedic trauma patients. Another goal of the study was to better understand patient characteristics and challenges in the home environment that might lead to increased difficulty with adhering to NWB instructions in the orthopaedic trauma patient population.

Methods: A survey study was conducted in person during orthopaedic trauma clinic. The survey was administered from August 2020 to February 2021. Patients were qualified for the survey if they had a lower extremity injury (treated operatively or nonoperatively) for which they were prescribed a non-weightbearing course of eight weeks or longer. Summary statistics were compiled from the survey results. Statistical significance was defined as $p < 0.05$.

Results: Sixty-seven patients participated in the survey study. Thirty-six (53.7%) reported full compliance with NWB instructions, while 19 (28.4%) reported they had ambulated <5 times and 12 (17.9%) reported they had ambulated many times prior to being cleared to begin weightbearing by the orthopaedic surgeon. Race, age, BMI, injury location, and living situation during recovery were not found to be correlated with inability to comply with NWB instructions. Patients who responded that they did not have adequate support during their recovery were statistically more likely to ambulate early ($p = 0.026$).

Discussion/Conclusion: There are many factors that may influence orthopaedic surgeons to prescribe a prolonged NWB course for lower extremity injuries. Our study echoes the results of previous studies that have investigated the ability of orthopaedic patients to comply fully with NWB instructions, which suggest that patient compliance is often poor. Offering additional resources to patients who feel inadequately supported in their recovery may help to improve the ability of patients to comply with NWB instructions.

A Systematic Review of Local and Intravenous Steroid Use for Dysphagia After Anterior Cervical Discectomy and Fusion (ACDF)

Rajkishen Narayanan, Ronit Shah, Theresa Pazionis

Introduction: Dysphagia is a common complication after ACDF and can be a source of significant postoperative morbidity. The purpose of this study is to present the current literature regarding the effect of intravenous (IV) and locally-administered steroids intraoperatively in the management and prevention of postoperative dysphagia.

Methods: We searched MEDLINE, EMBASE, and the Cochrane library databases without time restriction using the terms "dysphagia" and "ACDF." We included in our review randomized control trials (RCTs) that investigated the effects of IV and local steroids on dysphagia after ACDF. Studies which did not evaluate pre- and post-operative dysphagia with a specific clinical or radiographic outcome were excluded.

Results: The initial search yielded 259 citations. Ten of these studies met the inclusion and exclusion criteria. All of them were prospective RCTs which were evaluated as level 1 evidence. One study found no significant difference between locally and IV administered intraoperative steroids. Four studies found a significant reduction in dysphagia symptoms in the short-term postoperative period when comparing local steroids to a placebo. Another four studies found similar effects on dysphagia when comparing IV steroids to a placebo. Of the two studies comparing IV to local steroids, one study found no difference in the effect on dysphagia while another found that local steroids had a greater impact on dysphagia reduction in the first six weeks after surgery, but at one year, both local and IV steroids had significantly reduced dysphagia rates compared to the control.

Conclusions: More recent literature provides supporting evidence that perioperative IV and local steroid use can reduce incidence and severity of dysphagia after ACDF. For patients who receive locally-administered steroids, there may be a greater protective effect in the early postoperative period compared to IV steroids.

Civilian Firearm vs Non-Firearm Humeral Shaft Fractures: Comparing Rates of Neurovascular Injury, Compartment Syndrome, Early Infection, and Union

Bradley D. Wiekrykas, Rachel Thomas, Saqib Rehman

Purpose: Humeral shaft fractures account for about 1–2% of all fractures and 14% of fractures of the humerus. Approximately 10% of gunshot fractures to the extremities involve the humerus. Successful union rates have been reported with nonoperative, intramedullary nail, open reduction and internal fixation, and minimally invasive plate osteosynthesis treatment. The primary purpose of this study was to determine if civilian firearm humeral shaft fractures have similar union rates to non-firearm humeral shaft fractures when treated nonoperatively and operatively. The secondary purpose was to compare rates of neurovascular injury, compartment syndrome, and early infection.

Methods: A retrospective review was performed using International Classification of Diseases, Ninth (ICD-9) and Tenth (ICD-10) Revision codes to identify all adult patients treated for an extraarticular humeral shaft fracture at a single level 1 trauma center over a period of 10 years with at least 12 weeks of follow-up. Chart and radiographic review were performed to identify patient demographics, injury mechanism, neurovascular injury, compartment syndrome, infection, definitive treatment, and union.

Results: Over the 10-year period, there were 1,127 patients with an ICD code for a humerus fracture. Of these patients, 123 met inclusion criteria. There were 32 firearm fractures of which 18 (56.3%) were initially treated operatively and 14 (43.7%) nonoperative and 91 non-firearm fractures, 33 (36.3%) treated operatively and 58 (63.7%) nonoperative. Overall, there were eight vascular injuries, 7/32 (21.9%) in the firearm group and 1/91 (1.1%) in the non-firearm group ($p = 0.0002$). A nerve injury was observed in 11/32 (34.4%) of firearm fractures and 5/91 (5.5%) non-firearm fractures ($p < 0.0001$). Infections were diagnosed in 5/32 (15.6%) of firearm fractures and 2/91 (2.2%) non-firearm fractures ($p = 0.007$). Of the firearm infections, two were initially treated with external fixation and had prophylactic fasciotomies, one had a draining sinus two years post open reduction and internal fixation, and two initially treated nonoperative had a superficial firearm wound infection treated with oral antibiotics. There were no deep infections in the firearm initial nonoperative treatment group. Overall, 107/123 (87.0%) fractures went on to union, 28/32 (87.5%) in the firearm group and 79/91 (86.8%) in the non-firearm group ($p = 0.88$). 58/72 (80.6%) of fractures treated initially with nonoperative treatment went on to union, 12/14 (85.7%)

in the firearm group and 46/58 (79.3%) in the non-firearm group (p = 0.59). 49/51 (96.1%) of fractures treated initially with operative treatment went on to union, 16/18 (88.9%) in the firearm group and 33/33 (100%) in the non-firearm group (p = 0.06). The two nonunion in this group were initially treated in external fixation due to a vascular injury. 15/72 (20.8%) failed initial nonoperative treatment (14 nonunion and one loss of acceptable alignment) with 2/14 (14.3%) in the firearm group and 13/58 (22.4%) in the non-firearm group (p = 0.59). No patients were diagnosed or treated for compartment syndrome although prophylactic fasciotomies were performed in 7/8 patients who had a vascular injury and repair.

Conclusions: Firearm humeral shaft fractures have similar rates of fracture union and failed nonoperative treatment but higher rates of neurovascular injury compared to non-firearm humeral shaft fractures. Treatment of these injuries without surgical irrigation and debridement yields a low infection rate.

The Impact of Race on Outcomes After Hip Fracture

Dana L. Cruz, Patrick Donaghue, David Galos

Objectives: 1) To investigate the impact of race on patient outcomes after hip fracture fixation and 2) to examine the impact of race on length of stay (LOS), readmission and perioperative mortality after hip fracture.

Methods: IRB-approved, retrospective chart review of patients presenting after an acute hip fracture to a single institution between January 2016 and January 2020.

Results: Preliminary analysis of 112 patients includes 41 Caucasian, 40 Black, 28 Hispanic and three Other with a mean age of 74.3, 74.5, 75.1 and 71.3 respectively (p = 0.9406). Average LOS was greater amongst Black patients (9.2 days) compared to Hispanic (7.5 days) and Caucasian patients (6.3 days). There were 7/40 (17.5%) deaths amongst Black patients, 2/28 (7.1%) amongst Hispanic patients and 1/41 (2.4%) amongst Caucasian patients. Rates of 30-day readmission were higher for Black (OR = 1.27 [95% CI, 0.35 to 4.55]; p = 0.713) and Hispanic (OR = 1.05 [95% CI, 0.26 to 4.16]; p = 0.93) patients when compared to Caucasian although this did not meet statistical significance. Similarly, rates of 90-day mortality were higher for Black (OR = 8.48 [95% CI, 0.99 to 72.505]; p = 0.051) and Hispanic (OR = 3.08 [95% CI, 0.27 to 35.68]; p = 0.37) patients when compared to Caucasian.

Conclusion: In concordance with previous studies involving racial disparities in orthopaedics, preliminary analysis suggests that Black and Hispanic patients suffer worse outcomes in terms of 30-day hospital readmission and 90-day mortality when compared to their Caucasian counterparts. Although this analysis did not reach statistical significance, this preliminary analysis remains underpowered. Future studies examining patient co-morbidities, socioeconomic status and complications are pending.

Thigh Compartment Syndrome Is More Common After Femur Fractures Caused by Firearms

Alexander Johnson, Dustin Greenhill, Alec Talsania, Nathan Winek, Christopher Haydel, Saqib Rehman

Introduction: Thigh compartment syndrome is a rare diagnosis with significant associated morbidity. Currently available data is limited to several small case series with variable conclusions. The purpose of this study was to outline our experience treating thigh compartment syndrome with a specific focus on traumatic mechanisms and injury characteristics that most commonly lead to this disorder.

Methods: We conducted a retrospective review of patients who underwent fasciotomy for TCS at a Level-1 urban academic trauma center between August 2006 and July 2016 with collected data including demographics, details/timeline of presentation, associated risk factors for compartment syndrome, and outcomes. Additionally, all femoral shaft fractures (AO/OTA type 32) treated at the same institution during this time period were also reviewed to determine fracture mechanism and classification that were most likely to lead to development of thigh compartment syndrome.

Results: Thirty-five total cases of thigh compartment syndrome were included. Mean time from presentation to diagnosis was 18 hours; mean time from diagnosis to fasciotomy was one hour. The most common traumatic mechanism was penetrating firearm injury in 19/35 cases. There was an ipsilateral femur fracture present in 23/35 cases. During the study period, 461 total femoral shaft fractures were treated at the same institution. Patients with femur fractures caused by firearm trauma were significantly more likely to develop thigh compartment syndrome than patients with femur fractures from other mechanisms (11.2% vs 2.2%; p < 0.001). Finally, patients with femur fractures classified as AO/OTA type 32B or 32C are significantly more likely to develop thigh compartment syndrome than those with AO/OTA type 32A fractures (2.6% of 32A, 8.3% of 32B, 8.1% of 32C; p < 0.05). At final follow-up, 65.2% of patients experienced persistent symptoms.

Conclusion: Thigh compartment syndrome remains a relatively rare clinical entity with high morbidity, as 65.2% of patients experienced symptoms at final follow-up. All patients with a femur fracture are at risk of developing thigh compartment syndrome, but those caused by firearms, or with a higher OA/OTA classification, are at significantly higher risk. As the mean time from presentation to diagnosis

was 18 hours, we recommend compartment checks for 24 hours in any patient presenting with trauma to the thigh.

Effect of Walking on *In Vivo* Tibiofemoral Cartilage Strain in ACL-deficient Versus Intact Knees

Nimit K. Lad, Bryan S. Crook, Amber T. Collins, Charles E. Spritzer, Jocelyn R. Wittstein, Louis E. DeFrate

Introduction: Anterior cruciate ligament (ACL) injuries are a common injury with a major long-term sequelae of early development of knee osteoarthritis (OA), seen within 10–15 years of injury in many patients. Altered mechanical loading of cartilage in the setting of ACL deficiency may predispose cartilage to the degenerative changes leading to knee OA. However, there is limited data regarding the *in vivo* biomechanical response of tibiofemoral cartilage to activities of daily living (ADLs) in ACL-deficient knees. Therefore, the objective of this study was to assess mechanical loading of tibiofemoral cartilage in response to a treadmill walking stress test.

Methods: In this study, eight otherwise healthy participants with unilateral ACL deficiency completed a stress test to assess the effect of 20 min. of level treadmill walking at a speed of 2.5 mph on tibiofemoral cartilage in their ACL-deficient and contralateral ACL-intact knees. Three-dimensional surface models developed from pre- and post-activity magnetic resonance (MR) images of the injured and uninjured knees were used to determine compressive strain across multiple regions of tibiofemoral cartilage (medial and lateral tibial plateaus, medial and lateral femoral condyles, medial aspect of femoral condyle adjacent to intercondylar notch of the femur).

Results: In the ACL-deficient knees, significantly-increased cartilage strain was observed in the region of the medial femoral condyle adjacent to the intercondylar notch (6% in deficient vs. 2% in contralateral, $p = 0.01$) as well as across the medial and lateral tibial plateaus (4% vs. 3%, $p = 0.01$) relative to the contralateral ACL-intact knees. No significant differences in strain were observed in the medial ($p = 0.49$) or lateral ($p = 0.10$) femoral condyles with strain values ranging from 0–3%.

Discussion: This study demonstrated differences in cartilage strain between ACL-deficient knees and contralateral intact knees in response to walking. Increased compressive strain at the medial intercondylar notch and tibial plateau suggests alterations in mechanical loading or the response to load in these regions, presumably related to altered knee kinematics after ACL injury. These changes may disrupt cartilage homeostasis and contribute to subsequent development of osteoarthritis.

Return to Work After Distal Biceps Tendon Repair

John Reynolds, Michael Reynolds, Jennifer T. Eurich, Asif Ilyas

Background: Distal biceps tendon ruptures can cause significant functional impairment, especially for patients with physically demanding occupations. The purpose of this study is to determine the amount of time required for distal biceps tendon tear patients receiving workers' compensation to return to modified and full work duties after a distal biceps tendon repair (DBTR) relative to the patient's occupation and surgical techniques used.

Methods: A procedural database from the Rothman Institute identified patients that underwent DBTR from January 1, 2012 to December 31, 2014. Sixty-seven patients met eligibility criteria, which included undergoing DBTR and receiving workers' compensation. A retrospective chart review was performed and examined type of occupation, return to work times, type of biceps tendon tear, time from injury to surgery, number of post-op immobilization days, and surgical techniques used.

Results: The average return to modified work duty was 48.42 days (range, 6–246) and the average return to full work duty was 133.51 days (range, 40–356). Occupational groups did not significantly differ on days to modified RTW, ($X2\ (2,60) = 1.66$, $p = 0.44$) or days to full RTW ($X2\ (2,55) = 0.002$, $p = 1.00$). Patients with complete tendon tear and partial tendon tear did not significantly differ in days to modified RTW ($p = 0.44$) or full RTW ($p = 0.73$). Patients who underwent different surgical techniques did not significantly differ on days to full RTW ($X2\ (2,55) = 2.07$, $p = 0.36$), although they marginally differed on days to modified RTW ($X2\ (2,60) = 5.49$, $p = 0.06$). Patients with two incisions had significantly more days to modified RTW (median = 41) than patients with one incision (median = 34), ($p = 0.04$). Time from injury to surgery did not significantly influence days to modified RTW ($p = 0.215$) or full RTW ($p = 0.721$). The number of post-op immobilization days was not significant in days to modified RTW ($p = 0.682$); however, it was significant in days to full RTW ($p = 0.046$) with increased post-op immobilization days correlating with increased days to full RTW ($r = 0.270$).

Conclusions: This study demonstrates that a reduction in post-operative immobilization days and the single incision technique were the only parameters that were significant in decreasing RTW in workers' compensation patients. Patients should be counseled on the importance of early mobilization and post-operative rehabilitation, as well as the potential benefit of the single incision surgical technique over the double incision. The findings of our study may have substantial impacts on improving patient rehabilitation, workers' compensation policymaking, and employing surgical techniques in practice.

Medical Student Research Project

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Assessing Numeracy and Mathematical Literacy in an Urban Population Being Considered for Elective Total Joint Arthroplasty

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Abstract

The objective of this study is to assess the level of numerical and risk literacy in an urban patient population for the effect it can have in on a patient's decision to undergo an elective surgical procedure. Numerical and risk literacy was assessed with a 10-question risk literacy test and the General Health Numeracy Test (GHNT-6). The assessment was given to patients in elective total joint arthroplasty clinics at Temple University Hospital (TUH). The results show that numerical and risk literacy is exceedingly low in urban patient populations of low socioeconomic status. Surgeons should consider this when recommending elective surgeries and communicating associated risks and benefits.

Introduction

The main goal of elective surgery is to improve a patient's quality of life. The decision to undergo an elective procedure is undertaken together by a patient and a physician. Low health literacy can alter patient decision making as well as negatively affect patient expectations and post-surgical behavior, potentially leading to suboptimal outcomes.[1] There is a great deal of complex information provided to patients when discussing surgical intervention and this information is often lost in translation. Studies have shown that the level of understanding and recall can vary greatly between patients. Seven to 47% of patients do not understand their diagnosis. Furthermore, the percentage of information patients are able to recall varies between 40 and 80%.[2] It is understandably difficult for patients to synthesize all the information they receive before a procedure. A patient's health literacy affects this processing of information and should therefore be assessed and improved to assure better outcomes, patient satisfaction, and consent.[1, 3]

There are currently many methods to help increase the level of patient understanding, such as the use of brochures and pamphlets. However, these medical brochures and pamphlets are often not written to the reading level of patients, with many filled with medical jargon. With most adults reading at an eighth-grade reading level, it is imperative to change the way this information is communicated.[4] Teach-back methods have also shown great promise, but the lack of strict implementation means that it is not being commonly practiced amongst physicians.[5]

Numeracy refers to a patient's ability to understand mathematical concepts.[6] Numeracy becomes an important aspect of health literacy when evaluating statistical numeracy, which refers to the ability to understand numbers when presented as risk.[6] Therefore, assessing numeracy becomes important when presenting information as probabilities and risks to patients consenting to undergo an elective surgery.[6–7] Furthermore, studies have shown that physicians themselves can have low numeracy and an inadequate ability to assess risk, therefore providing patients substandard recommendations and poorly communicating numerical information.[6] Breaking this communication barrier is especially important in communities where most of the population does not have a high level of education.

Urban community hospitals, especially those that treat patients from low socioeconomic backgrounds, minority groups, and non-English speakers face the biggest challenge because they treat populations that show the largest disparity in health literacy and numeracy.[4, 8] To date, the exceptionally low level of mathematical literacy and numeracy in patients in an urban setting being evaluated for elective surgery has not been demonstrated. Here, we attempt to determine how well patients in an elective total joint arthroplasty clinic are able to understand numerical information. We plan to assess all patients presenting to clinic, regardless of whether they have already consented to a surgical procedure or not, in order to include a large pool of possible candidates for an elective procedure. We assessed statistical numeracy by giving them math problems that correlate with a sixth grade level according to the PA Department of Education Aca-

demic Standards for Mathematics, which includes the ability to understand fractions, statistics, and probability.[9] By standardizing the questions to a sixth grade level, we can get gather a baseline of the level of understanding of statistics and probabilities. In addition, we included the General Health Literacy Test (GHNT-6), a validated assessment used to measure numeracy, to add validity to our assessment.[10]

Methods

This study is intended to be a performance improvement project and therefore required no IRB approval. A 10-question multiple choice sample to assess ability to understand basic percentages, fractions, decimals, and their relationships was created. The math exercises were multiple choice and designed to be at a sixth grade level of mathematical comprehension. This assessment was administered along with the General Health Literacy Test (GHNT-6), a validated assessment used to measure numeracy.[10]

The assessment was offered in person to patients 18 and older being treated at the Temple University Hospital orthopaedic outpatient joint clinic. All patients presenting to joint clinic, regardless of chief complaint, were offered the assessment. A Spanish version was offered to patients who were only Spanish speaking. Non-English and non-Spanish speaking patients were excluded from the study. Demographic data including sex, age, ethnicity, education level, and zip code was collected. We utilized zip codes to determine which patients resided in the community surrounding Temple University Hospital, our target population. A copy of the complete assessment can be seen in Figure 1.

Results

A total of 78 patients were surveyed. Patient demographics are listed in Table 1. The results show that African Americans make up the majority of the patients visiting the TUH orthopaedic clinic. The results also show that the majority of the patients are over 50 years old. The demographic results also pointed out that a majority of the participants had little to no college education, with about 40% of them obtaining a high school diploma or GED equivalent as their highest level of education.

Table 2 shows the results for the assessments, with the averages for each part of the assessment separated by demographics. The mean percent correct for the new assessment is 37.6% and the mean percent correct for the GHNT-6 is 16.7% for our participants. The reference mean percent correct for the GHNT-6 is 42% with a standard deviation of 30%. In interpreting the results for the GHNT-6, higher scores are associated with high health literacy, objective numeracy, education level, and income.[10] The results show drop in scores with age for both assessments. Conversely, it shows an increase in scores with higher education levels. The results also show an imbalance of scores by ethnicity, with Black/African Americans and Hispanic/Latinos scoring lower than White/Caucasians.

Lastly, Table 3 shows the list of zip codes collected from participants along with the mean annual household income according to the U.S. Census Bureau, 2014–2018 American Community Survey 5-Year Estimates. Figure 1 shows a map of Philadelphia with the location of TUH in the North Philadelphia neighborhood. The circles around TUH serve as a reference for distance when analyzing Table 3 with the map. The total mean household income average according to the U.S. Census for the 78 participants is $47,706. The most common zip code among participants is 19140,[12] the same as TUH. In addition, the mean household income average for the five most collected zip codes, comprising over half of participants, is $36,083.

Discussion

The results show that the majority of the patient population coming into TUH orthopaedic clinic are of lower socioeconomic status and most importantly, from the surrounding community. There is a significant race and economic disparity in the surrounding neighborhood compared to the rest of Philadelphia and to state and national averages. Therefore, efforts to enhance both care and patient autonomy should be improved in order to properly serve members of the community. This includes taking into consideration the education disparity between a physician and a patient as well as the economic impact that certain medical procedures can have. One strategy to close the communication gap between patient and provider can be by bringing awareness to the disparity in numeracy. Our results show that a majority of patients have difficulties understanding percentages, fractions, and decimals based on our created assessment. In addition, the low GHNT-6 scores support that these participants most likely have low health literacy and numeracy scores.[10]

Rodríguez et al. found inadequate health literacy in older and more obese individuals and individuals with many comorbidities and from low socioeconomic backgrounds.[11] They also found lower levels of literacy in African American individuals compared to Caucasian individuals.[11] The results of this study are similar and exemplify the low levels of mathematical literacy and numeracy in patients presenting to TUH for an elective orthopaedic procedure. This exemplifies the gaps in education and the disparity that exist in healthcare because these patients will not be able to make the best-informed decision about their own health. Additionally, the geographic data shows that most of the patients coming to TUH are from the surrounding neighborhood, highlighting educational gaps between this particular neighborhood compared to the rest of the country. Therefore, catering to the needs of these patients by increasing patient education efforts could improve health outcomes in the community.

This data should be utilized to implement changes in the way surgeons educate patients and communicate risks in the informed consent process. In the specific example of elec-

Figure 1. Map of Philadelphia: The map shows the location of TUH and the surrounding neighborhoods for reference. Inner circle has a radius of one mile; outer circle has a radius of three miles.

tive total joint arthroplasty, the surgeon must successfully communicate the numerical chance of the underlying intraarticular pathology, most commonly osteoarthritis, progressing without surgical intervention. Furthermore, the risks of surgical intervention must also be successfully communicated. Patients should understand risks from a numerical standpoint. If the surgeon, for example, states that there is approximately a 2% chance of infection, the patient should be able explain that this means that approximately two in every 100 patients who receive this surgery will have an infection.

By identifying that the urban patient population has an exceedingly low level of numeracy, it is our hope that specific strategies can be targeted to improve understanding. This process could involve the use of supplemental visual aids. Transparent visual aids are images that clearly display information in a part-to-whole relationship, such as pie charts and pictograms. When used in support of complex concepts such as incremental risk, they have been shown to increase understanding when compared to numbers alone.[12] Another strategy is to use pictograms to convey perioperative risks. Magliano et al. showed pictograms were effective at communicating perioperative mortality risks in patients undergoing cardiac surgery. When deciding between two treatment scenarios, qualitative and quantitative measures indicated that patients' answers were consistent and rational.[13] The use of visual aids and pictograms could increase patient understanding and compliance when undergoing

Table 1. Patient Demographics

Demographic Variable	Number of Patients	Percentage of Total
Age Range (years)		
18–29	2	2.6
30–39	6	7.7
40–49	7	9.0
Over 50	64	82.0
Missing	0	0.0
Gender		
Female	52	66.7
Male	26	33.3
Missing	0	0.0
Ethnicity		
White/Caucasian	6	7.7
Black or African American	60	76.9
Hispanic/Latino	10	12.8
Asian	1	1.3
Native American	0	0.0
Pacific Islander	0	0.0
Other	1	1.3
Missing	0	0.0
Education Level		
No Schooling	0	0.0
Grade School (grades 1–5)	0	0.0
Middle School (grades 6–8)	0	0.0
Some High School, No Diploma	13	16.7
High School/GED	31	39.7
Some College, No Degree	14	17.9
Technical/Trade/Vocational Training	5	6.4
Associate Degree	5	6.4
Bachelor's Degree	8	10.3
Advanced Degree	2	2.6
Missing	0	0.0

elective total joint surgery. In addition, it would foster an ethical patient-physician relationship and improve autonomy by empowering patients to be decision makers.

Limitations of this study include the small sample size. Participants were predominantly African American, over 50 years of age, from a low socioeconomic status, and all presenting to the same urban hospital. As such, comparison control groups were not able to be formed due to the limitation of only giving the assessment to patients presenting to TUH, which the data showed, were predominantly from surrounding community. Future studies should include patients from other urban and nonurban hospitals that serve different patient populations. Furthermore, participants were surveyed from a single orthopaedic clinic. The inclusion of patients undergoing other forms of elective surgery or other types of procedures would increase the generalizability of the results. Strengths include its broad inclusion criteria and incorporation of a standardized and validated assessment. Future research will focus on the implementation of strategies such as visual aids to improve numerical understanding in this patient population. It is our hope that by bringing to light the low levels of mathematical literacy in this patient population, we can motivate surgeons to communicate information to their patients in a more effective manner.

Table 2. Assessment Results

Demographic Value	Number of Patients	New Assessment (Mean % Correct)	GHNT-6 (Mean % Correct)
Age Range (years)			
18–29	1	65	33
30–39	6	43	14
40–49	7	36	17
Over 50	64	36	16
Missing	0	—	—
Gender			
Male	26	36	20
Female	52	41	15
Missing	0	—	—
Ethnicity			
White/Caucasian	6	58	25
Black or African American	60	35	16
Hispanic/Latino	10	39	13
Asian	1	80	50
Native American	0	—	—
Pacific Islander	0	—	—
Other	1	3	0
Missing	0	—	—
Education Level			
No Schooling	0	—	—
Grade School (grades 1–5)	0	—	—
Middle School (grades 6–8)	0	—	—
Some High School, No Diploma	13	27	17
High School/GED	31	31	11
Some College, No Degree	14	40	15
Technical/Trade/Vocational Training	5	33	17
Associate Degree	5	46	23
Bachelor's Degree	8	65	35
Advanced Degree	2	55	25
Missing	0	—	—

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Table 3. Patient Provided Zip Codes

Zip Code	Distance to TUH (Miles)	Average Household Income
19140*	—	$34,159
19133	1	$32,496
19132	1.3	$31,880
19122	1.8	$55,359
19129	2	$89,801
19121	2.2	$34,436
19141	2.4	$46,177
19144	2.4	$49,886
19123	2.8	$98,166
19130	2.8	$114,019
19134	2.9	$43,714
19120	3	$47,676
19124	3.2	$46,870
19138	3.4	$51,316
19131	3.7	$47,086
19119	3.9	$96,034
19139	5.1	$38,352
19143	5.7	$48,165
19151	5.8	$63,244
19142	7.1	$39,360
19145	7.1	$63,142
19136	7.2	$59,546
19032	10.4	$65,928
08083†	13.2	$91,881
08053†	17.6	$119,427
19055	19.1	$79,807
08081	21.5	$100,177
08109†	36	$78,213
Philadelphia County	—	$65,090
Pennsylvania	—	$81,549
USA	—	$84,938

*Temple University Hospital (TUH) zip code is 19140.
†Not in Philadelphia.

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Medical Student Research Project

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Combining Flexion Lateral Radiographs with a Supine MRI Is Superior to a Combination of Flexion and Extension Lateral Radiographs at Detecting Vertebral Instability in Patients with Spondylolisthesis

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Abstract

To evaluate the efficacy of combined supine MRI with a flexion lateral radiograph versus flexion and extension lateral radiographs alone for identifying lumbar vertebral instability in patients with spondylolisthesis. Electronic medical records (EMRs) were utilized to identify patients with documented spondylolisthesis and flexion/extension lateral radiographs and a supine lumbar spine MRI between the years 2010 and 2018. Only those patients with instability on flexion extension lateral radiographs were included. Patients with prior spinal surgery, high grade spondylolisthesis (Meyerding grade V), and those without instability or complete imaging were excluded. One hundred seven potential patients were identified and 57 were excluded. Thirty-two patients (64%) demonstrated greater instability (>3%) on supine MRI and three patients (6%) showed greater instability on extension lateral radiograph. Supine MRI was superior at detecting vertebral instability in the setting of spondylolisthesis ($p < 0.001$). The combination of a flexion lateral radiograph with a supine MRI showed a 4.52% (95% CI [4.9, 7.3]) greater reduction in unstable spondylolisthesis when compared to a combination of flexion and extension lateral radiographs ($p < 0.05$). Lateral flexion X-ray paired with supine MRI is a superior imaging technique for diagnosing vertebral instability when compared to flexion and extension lateral radiographs.

Introduction

Lumbar vertebral instability is the abnormal movement of vertebrae while under physiologic stress causing displacement beyond normal constraints.[1] One of the more commonly-cited instances of lumbar "instability" is in spondylolisthesis, which is defined as anterior translation of the more cranial vertebrae on the next most caudal vertebrae.[2] Spondylolisthesis can be categorized into five different classes based on the etiology.[3] These classes include dysplastic, isthmic, degenerative, traumatic and pathologic types. The degree of slippage is often described according to the Meyerding classification, with higher grades corresponding to greater anterior cranial vertebral translation.[4]

Degenerative spondylolisthesis occurs in 60% of all patients in the seventh decade and can present as chronic back pain with or without associated radicular symptoms.[5] Extension of the back can exacerbate the symptoms by producing sharp, radicular pain, presumably due to compression of the traversing nerve root. For most, management is conservative and may include rest or physical therapy. The decision to pursue surgical intervention takes into account the degree and nature of symptoms, prior treatment, degree of slippage, as well as the presence and amount of instability.[6] Spinal surgery, which typically consists of direct or indirect decompression and fusion, is reserved for select patients.[6–10] Although there is no strong direct correlation, it is theorized that vertebral instability can lead to worsening neurologic symptoms and increased back pain, hastening the need for surgical intervention.[1]

The current gold standard for diagnosing instability utilizes a combination of flexion and extension lateral lumbar radiographs. First, this method relies on adequate patient positioning to obtain a true lateral radiograph of the vertebral levels in question. Second, it relies on the absence of significant lumbar scoliosis. Scoliosis is a three-dimensional deformity and the presence of any axial rotation may alter sagittal parameters and the ability to detect instability on plain radiographs.[11, 12] There are limited studies evaluating

the use of advanced imaging to evaluate sagittal vertebral instability.

In this article, we seek to determine the accuracy of a lateral flexion lumbar radiograph combined with a supine lumbar spine MRI at detecting vertebral instability in patients with degenerative spondylolisthesis. Specifically, the purpose of this study is to determine if this method is superior to flexion-extension lateral radiographs alone. We predict that the supine sagittal MRI, with increased cranial vertebral reduction, will provide a better estimate of the degree of vertebral instability as compared to the combined flexion and extension lateral radiographs.

Methods

Study Design and Patient Selection

This study is a retrospective cross-sectional chart review of patient imaging from 2010 to 2018. Patients were first identified by ICD10 code of degenerative lumbar spondylolisthesis (M43.16) along with flexion-extension lateral lumbar radiographic series and a lumbar spine MRI within six months. Patients with prior spine surgery and/or high grade spondylolisthesis (Meyerding grade V) were excluded in addition to patients that did not demonstrate instability on flexion and extension lateral radiographs. When patients had spondylolisthesis at multiple levels, the spondylolisthesis that was most severe by degree of slippage was used. In the setting of patients having an anterolisthesis and a retrolisthesis, the anterolisthesis was analyzed since retrolisthesis was seen much less frequently and is of less clinical significance.

Image Analysis

Patient imaging was collected and evaluated by two independent observers. First, the length of the superior endplate of the more caudal vertebrae was calculated. Displacement was measured as the distance between a perpendicular line from the posterior aspect of this endplate to the posterior aspect of the inferior endplate of the more cranial vertebrae. Once the displacement length was measured, the percent displacement was determined based on the length of superior endplate of the caudal vertebrae. Figure 1 demonstrates an example of this analysis. The MRI review utilized a similar methodology where the percent displacement was based on the superior endplate of the caudal vertebrae. The sagittal T1 weighted MRI image (TE 9-12ms/TR400-500ms) from the GE 1.5 Tesla (Chicago, IL) or Siemens 3 Tesla (Erlangen, Germany) scanners used at our institution was chosen based on cross-sectional imaging so that it was as close to the midline of the vertebral body as positioning and available imaging allowed. In both scanners, the patients were supine in a standard body coil typically used for lumbar spine MRI imaging. In both the MRI and radiographic analyses, osteophytes and curved endplates provided additional measurement challenges. The curved endplates were accounted for by using a drop-off analogy. The measurements were taken as if the length of the endplate measured was a cliff and the measurement stopped once the edge of the cliff was met. The osteophytes proved difficult to assess as they were sometimes not entirely distinguishable from the vertebral body. When osteophytes were readily apparent, they were excluded from the analysis for both the length of the vertebral body and the displacement measurement. When they were not distinguishable, they were excluded by estimating the true edge of the vertebral body based on the architecture of the bone as it led up to the osteophyte.

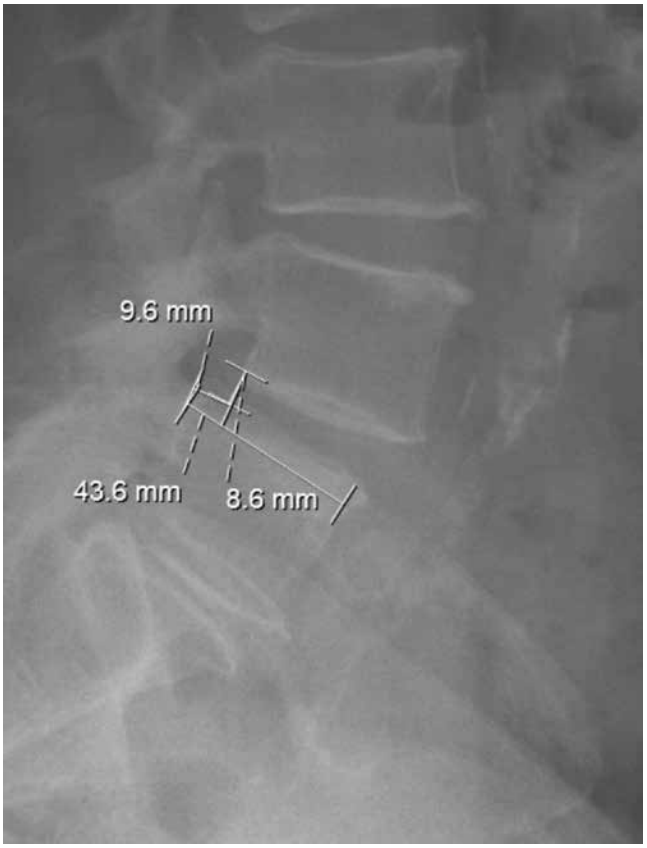

Figure 1. Vertebral Body Translation Calculation A line is drawn at the superior endplate of the inferior vertebral body. A second line is drawn as the posterior continuation of the inferior endplate of the superior vertebral body. A perpendicular line is drawn from the most anterior aspect of the second line to the first line. The length of the first line posterior to this point is calculated as a percentage of the length of the line.

Measurements

Measurements were obtained and percent translation determined for flexion and extension lateral radiographs and for supine MRI as described above. Flexion and extension radiographs were then compared as a means to determine differences in percent displacement (Group A). A similar methodology was utilized for the flexion radiographs and supine MRIs (Group B). This provided an assessment of the motion for later comparison. Group B's instability was then subtracted from Group A (Group A–Group B) to determine the difference between the two imaging modalities. If there

was a >+3% difference between the two imaging modalities, then Group A was determined to better demonstrate vertebral instability. If there was a <–3% difference between the two imaging modalities, Group B was determined to better demonstrate vertebral instability. If the value was between +3% and –3%, neither imaging modality was superior. The same two investigators did all image interpretation and recording separately.

Statistics

Statistical analysis was performed conducted using SAS 9.4 (SAS Institute, Cary, NC) and significance was defined as $p < 0.05$. One sample t-tests were conducted to determine whether the difference between Group A and Group B is greater than 3%. This was done independently for each observer. The sign test was then applied to determine if there is a higher likelihood of MRI detecting vertebral instability (defined as >3% in vertebral body translation) compared to plain radiographs.

Results

A total of 107 patients were identified with the diagnosis of degenerative lumbar spondylolisthesis. Of these, 57 patients were excluded by observer 1 and 53 patients were excluded by observer 2 using the aforementioned criteria. Baseline patient characteristics were similar between groups (Table 1). Level of spondylolisthesis and calculated Meyerding grade were also similar (Table 2). The results from the analysis are included in Tables 3 and 4. Of the 50 patients meeting inclusion criteria by observer 1, 33 patients (66%) demonstrated greater instability (defined as >3% difference) on supine MRI and two patients (4%) showed greater instability on extension lateral radiograph. Supine MRI was determined to be superior at detecting vertebral instability in the setting of spondylolisthesis ($p < 0.001$). The combination of a flexion lateral radiograph with a supine MRI showed a 4.78 $\pm$ 5.6% greater degree of instability when compared to a combination of flexion and extension lateral radiographs ($p = 0.015$). Results for the second observer were similar with an Intraclass Correlation Coefficient of 0.69 and also yielded a statistically significant difference ($p < 0.05$) (Figures 2–5).

Discussion

Spondylolisthesis is a common cause of back pain that has been historically assessed using the Meyerding Technique for degree of slippage and flexion-extension lateral radiographs to estimate instability. Though there are no absolute surgical indications for this pathologic process the majority of patients who undergo surgical intervention do so as a result of failed medical treatment or development of neurologic signs from spinal cord or nerve root compression. Spondylolisthesis in the presence of cauda equina syndrome or progressive neurologic deficit obviously require emergent operative treatment, typically in the form of decompression and fusion with or without reduction.

Despite their widespread utilization as the current gold standard, flexion and extension radiographs have been suggested by other studies to be inferior to other modalities at diagnosing instability in patients with spondylolisthesis. Hey et al. described the use of sitting slumping flexion lateral radiographs and determined this method to be superior the use of a flexion lateral radiograph.[13] Chen et al. determined the use of upright lateral radiographs in combination with a supine lumbar spine MRI was superior in patients with a more kyphotic spine.[14] Tarpada et al. showed that supine lateral radiographs paired with standing radiographs were superior to standing lateral radiographs alone.[15]

Similarly, our study suggests that a combination of flexion and extension lateral lumbar radiographs may underestimate the degree of instability seen in these patients. The flexion lateral radiograph paired with a supine lumbar MRI appears to be a better imaging technique for this purpose. The appropriate identification of instability may assist surgeons in their decision to offer patients surgical intervention. Although instability alone cannot be accurately correlated with patient symptoms, its presence in conjunction with other clinical findings may influence surgical planning (decompression alone versus decompression with fusion) and thus influence clinical outcomes.

Limitations of this study include its retrospective nature. Due to the relatively small sample size, it was also not possible to group patients based on subtype of spondylolisthesis. Furthermore, it is possible that the patients that were excluded because they did not have both flexion and extension lateral radiographs and a supine MRI created a degree of selection bias. Another limitation results from the presence of vertebral body osteophytes and curved bony endplates. As previously mentioned, the endplate concept was addressed using an "edge of the cliff" analogy. The osteophytes, especially on plain radiographs, made measurements challenging as they were not always entirely identifiable. In most of the reviewed radiographs, osteophytes were readily distinguished from the typical bony anatomy. However, a small number of patients may have had osteophytes that blended well with the bony anatomy. Both reviewers used estimations based on the unaffected bony anatomy to determine the length of each endplate. Strengths of this study include its broad inclusion criteria, standardized measurement technique, and use of two independent observers.

Several different imaging modalities have been suggested to determine the presence of vertebral instability in patients with spondylolisthesis. The results of our study suggest that lumbar spine instability may be best assessed using a flexion lateral radiograph combined with supine MRI. This may be due to MRI having better image resolution and as a result, improved ability to define the margins of the endplates while also limiting the effect of patient rotation. It is also possible that the increased instability seen on supine MRI is due to

Table 1. Baseline Patient Demographics

	Observer 1 Data				Oberver 2 Data			
	MRI Superior	**Neither Superior**	**Flex-Ex Superior**	**P-Value**	**MRI Superior**	**Neither Superior**	**Flex-Ex Superior**	**P-Value**
Number of Patients	32	15	3		33	17	4	
Age	Mean, SD 59.2, 9.9	Mean, SD 60.1, 12.9	Mean, SD 61.0, 4.2	0.948	Mean, SD 57.6, 10.3	Mean, SD 61.9, 11.3	Mean, SD 68.3, 4.9	0.097
Sex				0.348				0.052
Female	26	9	2		23	16	2	
Male	7	6	0		10	1	2	
Comorbidities								
Obesity or overweight	13	3	0	0.325	12	5	1	0.901
Hyperlipidemia/dyslipidemia	16	9	2	0.475	13	12	4	0.016
Headache or migraine history	3	5	0	0.135	4	4	1	0.408
GERD or esophageal reflux	9	6	0	0.544	10	5	1	1
Depressive disorder	16	3	1	0.126	15	7	2	1
Arthritis or arthralgia	17	4	2	0.059	15	7	2	1
Hypertension	26	11	2	0.831	25	14	4	0.662
Diabetes mellitus	10	7	1	0.425	9	8	2	0.324
Osteoarthritis	4	5	0	0.177	5	4	1	0.545
Allergic rhinitis	3	2	0	0.71	3	1	1	0.545
Smoking tobacco	4	0	0	0.404	4	1	0	0.765
Heart dysfunction	2	2	1	0.137	2	4	0	0.206
COPD	2	1	1	0.226	2	1	1	0.35
Asthma	9	3	0	0.844	8	3	2	0.418
Degenerative disc disease	3	2	0	0.71	2	3	0	0.428
Cancer history	2	3	1	0.085	3	3	1	0.337
Substance use history	1	2	0	0.318	1	2	0	0.418
Viral hepatitis	2	3	1	0.085	3	3	0	0.628
Thyroid disease	2	1	0	1	2	1	0	1
Myocardial infarction	3	0	0	0.596	2	1	0	1
Gout	0	1	0	0.34	1	0	0	1
Chronic renal disease	3	1	0	1	3	0	2	0.027
Osteoporosis	2	2	0	0.645	1	2	1	0.097
Vitamin D deficiency	1	2	0	0.318	1	2	0	0.418
Obstructive sleep apnea	2	1	1	0.226	2	1	1	0.35
Atrial fibrillation	2	0	0	1	1	1	1	0.237
Stroke	3	1	0	1	1	4	1	0.04
Atherosclerosis or PVD	2	2	0	0.645	3	1	0	1
Rheumatoid arthritis	0	1	0	0.34	1	0	0	1
Sarcoidosis	0	1	0	0.34	0	1	0	0.389
B12 deficiency	0	1	0	0.34	0	1	0	0.389
Lyme disease	0	1	0	0.34	0	1	0	0.389
Spina bifida	0	0	0	n/a	1	0	0	1
Schizophrenia	0	0	0	n/a	1	0	0	1

positional reduction. Tarpada et al.'s study further supports this hypothesis.[15] Due to the prohibitive cost of obtaining MRI imaging on all patients, it is possible that supine lateral lumbar radiographs may be an acceptable alternative. Further studies are required to assess the validity of this theory.

Table 2. Radiographic Characteristics

	Observer 1 Data				Oberver 2 Data			
	MRI Superior	Neither Superior	Flex-Ex Superior	P-Value	MRI Superior	Neither Superior	Flex-Ex Superior	P-Value
Location of Spondylolisthesis				0.671				0.498
L3-L4	3	2	0		3	2	0	
L4-L5	26	13	2		25	15	4	
L5-S1	4	0	0		5	0	0	
Meyerding Grade								
Grade 1	25	2	13	0.525	24	4	16	0.112
Grade 2	8	0	2		9	0	1	
Grade 3	0	0	0		0	0	0	
Grade 4	0	0	0		0	0	0	
Grade 5	0	0	0		0	0	0	

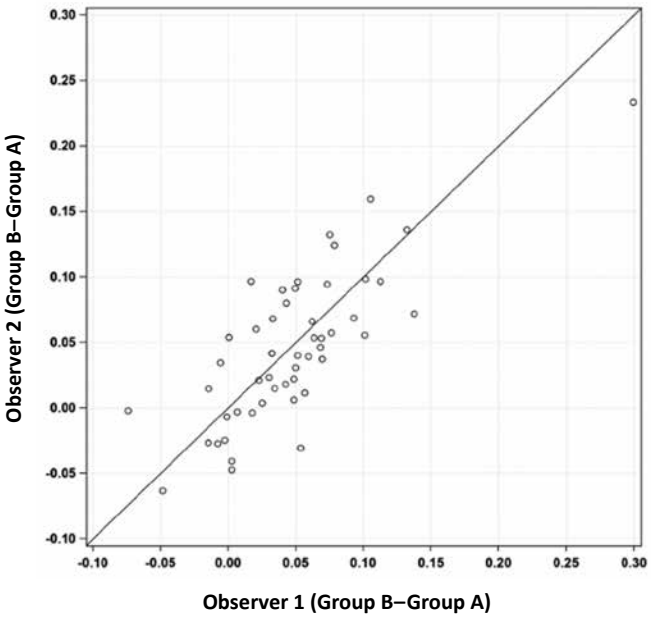

Figure 2. Datapoints obtained by Observer 1 compared with those obtained by Observer 2.

Table 3. Vertebral Instability

	Difference in Percentage Vertebral Translation (SD)			
	Group A	Group B	Group A and Group B Difference	P-Value
Observer 1	5.64 (3.56)	10.41 (5.74)	4.78 (5.62)	0.015
Observer 2	5.18 (3.15)	9.70 (5.45)	4.51 (5.54)	0.025

Table 4. Comparison of Imaging Modalities

	Superior Imaging Modality (%)		
	Lateral Flexion and Extension Radiographs (%)	Lateral Flexion Radiograph and Supine MRI (%)	Neither Imaging Modality (%)
Observer 1	2 (4)	33 (66)	15 (30)
Observer 2	4 (7.41)	33 (61.11)	17 (31.48)

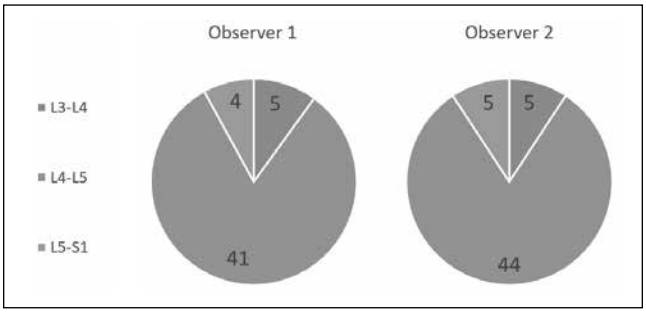

Figure 3. Number of patients with spondylolisthesis by level of spondylolisthesis.

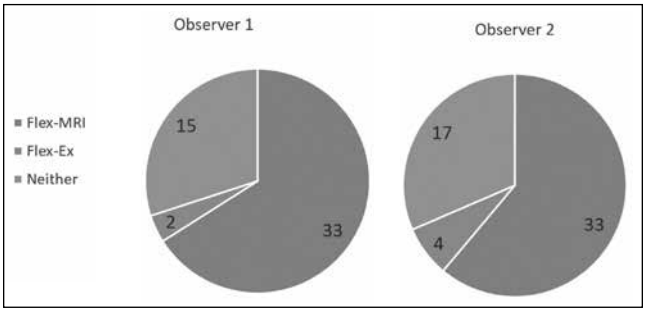

Figure 4. Number of patients by imaging modality outcomes.

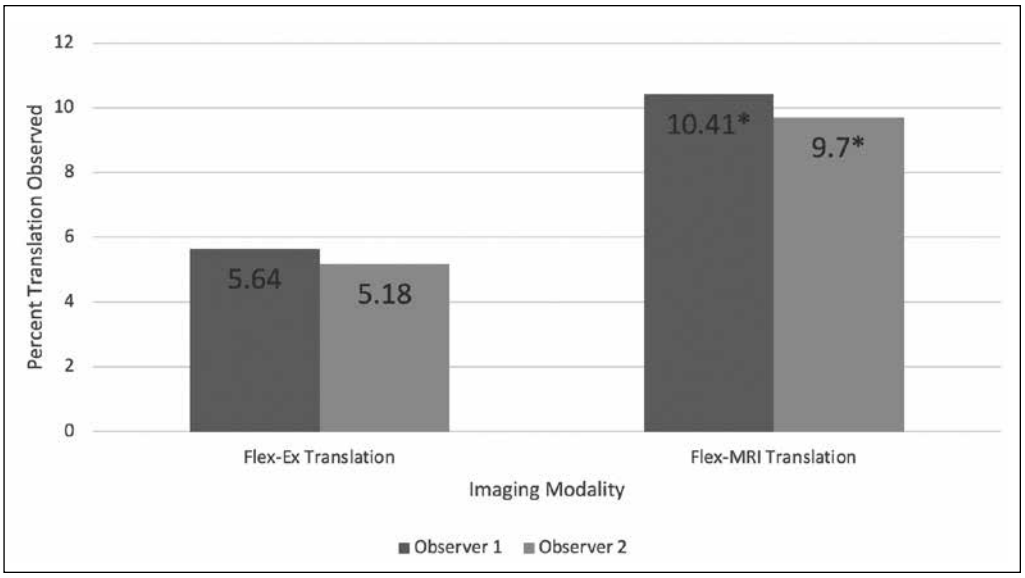

Figure 5. Percent translation seen by Observers 1 and 2 per imaging modality.

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Medical Student Research Project

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Devising an Optimal Care Plan for Patients with Severe Mental Disabilities Who Need Arthroplasty: Identifying Barriers and Potential Solutions

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Abstract

The objective of this study is to assess the special needs of patients with mental disabilities requiring hip or knee arthroplasty at a level one academic medical center. A focus group of medical staff involved in preoperative and postoperative surgical pathways provided information on challenges experienced in this population. The following themes from the survey were deduced: difficulty communicating, lack of adherence to instructions, lack of family support, presence of comorbid illnesses, limited healthcare resources, and limited economic resources. A case review of a 50-year-old male patient with Down syndrome who underwent a left total hip arthroplasty was conducted. In reviewing the patient's progression through the hip replacement care pathway, areas of improvement supported the themes deduced in the survey. A literature search was conducted to find articles pertaining to the relationship between arthroplasty and mental disorders. There was a paucity of literature focusing on patients with chronic cognitive mental disorders needing knee or hip replacement. This highlighted the research gap in this area. Potential solutions for modifying current standard pathways were explored.

Introduction

Arthroplasty has proven to be a successful procedure for individuals dealing with degenerative joint disease after non-operative management has failed.[1] The most common indication for joint replacement is end stage osteoarthritis. Osteoarthritis continues to increase in prevalence in the United States, doubling from 1999 to 2014. It remains the most common joint disease affecting North Americans.[2, 3]

Individuals with severe mental disabilities, who would benefit from hip or knee arthroplasty, present challenges that are different than those individuals without mental disabilities. A recent study showed that psychiatric comorbidities were correlated with higher prevalence of surgical complications, longer hospital length of stay, and higher in-hospital mortality.[4]

Due to unique challenges of patients with cognitive disorders, a more comprehensive pre-operative and post-operative care plan following total hip or knee arthroplasty is critical to improve patients' outcomes and reduce hospital costs. The objective of this study is to assess the needs of patients with mental disabilities requiring hip or knee arthroplasty by evaluating current preoperative and postoperative surgical pathways for arthroplasty patients at a level one academic medical center.

Methods

This study focused on mental health patients with the diagnosis of intellectual disabilities, congenital cognitive impairments, or who have experienced traumatic brain injury.

Study Type

This was a performance improvement study focused on developing a care plan addressing barriers when treating patients with mental illness who require hip or knee arthroplasty. Information was obtained from the following sources: a focus group, retrospective chart review, and literature review.

Focus Group

Feedback on barriers and challenges encountered when caring for arthroplasty patients of the identified population was obtained from attending orthopaedic surgeons, orthopaedic residents, nursing manager, clinical dietician, case manager, and administrative assistant from a level one academic medical center. A survey was distributed via Survey Monkey. The survey asked the following: (1) What is your role in the healthcare team? (2) Have you had experience providing care for patients in the aforementioned population of interest? (3) What are the major challenges you faced with treating this population? (What do you see as impediments to profession of care?) (4) From your perspective, what are the key challenges patients in this population experience during the course of seeking and undergoing treatment and through the recovery process?

Chart Review/Case Analysis

A retrospective chart review from a level one academic medical center's electronic medical record was conducted. Patients with the following ICD10 codes: F70, F71, F72, F73, F78, F79 (Disability Intellectual Deficiencies) and Q90.0, Q 90.1, Q90.2, Q90.9 (Down Syndrome) who had interaction(s) with the orthopaedic department within the time period of June 6th, 2014 to June 6th, 2019 were identified. Of the cases identified, a detailed analysis of one case in comparison to the standard orthopedic pathway was conducted with the goal of identifying complications.

Literature Review

A literature search was conducted using Pubmed and Medline database to find articles pertaining to the relationship between arthroplasty and mental disorders. Relevant articles were selected based on the abstract.

Results

Focus Group

A total of nine individuals completed the survey (four orthopaedic surgeons, one nurse, one clinical dietitian, one orthopaedic resident, one discharge planner, and one administrative assistant). Only one respondent answered "no" to "Have you had experience providing care for patients in the aforementioned population of interest?". Responses for question 2 (What are the major challenges you faced with treating this population?) and 4 (From your perspective, what are the key challenges patients in this population experience during the course of seeking and undergoing treatment and through the recovery process?) were categorized into themes. The following themes were deduced: difficulty communicating, lack of adherence to instructions, lack of family support, presence of comorbid illnesses, limited healthcare resources, and limited economic resources.

Chart Review/Case Review

A total of 20 patients were identified that had the following ICD10 codes: F70, F71, F72, F73, F78, F79 (Disability Intellectual Deficiencies) and Q90.0, Q 90.1, Q90.2, Q90.9 (Down Syndrome) who had interaction(s) with the orthopaedic department at a level one academic medical center within the time search period were identified. Of those 20 patients, only one patient had undergone hip or knee arthroplasty.

The patient identified is a 50-year-old male resident of an Intermediate Care Facility for persons with intellectual disabilities. He had the following diagnosis: Down syndrome, obstructive sleep apnea, orthostatic hypotension, seizure disorder, major depressive disorder, and Alzheimer disease. On presentation, he was found to have significant left hip degenerative changes in the setting of dysplasia. He ultimately underwent left total hip arthroplasty.

In reviewing the patient's progression through the hip replacement care pathway, there were some identified areas that may be improved to optimize care in this unique scenario (see Fig. 2). For example, surgery was delayed as the patient was unable to consent and was not accompanied by his medical decision-maker during the surgical consult phase. Because of this hurdle, an additional clinic visit was needed to obtain surgical consent.

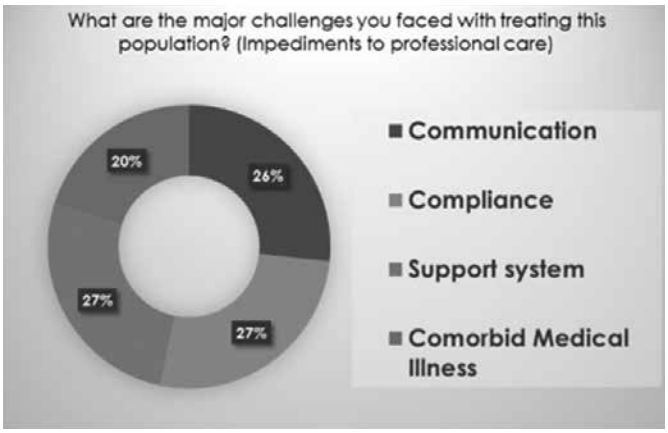
This patient and medical staff caring for him also faced challenges with communication. Based on chart review, clinicians and staff had difficulty conducting physical examinations, performing review of systems, and assessing pain severity because the patient was non-verbal. In addition, there were difficulties managing the patient's agitation and self-injurious behaviors while he was an inpatient during the post-operative period. The patient displayed disruptive behaviors such as yelling, spitting and hitting oneself, which are not frequently observed with patients without mental disabilities undergoing total hip arthroplasty. Lastly, there was limited care coordination between the hospital team and patient's care providers at his residential care facility during the hospital course.

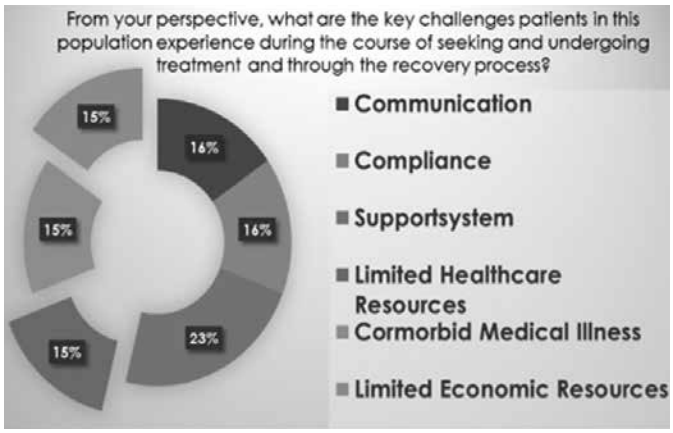
Literature Review

There was a paucity of literature focusing on patients with chronic cognitive mental disorders needing knee or hip replacement. This highlighted the research gap in this area. Of the limited articles found, there was consensus showing that people with intellectual disability generally have unique challenges when hospitalized. A case report showed how delays in care was attributed to physician bias when dealing with patients with cognitive challenges such as in Down syndrome.[5] In a systematic review, Lacono et al. highlighted various themes that pose a challenge in treating intellectually-disabled individuals when hospitalized. These themes include over reliance of clinical staff on family members, limited knowledge on severe mental illness, and limited knowledge in managing disruptive challenging behaviors.[6] From a solution standpoint, an article focusing on the assessment and management of patients with intellectual disabilities by psychiatric consultants provided the following recommendations: adjusting intake to include assessment of cognitive, language and sensory status, having a high threshold for discontinuing psychoactive medication under careful considerations for the benefits and risks, and including behavioral modifications to address potential agitation by minimizing overstimulation and behavioral modification to prevent deconditioning during recovery.[7]

Discussion

This study explores the complex issues surrounding mental health patients with cognitive limitations needing total hip or knee arthroplasty and the need for a collaborative healthcare team. The barriers affecting the optimization of care in this special population, as identified by the focus group (Fig. 1), resonates with the literature search conducted





Figures 1 and 2. Response themes for "What are the major challenges you faced with treating this population?" and "From your perspective, what are the key challenges patients in this population experience during the course of seeking and undergoing treatment and through the recovery process?"

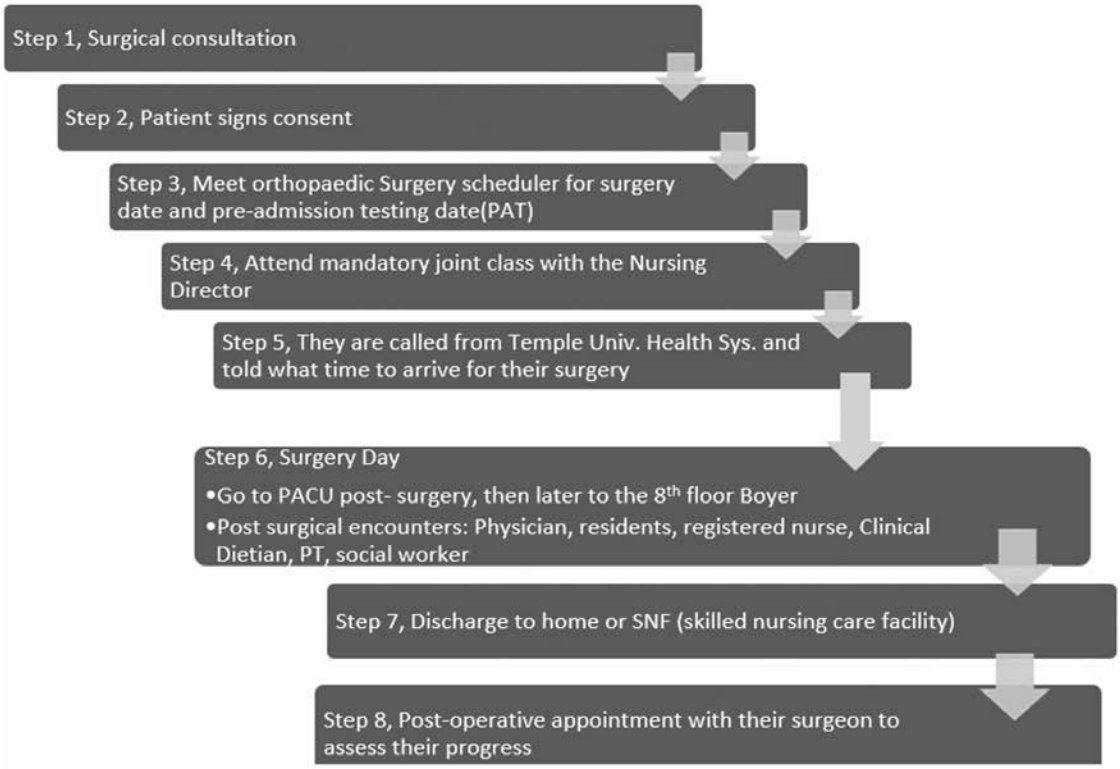


Figure 3. General arthroplasty care pathway outline at Temple University Hospital (current standard pathway).

and the case reviewed. Potential solutions for modifying current standard pathways may be deduced from the identified barriers in this study.

The preoperative stage of the pathway may benefit from a more robust mental health assessment. Factors that should be included are history of aggression and self-injurious behavior, level of cognitive/skill deficit, and ability to verbalize pain. This could involve the utilization of psychiatry consultants in the pre-operative period.[7] Given the reasonable probability of limited cognitive and/or verbal ability in this special population, adjustments will need to be made to facilitate communication and clinical assessments. Establishing a "coach" (a family member or care coordinator) to be present at all facets of patient care (preoperative to recovery stage) could facilitate communication between stages of care and aid with follow-through of care instructions. As seen with the case review, patients in this population are likely to have other chronic medical comorbidities. Accordingly, caretakers may be overwhelmed with responsibilities.[6, 8] Preoperatively, an assessment of caretaker burnout may be imperative to negate non-adherence to follow-up and postoperative instructions (Fig. 4).

PRE-OPERATIVE PLAN

- ➡ Surgical consult
  - ➡ Evaluation for need of arthroplasty
  - ➡ Input from caretaker or residential facility if patient resides in such
  - ➡ Coordinate scheduling of surgery
- ➡ ***Mental health/behavior at history — That could complicate treatment and recovery***
  - ➡ Understanding/obtain information on how the patient communicates, especially if non-verbal
  - ➡ How does patient express pain/discomfort
  - ➡ History of aggression and or self-injurious behavior
  - ➡ Interventions that have helped alleviate aggression/agitation
- ➡ Establishing if patient has capacity for informed decisions or the need of a power of attorney for the patient
- ➡ ***Establishing a "coach" (can be a family member or care coordinator) to be present at all facets of patient care (pre-operative to recovery stage). This will help ensure that vital instructions are followed through the various stages of care.***
  - ➡ Caregiver questionnaire
  - ➡ Pre-operative education for patient and coach (e.g., joint class)
- ➡ Pre-admission testing (labs etc.)

POST-OPERATIVE PLAN (Hospitalization)

- ➡ ***Treatment team/staff made aware of mental health/behavioral agitation history and how patient expresses pain/discomfort***
  - ➡ Pain management
- ➡ Determine appropriate disposition and rehabilitation plan
- ➡ Consideration for possible cognitive/skill deficit
  - ➡ Assess for ability to follow-through discharge care plan
  - ➡ If needed, modify home instruction post-operative care plan and/or arrange for home nursing aid

POST-OPERATIVE PLAN (Post-hospitalization)

- ➡ ***Address transportation needs if necessary, so as to facilitate follow-through with postoperative ambulatory clinic appointments***
- ➡ If patient resides in residential care facility, input from the facility will be helpful to assess recovery/ response to treatment

Figure 4. Suggested modifications to care pathway are in ***bold italic.***

The postoperative plan during hospitalization may be modified to ensure follow-through of preoperative mental health assessment/recommendation by a brief psychoeducation for clinicians and staff caring for the patient. Discharge plans may need to be more robust and comprehensive given the likelihood of more psychosocial needs. These requirements can be predicted in the pre-operative period to ensure the post-operative course and discharge plans are solidified by the time the patient is ready to be discharged.

This study has multiple limitations. The first being the generalizability of the arthroplasty pathway and medical records reviewed at the level one academic medical center in this study. However, the barriers identified locally correlates with the barriers identified in the literature. Also, the chart review was limited as only one patient met the criteria. A longer data search window and/or an expanded ICD9 and ICD10 codes may have provided additional cases for review. This study could have been strengthened by comparing non-mental health to mental health patients needing arthroplasty if more cases were available for review. Lastly, a review of resource/medical cost utilization may have also provided information on the unique needs of this special population when requiring total hip or knee arthroplasty.

In summary, our study has allowed us to make suggestions for optimizing the care plan for patients with severe mental disabilities who need hip or knee arthroplasty. We

have been able to dissect a standard arthroplasty pathway utilized at a local institution and make modifications on the directions of identified barriers to care. Furthermore, our finding is an addition to the limited research on this topic and indicates avenues for future studies.

Acknowledgments

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Original Research

Bone Morphogenetic Protein Use to Achieve Successful Arthrodesis in the Lumbar Spine: A Review of the Recent Literature

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Abstract

The objective of this study is to review level 1 and 2 literature published after the year 2016 evaluating the use of bone morphogenetic protein (BMP) to achieve arthrodesis in the lumbar spine. Independent Pubmed and Medline searches were completed by two independent researchers using the terms 'bone morphogenetic protein,' 'BMP,' 'lumbar fusion,' and 'lumbar arthrodesis.' All level 1 and 2 studies from the year 2016 onwards were identified independently by the same individuals. Studies selected by both reviewers were included for discussion. Three level 1 and two level 2 studies were published after the year 2016 pertaining to the use of BMP to achieve arthrodesis in the lumbar spine. With the exception of one level 1 study, BMP was associated with a high rate of successful arthrodesis and a minimal complication profile. There remains wide potential for further prospective studies to evaluate the safety of BMP use, determine optimal dosing, and perform thorough cost benefit and value analyses.

Introduction

In contemporary spine practice, there has been a rise in the frequency of lumbar fusions.[1, 2] A number of advanced techniques and variations in instrumentation have been developed in recent years to increase fusion rates.[3, 4] Despite this, pseudarthrosis rates of over 20% are still reported.[12, 16] While the clinical significance of pseudarthrosis may remain unclear, these may nevertheless contribute to patient disability and increased cost of healthcare.[3, 4]

The current "gold-standard" grafting material to achieve spinal arthrodesis is iliac crest bone autograft (ICBG). This is associated with substantial morbidity.[5, 6] To avoid this, use of recombinant human bone morphogenetic proteins (BMP) became a common alternative for grafting material. These factors are part of the transforming growth factor beta (TGF-beta) superfamily.[5] They were originally discovered in 1965 and were found to have strong osteoinductive properties.[7] In the year 2002, the FDA approved the use of rh-BMP2 in lumbar spinal fusion procedures.[5] While initially very popular, there was a decline in usage after 2008 after the emergence of fatal complications associated with the use of BMP in the cervical spine.[8, 9] It was also noted that many of the original trials were sponsored by industry, highlighting potential conflicts of interest. These failed to acknowledge many subsequently reported adverse events including for example heterotopic ossification, osteolysis, infection, arachnoiditis, retrograde ejaculation, and malignancy.

There is an extensive volume of literature on the outcomes and complications associated with BMP use to achieve lumbar spinal arthrodesis. Most studies show that BMP use can be used successfully with a minimal complication profile. Despite this, significant controversy still exists regarding its safety, efficacy, dosing, and cost-effectiveness.[10–13] While there are a number of review papers looking at BMP use in the 2000s and early 2010s, there is a paucity of recent systematic and literature reviews. Here, we present a review of literature pertaining to BMP use in lumbar spine surgery from the year 2016 onwards. This time period was chosen for two reasons. First, the authors' goal is to specifically highlight new data pertaining to BMP usage. Second, to the authors' knowledge, there have been no systematic reviews or meta-analyses published on this topic during this time period.

Material and Methods

Two independent researchers conducted a Pubmed search using the terms 'bone morphogenetic protein,' 'BMP,' 'lumbar fusion,' and 'lumbar arthrodesis.' The same researchers then performed a Medline search using the identical terms. Results from the two searches were combined and all clinical English language publications studying outcomes after use of BMP to achieve lumbar spinal arthrodesis were selected. Levels of evidence were assigned to each study by both researchers in an independent fashion.[14] Results were then narrowed to include only level one or two studies from the year 2016 onwards. Only papers selected by both researchers were included.

Results

A total of 92 Pubmed studies and 80 Medline studies were found pertaining to the use of BMP in lumbar spine fusions. There were a total of 29 level one studies and 12 level 2 studies independently agreed upon by the two researchers. A flowchart demonstrating this search is presented in Figure 1. Of these studies, three level 1 studies and two level 2 studies were published after the year 2016. These papers are presented in Table 1.

Discussion

The primary motivations for the increase in use of BMP include reportedly higher fusion rates and less donor site morbidity than associated with autograft harvest. Cho et al. reported on a randomized controlled trial (RCT) of 100 patients. BMP was found to be noninferior to iliac crest bone graft (ICBG) in obtaining successful fusion without a higher rate of adverse effects.[15] One weakness of this study was that there was only a 24-week follow-up period. It is possible that some patients may have gone on to fusion after this follow-up period. Coughlan et al., in a level 1 RCT, also found high levels of fusion with BMP without adverse outcomes.[16] Another recent RCT by Delawi et al. consisting of 119 patients found, in contrast, inferior fusion rates with BMP.[17] The authors discussed that their results may have been related to the fact that there were more smokers in the BMP experimental group. In addition, more patients had fusion procedures at the L5-S1 level in the BMP group, although the effect of this on the final results was believed to be minimal.

While there appears to be the potential for higher fusion rates with BMP use, recent level 3 studies have shown significant complications. Colom-Beauchamp et al. reviewed their experience with BMP and found a significant complication profile that included stroke, dural tear, hardware failure, post-operative paresthesia, paralysis, radiculitis, seroma formation, and surgical wound infection.[18] The main weakness of this study was the lack of a control group. Khan et al. conducted a retrospective cohort study (N = 187) and

Figure 1. Flowchart Highlighting Search Terms, Basic Methodology and Results

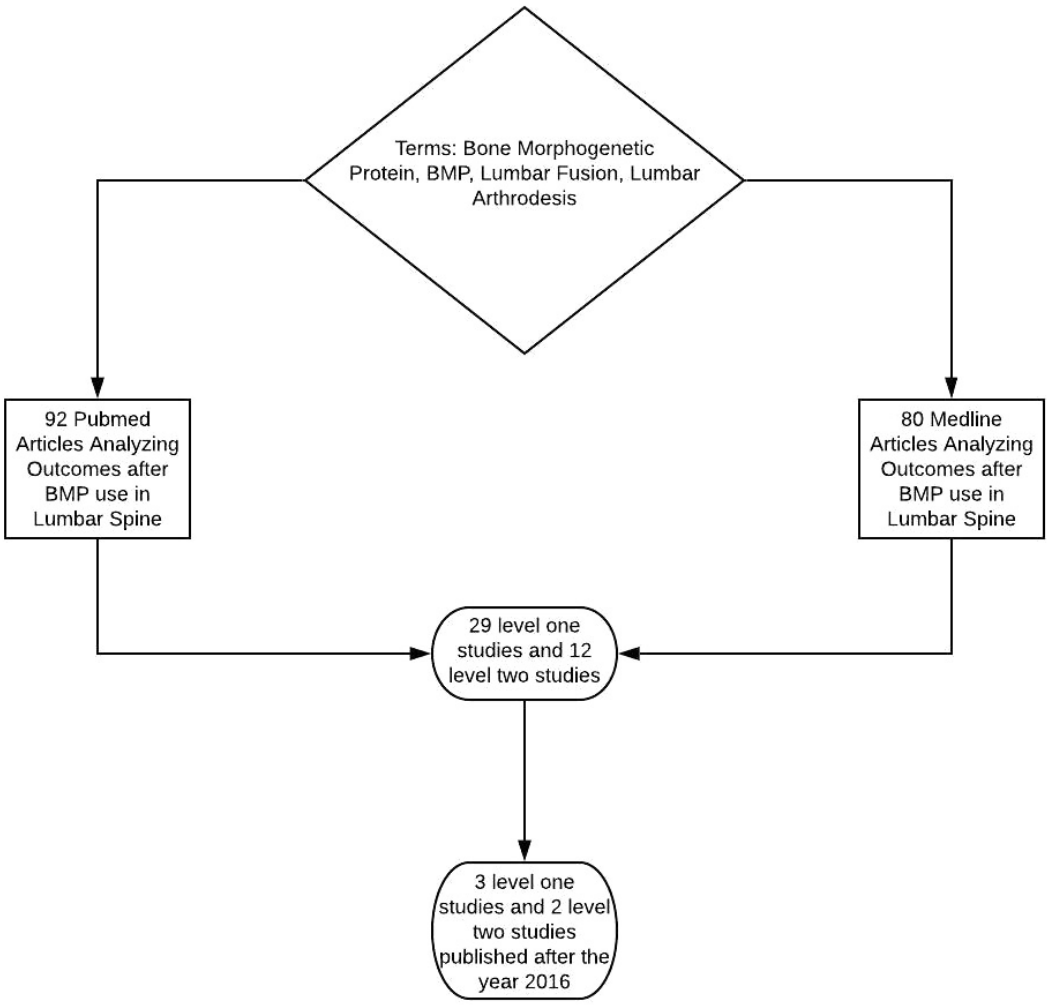

Table 1. List of Level 1 and 2 Studies Published After 2016 in Combined Pubmed and Medline Searches

Year	Title	Authors	Journal	Type
Level 1 Studies				
2016	OP-1 Compared with Iliac Crest Autograft in Instrumented Posterolateral Fusion	Delawi et al.	Journal of Bone and Joint Surgery	Randomized Controlled Trial
2017	Efficacy of Escherichia Coli Derived Recombinant Human Bone Morphogenetic Protein-2 in Posterolateral Lumbar Fusion: An Open, Active-Controlled, Randomized, Multicenter Trial	Cho et al.	The Spine Journal	Randomized Controlled Trial
2018	A Prospective, Randomized, Multicenter Study Comparing Silicated Calcium Phosphate Versus BMP-2 Synthetic Bone Graft in Posterolateral Instrumented Lumbar Fusion for Degenerative Spinal Disorders	Coughlan et al.	The Spine Journal	Randomized Controlled Trial
Level 2 Studies				
2017	Comparison of a Calcium Phosphate Bone Substitute with Recombinant Human Bone Morphogenetic Protein-2: A Prospective Study of Fusion Rates, Clinical Outcomes and Complications with 24-month Follow Up	Parker and Malham	European Spine Journal	Prospective Cohort Study
2019	Prospective Evaluation of Radiculitis Following Bone Morphogenetic Protein-2 Use for Transforaminal Interbody Arthrodesis in Spine Surgery	Sebastian et al.	Asian Spine Journal	Prospective Cohort Study

reported showed seven complications in the BMP group and two in the control group.[19]

In contrast, there are recent level 3 studies that show high fusion rates with BMP and associated improvement in patient symptoms without significant adverse events.[20–23] Furthermore, level 2 studies have also shown a slightly better complication profile. Sebastian et al. showed an increase in bone formation in the BMP group without clinically evident radiculitis.[24] Similarly, Siddiqui et al. showed improved clinical outcomes and fusion with BMP use without adverse events.[25] No recent studies have shown an increase in the rate of malignancy in the BMP group.

Overall, as demonstrated in this literature review, there is a paucity of literature after the year 2016 pertaining to the use of BMP to achieve lumbar arthrodesis. When analyzing level 1 and 2 literature, with the exception of Delawi et al., there does appear to be high levels of fusion with BMP without significant complications. Despite this, questions remain over appropriate dosing and whether the costs associated with BMP use represent value for the health care system. There are no recent level 1 or 2 studies addressing these questions. White et al. in a 2019 retrospective review showed higher rates of foraminal hyperostosis associated with a higher dose of BMP use without significant improvement in fusion rates. Their conclusion was that lower BMP doses may lead to equivalent rates of fusion without the potential for post-operative radiculitis.[26]

It is important to note that all reported fusion rates in this review refer to radiographic fusion rates. The gold standard for assessing fusion is surgical re-exploration. As a result of ethical concerns and potential patient morbidity, no known studies have utilized this standard as a primary end point for assessing fusion. It is possible that BMP use does in fact lead to higher fusion rates compared to iliac crest autograft if this standard is utilized.

Conclusions

Recent studies investigating the use of bone morphogenetic protein to obtain fusion in the lumbar spine are conflicting. Higher level evidence, however, points towards BMP being a viable alternative to autogenous iliac crest bone graft. Despite the increasing use of BMP in spine procedures, further high-quality, prospective research is needed to elucidate the risks and benefits of BMP use to achieve arthrodesis in the lumbar spine.

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Medical Student Research Project

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Do Physical Challenges at Home Lead to Worse Patient Outcomes After Orthopaedic Trauma Surgery?

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Abstract

Patients who live at home prior to orthopaedic trauma surgery will often return home at some point after their procedure, with studies suggesting those discharged directly home reporting better outcomes. However, little is known about physical challenges within the home environment that may influence patient outcomes after discharge. This study aims to evaluate how obstacles in the home may be associated with patient-reported outcomes. Two hundred seventy-three patients who underwent orthopaedic trauma surgery at an urban academic medical center and completed PROMIS surveys at two weeks, six weeks, three months, six months, and one year after surgery were considered eligible for this study. A cross-sectional survey was administered to eligible patients. Statistical analysis was conducted using parametric methods. One hundred twenty completed the cross-sectional survey, with statistically significant differences found in a number of categories, including housing type, bath accessibility, and taking the stairs. Results are summarized in Table 1 and Table 2. The findings of this study suggest there may be an association between certain challenges in the home environment and patient-reported outcomes. Findings were limited by sample size at each time period, and future studies should seek to broaden the sample size and look at more specific challenges.

Introduction

Patients who undergo surgical fixation for a fracture are often discharged from the hospital to either an inpatient rehabilitation facility (IRF) or to their home. Discharge disposition has been shown to impact patient outcomes in orthopaedic trauma patients. Patients discharged to inpatient rehabilitation centers had 56% lower odds of reporting a better functional outcome than those discharged home.[1] Additional studies have shown that patients discharged to a non-home location are significantly more likely to experience both severe and minor adverse events, as well as infectious complications when compared to those discharged home.[2] Fortunately, many patients who were living at home prior to the occurrence of the fracture will return home after surgery. One study found that after repair of a hip fracture, 31.8% of the patients were discharged directly to their own home, 72.9% returned to their home within three months, and 72.8% had returned to their home within 12 months.[3]

In order for patients to make it home, they need to be able to complete activities of daily living (ADLs) and navigate through potential challenges and obstacles in their home safely. It has been documented that an individual's mobility and ability to perform ADLs decreases after fracture occurrence.[4–9] Patients have also experienced decreased quality of life, increased disability,[10] and increased dependency on others to complete ADLs,[11, 12] which may be attributable to pain. Studies have found that 28–93% of patients who experience a traumatic musculoskeletal injury will experience pain[9, 13] which can persist between three to 84 months after injury.[13] Despite these factors being intricately related, very few studies have focused on environmental factors in the home that may influence patient-reported functional outcomes and pain.

This study will investigate the potential association between environmental challenges in the home and patient-reported outcomes. Specifically, this study will evaluate a possible link between the presence of physical challenges, such as stairs in the home, and patient-reported physical function, pain interference, and global health.

Methods

Institutional Review Board (IRB) approval was obtained to conduct a cohort study on patients who underwent orthopaedic trauma surgery and who completed Patient Reported Outcome Measurement Information System (PROMIS) surveys at an urban academic medical center between April 16, 2019 and June 18, 2020. Surveys on these patients' home environment were conducted between July 8, 2020 and July 17, 2020.

Patients were included in the study if they had undergone orthopaedic trauma surgery, had previously completed at least one set of PROMIS surveys in the trauma clinic between two weeks and one year post-operatively, were between the ages of 18 and 89, and were English-speaking. Type, mechanism, and location of injury were not considered inclusion criteria so as to survey a broad range of trauma patients. Patients with severe Alzheimer's, dementia, or other severe mental conditions that prevented them from completing the survey were excluded from the study. Individuals who were not able to consent, including minors and prisoners, were also excluded from this study. In total, 273 patients fulfilled inclusion criteria.

This study was part of a larger study that also looked at the effect of education and transportation on patient-reported outcomes. A cross-sectional survey was created and conducted to collect data on the patient's home environment, education level, and transportation. Specific questions asked in the survey related to the home environment included: whether they live in a house or apartment, the presence of stairs both inside and outside the apartment/home, the number of flights of stairs inside the apartment/home, how frequently the individual found themselves navigating stairs, whether the bathroom is located on the same floor as the bedroom, if they had difficulty accessing the toilet or shower, and if they felt safe navigating their home. The survey also included questions on basic demographic information (employment status and type, income level, zip code, gender, race, and ethnicity). The survey was administered by three student researchers via email or by telephone, using REDCap to ensure all data was collected in a HIPAA-compliant manner. Informed consent was obtained from each patient prior to all data collection, and patient confidentiality was maintained throughout the study.

Patient reported outcome (PRO) data from PROMIS surveys after orthopaedic trauma surgery was retrospectively evaluated. PROMIS was created by the National Institutes of Health (NIH) to provide validated and standardized measures of PROs.[14] Three PROMIS surveys were administered by physician extenders via iPad at the orthopaedic trauma clinic just prior to the patient seeing their orthopaedic surgeon between two weeks to one year post-operatively. The PROMIS-10 SF Global Health survey assessed patients' overall physical and mental health, the PROMIS Bank v1.1 – Pain Interference survey assessed how much pain interferes with patients' daily lives, and the PROMIS Bank v2.0 – Physical Function survey assessed patients' self-reported physical performance capabilities. From these three surveys, four composite outcome scores were generated: Global Physical score (GP), Global Mental score (GM), Pain Interference score (PI), and Physical Function score (PF). For each score, 50 represented the mean score for the United States general population with a standard deviation of 10.[14] The Global Health survey generated the GP and GM scores, where higher scores indicated better physical and mental health. The Pain Interference and Physical Function surveys generated the PI and PF scores, respectively. For the Pain Interference survey, a higher score indicated that pain interfered with their daily life to a greater extent. For the Physical Function survey, a higher score indicated better physical function.[15]

Patients' cross-sectional survey answers were correlated with their PRO scores. Statistical analysis was conducted using parametric methods that compared the mean values for the different groups analyzed. In survey questions in which there were two possible answers, means were compared using a two-sample t-test. Means for three or more groups were compared using ANOVA. P-values of less than 0.05 were considered to be statistically significant.

Results

Of the 273 individuals that met the inclusion criteria, 120 of these individuals completed the cross-sectional survey. Data availability at each of the five reporting times are as follows: two weeks (n = 59), six weeks (n = 47), three months (n = 44), six months (n = 57), one year (n = 19). The mean age of the patients was 47 years old, with a standard deviation of 18 years. Of the 120 individuals who completed the survey, 112 had isolated lower extremity injuries, seven had isolated upper extremity injuries, and one had a bilateral lower extremity polytrauma injury. Additional demographic information on the included subjects is shown in Table 1. Some patients chose not to answer all of the demographic questions, so some categories may not add up to 120.

Table 1. Patient Demographic Data

Criteria	Value
Age Group	
18–39	49 (40.8%)
40–59	36 (30.0%)
60+	35 (29.2%)
Gender	
Male	44 (37.3%)
Female	72 (61.0%)
Prefer not to answer	2 (1.7%)
Race/Ethnicity	
Asian	6 (5.2%)
Black or African American	48 (41.4%)
Hispanic-origin (solely)	27 (23.3%)
White	35 (30.2%)
Work Situation	
Unemployed and seeking work	23 (19.8%)
Unemployed and not seeking work	25 (21.6%)
Employed (full, part, or family care)	30 (25.9%)
Unable to work	38 (32.8%)
Annual Income	
<$10,000	20 (33.9%)
$10,000 to $20,000	12 (20.3%)
$20,000 to $34,999	8 (13.6%)
$35,000 to $74,999	9 (15.3%)
$75,000+	10 (16.9%)
Location of Injury	
Isolated lower extremity	112 (93.3%)
Isolated upper extremity	7 (5.8%)
Polytrauma	1 (0.8%)

Significant differences in mean PROMIS scores that were found among social determinants of health factors are shown in Table 2. Survey questions that asked about an elevator in the apartment building, stairs outside the residence, and number of flights of stairs inside the home were not found to be associated with a significant difference in PROMIS scores, and are not included in Table 2.

Males were found to have better physical function (PF) scores at one year post-surgery when compared to females. Patients over the age of 60 scored better in global physical scores (GP), global mental scores (GM), and pain interference (PI) at six months. Black and Hispanic patients scored worse in PF scores at one year. Patients who were employed full-time, part-time, or who cared for family members scored better, while patients who were unable to work trended worse in PF at six months and in GP, GM, and PF at one year. It was also found that patients with <$10,000 in annual income scored worse in GP and PI at one year.

With respect to the home environment, patients who lived in an apartment had better GP and GM at three months and better PI at six months than patients who lived in a house. Patients who had no trouble accessing the toilet or shower had better PI and PF scores at two weeks, better PF scores at six weeks, better GM scores at three months, and better GP, GM, and PI scores at six months. Patients whose bedrooms were located on a different level than their bathrooms had better PF scores at two weeks. Patients who felt safe moving around their home after their injury had better GP at six months. Patients who had to navigate stairs in their home frequently had worse PI scores at six weeks. In addition, patients who navigated the stairs in their home 11–14 times a day trended worse in PI scores at two weeks and in GM scores at six months.

Discussion

After a patient undergoes orthopaedic trauma surgery, there are a number of potential factors that can affect their outcome. However, there has been a lack of studies evaluating how physical challenges in the home may influence outcomes after orthopaedic trauma surgery. Past studies have elucidated differences in patient outcomes based on discharge destination, with patients who are discharged to non-home locations reporting worse outcomes.[2, 3] Vochteloo et al. found that just over 70% of patients returned home within three months of surgery.[3] Given that the majority of patients who lived at home prior to orthopaedic trauma surgery will return home, further understanding of the home environment and the challenges that may be present in the home is important.

This study sought to build on the understanding that discharge to a home location leads to better outcomes, and to understand how challenges in the home environment may impact health outcomes, as reported by PROMIS scores. Our results suggest that housing type (e.g., apartment vs house), accessibility of the toilet and shower, and the use of stairs after returning home may play some role in patient-reported outcomes. It was found that patients who lived in apartments reported better outcomes around 3–6 months after surgery when compared to patients who lived in houses. The absence of a correlation in outcome scores and elevator access within a residence suggest that the difference in outcomes noted in housing type is likely not due to apartments containing elevators. This difference may be due to a residence in an apartment generally being a single floor, so the absence of stairs within a residence may play a role. Our results suggest that less utilization of stairs is associated with better outcomes, which would be consistent with this idea. However, further studies would be needed to better understand the reason for the differences observed in patients who live in apartments and houses.

Patients reporting no difficulty accessing the toilet or shower trended better in PROMIS scores at a number of time points after surgery. They reported better physical function within the first 2–6 weeks after surgery and less pain interference early in the post-operative period and at about six months out from surgery. These results suggest that there

Table 2. Statistically Significant Differences in PROMIS Scores

Social Determinants of Health	PROMIS Scores																			
	Global Physical					Global Mental					Pain Interference					Physical Function				
	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y
Age				X					X					X						
Gender																				X
Employment					X					X									X	X
Income					X										X					
Race/ethnicity																				X
Housing type			X					X						X						
Bath accessibility				X				X	X		X			X		X	X			
Bed bath level																X				
Feel safe				X																
Stair navigation												X								
Stairs frequency									X		X									

X = significance level, P < 0.05
2 weeks = 2w, 6 weeks = 6w, 3 months = 3m, 6 months = 6m, 1 year = 1y

Confidential

The Impact of Social and Environmental Factors on Patient Reported Outcomes After Orthopaedic Trauma Surgery

Please complete the survey below.

Thank you!

1) First Name

_____
(Please enter your name.)

2) Last Name

_____

3) Date of Birth

_____
(Please enter your date of birth)

4) What is your phone number?

_____

5) Email

_____

Education

6) What is the highest level of education completed?

- ◯ None (no education)
- ◯ Primary school (1st grade to 8th grade)
- ◯ Some high school (didn't graduate)
- ◯ High school diploma (or GED)
- ◯ Some college (no degree)
- ◯ Bachelor's degree
- ◯ Vocational/Technical degree
- ◯ Associate's degree
- ◯ Post-Graduate degree
- ◯ Prefer not to answer

Transportation

7) Do you have access to a vehicle that you can drive?

- ◯ Yes
- ◯ No

8) Could someone else drive you if you needed a ride?

- ◯ Yes
- ◯ No

9) Which of the following is the most common way you get around?

- ◯ Walk
- ◯ Bike
- ◯ SEPTA
- ◯ Personal car
- ◯ Borrow car
- ◯ Ask someone else to drive you
- ◯ Uber/Lyft
- ◯ UberPool/LyftPool
- ◯ Other

Confidential

10) Which of the following is the most common way you get to follow-up appointments after your surgery?
- ◯ Walk
- ◯ Bike
- ◯ SEPTA
- ◯ Personal car
- ◯ Borrow car
- ◯ Ask someone else to drive you
- ◯ Uber/Lyft
- ◯ UberPool/LyftPool
- ◯ specify

11) How long does it take you to get to doctor's appointments after your surgery? (please pick the closest choice)
- ◯ 15 minutes or less
- ◯ 30 minutes
- ◯ 45 minutes
- ◯ 1 hour
- ◯ 1.5 hours
- ◯ 2+ hours

12) Have you experienced any of the following due to not having transportation to a doctor's appointment? (pick as many are applicable)
- ☐ Missed an appointment
- ☐ Rescheduled an appointment
- ☐ Could not schedule the appointment you wanted
- ☐ N/A

Home Environment

13) Do you live in a house or apartment?
- ◯ House
- ◯ Apartment

14) Do you have to walk up stairs to get into your apartment or house? (stairs located outside of your residence)
- ◯ Yes
- ◯ No

15) If you live in an apartment, do you have access to an elevator, or do you need to take stairs? (if you do not live in an apartment or live on the ground floor of your apartment complex, select N/A)
- ◯ I have access to an elevator
- ◯ I have to take stairs
- ◯ N/A

16) How many flights of stairs are in your home, or in your apartment if there is no elevator? (excluding stairs to get into the house or apartment complex)

_____

17) Do you find yourself having to navigate stairs in your home frequently?
- ◯ Yes
- ◯ No

18) How many times a day do you find yourself navigating stairs in your home?

_____

19) Is your bathroom on the same level as your bedroom?
- ◯ Yes
- ◯ No

20) After your injury, did you have any difficulty accessing the toilet or shower? (e.g. is there a ledge that needs to be stepped over to enter the shower)
- ◯ Yes
- ◯ No

21) After your injury, did you feel safe navigating your home?
- ◯ Yes
- ◯ No

(Survey continued on next page)

Confidential

Employment

22) What is your current work situation?

- ◯ Unemployed and seeking work
- ◯ Unemployed and not seeking work
- ◯ Part-time work (less than 32 hours)
- ◯ Full-time work (32-40 hours)
- ◯ Care for family member(s) (i.e. care for children, eldery, or other family member that requires full time care)
- ◯ Unable to work

23) When you work, what type of work do you do?

_____

Income

24) What is your income level?

- ◯ Less than $10,000 per year (less than $833 per month)
- ◯ $10,000 to $20,000
- ◯ $20,000 to $34,999
- ◯ $35,000 to $49,999
- ◯ $50,000 to $74,999
- ◯ $75,000 to $99,999
- ◯ Over $100,000
- ◯ Prefer not to answer

Demographics

25) Zip Code

_____

26) Gender

- ◯ Male
- ◯ Female
- ◯ Non-binary
- ◯ Prefer not to answer

27) Race

- ◯ American Indian or Alaska Native
- ◯ Asian
- ◯ Black or African American
- ◯ Native Hawaiian or Other Pacific Islander
- ◯ White
- ◯ Prefer not to answer

28) Ethnicity

- ◯ Hispanic or Latino or Spanish Origin
- ◯ Not Hispanic or Latino or Spanish Origin
- ◯ Prefer not to answer

29) First Contact

_____

may be a correlation between difficulty getting into the shower/bathtub or accessing the toilet, and overall health, physical function, and pain interference after surgery. The survey question combined difficulty accessing the shower and toilet into one question, so it is not known if one has an association more than the other. In addition, the survey did not prompt the patient to identify what about the shower or toilet made it difficult to access. A number of factors like a ledge on the shower/bathtub or a small bathroom that is not easily maneuverable could lead to difficulty accessing them. It also may be possible that increased pain or decreased physical function as a result of the surgery led to the difficulty using the shower or toilet. Additional questions should be implemented into future studies to further flush out this point.

The major limitation of this study is limited sample size. While 120 individuals ultimately completed the cross-sectional survey, not every patient surveyed had patient reported outcome data at each time point. On average, there were between 40 and 60 patients in each time point, and this further diminishes the sample size within each group. It should also be noted that due to limited sample size, isolated upper extremity, isolated lower extremity, and polytrauma injuries were not analyzed separately from each other. It would be expected that these patients experience different challenges in the home environment after trauma, and future studies should seek to explore this point. There is also the possibility of errors and bias from patient reporting, as PROMIS scores and the cross-sectional survey were all gathered from questions posed directly to patients. Finally, this sample used for this study was based around an urban trauma center, which may be associated with less generalizability for rural settings. More research would need to be conducted to determine if there is consistency among different settings.

As has been noted above, there are some promising insights with regards to the challenges in the home environment and their potential impact on patient-reported health outcomes. This is one of the first studies to look at the effects of challenges within the home environment on outcomes after surgery, and initial findings suggest it may be worth exploring more. Future research should seek to look at specific challenges within the home in more depth, to further understand why the presence of the physical challenge is associated with different outcomes. In addition, future studies should look to evaluate how challenges may affect individuals based on the location of their injury, such as upper versus lower extremity injuries, and their post-operative restrictions, such as weightbearing versus non-weightbearing injuries.

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Medical Student Research Project

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The Impact of Education Level on Patient-Reported Outcomes After Orthopaedic Trauma Surgery

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Abstract

It has been established that education level impacts a variety of health outcomes. However, its association with patient-reported outcomes following orthopaedic trauma surgery remains unclear. The purpose of this study is to determine how education level may influence patient-reported outcomes in orthopaedic trauma patients. Patient-reported outcome PROMIS scores of 120 patients who had undergone orthopaedic trauma surgery were correlated with demographic data obtained via a cross-sectional survey. Data included four PROMIS scores (global mental and physical health, pain interference, and physical function), education level, and demographic information. Statistical analysis using a two-sample t-test found lower education level to be associated with better physical function at two weeks ($p = 0.05$) and six weeks ($p = 0.015$) postoperatively. Remaining associations found are summarized in Tables 2 and 3. It remains unclear why patients with lower education level reported better physical function in the early postoperative period. One may speculate that lower education level impacts health literacy, which in turn affects patient-reported outcomes; however, additional questions should be built into future studies with larger sample sizes to further explore these associations.

Introduction

Social determinants of health (SDOH) such as education level, economic stability, social and community context, health and health care, and the neighborhood and built environment have been recognized as important factors influencing a wide range of health outcomes.[1] Contributing to SDOH is a person's socioeconomic status (SES), a measure based on an individual's education level, income, and occupation.[2] In the field of orthopaedic surgery, one can imagine how these determinants of health impact the development of disease, risk of traumatic injury, access to health care, and patient outcomes following operative or nonoperative interventions, often reported as patient reported outcomes (PROs).[3] Education level is a widely studied SDOH and is often used as a proxy for SES. Thus, its association with interventional outcomes is of interest in all fields of medicine, especially in orthopaedic trauma where there remains a paucity of data regarding its effects on patient reported outcomes.

It has been established that education impacts health through various mechanisms such as increased neurological development, decreased biological aging, health literacy and health behaviors, and by providing patients a sense of control and empowerment.[4] It has also been found that lower educational level is a predictor for worse long-term outcomes following surgery.[5–12] For example, Kugelman et al. found education level to be an independent predictor of long-term functional outcomes following surgical management of (fracture) non-unions[5] and Bhandari et al. found that lower level of education is an independent predictor of physical function outcomes following surgical management of unstable ankle fractures.[12] On the other hand, higher education level was found to be associated with higher health-related quality of life (HRQoL) after total hip arthroplasty (THA), less pain after treatment, and higher satisfaction with THAs.[7] Similarly, Feldman et al. found a positive association between SES, using education level as a marker, and patient reported pain scores and functional outcomes following total knee arthroplasty (TKA).[10] However, such associations are not unanimously agreed upon. In a study on Dutch THA and TKA patients, Keurentjes et al. found there to be no differences in HRQoL improvement following THA between varying education groups with only a small effect noted in TKA patient.[13]

Although more research has recently focused on the association of SDOH on various PROs in orthopaedic surgery,[3] it is yet to be clearly defined how factors such as education level influence self-reported outcomes in orthopaedic trauma patients. Further, it is difficult to generalize results from non-orthopaedic trauma studies to a population of orthopaedic trauma surgery patients. The aim of this study is to correlate

patient-reported outcomes with educational level in urban orthopaedic trauma surgical patients.

Materials and Methods

This study was conducted as part of a larger study looking at how education level, access to transportation, and the home environment may impact patient reported outcomes. Approval was obtained from our Institutional Review Board to conduct a study on patients who underwent orthopaedic fracture repair surgery and who completed Patient Reported Outcome Measurement Information System (PROMIS) surveys at an urban academic level 1 trauma center clinic between April 16, 2019 and June 18, 2020. Surveys on these patients' education level, access to transportation, and home environment were conducted by telephone between July 8, 2020 and July 17, 2020.

Patients were included in the study if they had undergone orthopaedic fracture repair surgery, had previously completed at least one set of PROMIS surveys in the trauma clinic between two weeks and one year post-operatively, were between the ages of 18 and 89, and were English-speaking. Type, mechanism, and location of injury were not considered inclusion criteria so as to survey a broad range of trauma patients. Individuals who were not able to consent or complete the survey, including infants, children, teenagers, prisoners, and those with severe mental conditions, were excluded from this study. In total, 273 patients fulfilled inclusion criteria.

A cross-sectional survey was created and conducted to collect data on patients' education level, access to transportation, and home environment. Regarding education level, patients were placed in a lower education group, as defined by achieving a high school education or less, or a higher education group, defined by achieving any form of education past high school, such as college, vocational school, or graduate school. The survey consisted of questions on the above topics, as well as basic demographic information (employment status and type, income level, zip code, gender, race, and ethnicity). Informed consent was obtained from each patient prior to all data collection, and patient confidentiality was maintained throughout the study.

PRO data from the PROMIS surveys after orthopaedic trauma surgery was retrospectively evaluated. PROMIS was created by the National Institutes of Health (NIH) to provide validated and standardized measures of PROs.[14] Three PROMIS surveys were administered by physician extenders via iPad at the orthopaedic trauma clinic just prior to the patient seeing their orthopaedic surgeon between two weeks to one year post-operatively. The PROMIS-10 SF Global Health survey assessed patients' overall physical and mental health and generated two composite scores, the Global Physical score (GP) and Global Mental score (GM). The PROMIS Bank v1.1 – Pain Interference survey assessed how much pain interferes with patients' daily lives and generated the Pain Interference score (PI). The PROMIS Bank v2.0 – Physical Function survey assessed patients' self-reported physical performance capabilities and generated the Physical Function score (PF).[15] For each score, 50 represented the mean score for the United States general population with a standard deviation of 10.[14] For GP, GM, and PF, higher scores indicated better physical and mental health and function. For PI, a higher score indicated that pain interfered with their daily life to a greater extent.[15]

Patients' cross-sectional survey answers were correlated with their PRO scores. Statistical analysis was conducted using parametric methods that compared the mean values for the different groups analyzed. In survey questions in which there were two possible answers, means were compared using a two-sample t-test. Means for three or more groups were compared using ANOVA. P-values of less than 0.05 were considered statistically significant.

Results

One hundred twenty patients completed the cross-sectional survey and were included in final analysis. However, data availability for the various PROMIS scores varied depending on specific outcome reporting. Data availability at each of the five reporting times are as follows: two weeks (n = 59), six weeks (n = 47), three months (n = 44), six months (n = 57), one year (n = 19). Of the 120 respondents, 70 (58.3%) attained a high school education or less (lower education group) and 50 (41.7%) attained some form of a post-high school education (higher education group). The mean age of the patients was 47 ± 18 years. Remaining patient demographics are displayed in Table 1.

Statistically significant differences in PROMIS scores based on SDOH are displayed in Table 2. Outcome data and

Table 1. Patient Demographics

Criteria	Value
Age Group	
18–39	49 (40.8%)
40–59	36 (30.0%)
60+	35 (29.2%)
Gender	
Female	44 (37.9%)
Male	72 (62.1%)
Race/Ethnicity	
Asian	6 (5.2%)
Black or African American	48 (41.4%)
Hispanic-origin (solely)	27 (23.3%)
White	35 (30.2%)
Work	
Unemployed and seeking work	23 (19.8%)
Unemployed and not seeking work	25 (21.6%)
Employed (full, part, or family care)	30 (25.9%)
Unable to work	38 (32.8%)
Annual Income	
<$10,000	20 (33.9%)
$10,000 to $19,999	12 (20.3%)
$20,000 to $34,999	8 (13.6%)
$35,000 to $74,999	9 (15.3%)
$75,000+	10 (16.9%)

Some patients chose not to answer some survey questions — not all categories will add up to 120.

Appendix
Survey Questionnaire

Age:
1. How old are you?

Sex:
1. Male
2. Female
3. Prefer not to answer

Race:
1. American Indian or Alaska Native
2. Asian
3. Black or African American
4. Native Hawaiian or other Pacific Islander
5. White
6. Prefer not to answer

Ethnicity:
1. Hispanic or Latino or Spanish origin
2. Not Hispanic or Latino or Spanish origin
3. Prefer not to answer

Employment:
1. What is your current work situation?
   a. Unemployed and seeking work
   b. Unemployed and not seeking work
   c. Part-time work (less than 32 hours)
   d. Full-time work (32-40 hours)
   e. Care for family member(s) (i.e. care for children, elderly, or other family member that requires full time care)
   f. Unable to work
2. When you work, what type of work do you do?
   a. _____
   b. Prefer not to answer

Income Level:
1. What is your income level?
   a. Less than $10,000 per year (less than $833 per month)
   b. $10,000 to $20,000
   c. $20,000 to $34,999
   d. $35,000 to $49,999
   e. $50,000 to $74,999
   f. $75,000 to $99,999
   g. Over $100,000
   h. Prefer not to answer

Education:
1. What is the highest level of education completed?
1. None (no education)
2. Primary school (1st grade to 8th grade)
3. Some high school (didn't graduate)
4. High school diploma (or GED)
5. Some college (no degree)
6. Bachelor's degree
7. Vocational/Technical degree
8. Associate's degree
9. Post-graduate degree

Transportation:
1. Do you have a driver's license?
   1. Yes
   2. No
2. Do you have access to a vehicle that you can drive?
   1. Yes
   2. No
3. Which of the following is the most common way you got to doctor's appointments BEFORE your injury? (if more than 1, please rank your top 2)
   1. Walk
   2. Septa
   3. Personal car
   4. Borrow car
   5. Ask someone else to drive you
   6. Bike
   7. Uber/Lyft
   8. UberPool/LyftPool
   9. Other, specify
4. Which of the following is the most common way you get to your follow-up appointments AFTER your injury? (if more than 1, please rank your top 2)
   1. Walk
   2. Septa
   3. Personal car
   4. Borrow car
   5. Ask someone else to drive you
   6. Bike
   7. Uber/Lyft
   8. UberPool/LyftPool
   9. Other, specify
5. How long did it take you to get to doctor's appointments BEFORE your surgery? (please pick the closest choice)
   1. Under 15 minutes
   2. 30 minutes
   3. 45 minutes
   4. 1 hour
   5. 1.5 hours
   6. 2+ hours
6. How long did it take you to get to doctor's appointments AFTER your surgery? (please pick the closest choice)
   1. Under 15 minutes
   2. 30 minutes
   3. 45 minutes
   4. 1 hour
   5. 1.5 hours
   6. 2+ hours
7. Did you feel like it was harder to get to your follow-up appointments AFTER surgery?
   1. Yes
   2. No
8. Have you experienced any of the following due to not having transportation to a doctor's appointment? (pick as many are applicable)
   1. Missed an appointment
   2. Rescheduled an appointment
   3. Could not schedule the appointment you wanted

Home Environment:
1. Do you live in a house or apartment?
   a. House
   b. Apartment
2. Do you have to walk up stairs to get into your house/apartment from street level? i.e., 3 steps up from the street to get into your house (stairs outside the home/apartment building)
   a. Yes or no
3. If you live in an apartment building does it have an elevator or do you have to walk up to your level?
   a. Yes or no
      i. If yes, how many flights of stairs?
4. How many flights of stairs are in your home? (not including those outside the home)
5. Did you find yourself needing to navigate stairs at home frequently?
   a. Yes or no
      i. If yes, about how many times a day?
6. Is your bathroom on the same level as your bedroom?
7. After your injury did you have trouble accessing the toilet or shower? i.e. is there a ledge that needs to be stepped over to enter it?
8. After your injury did you feel safe moving around your home?

Table 2. Statistically Significant Differences in PROMIS Scores Based on Social Determinants of Health

	PROMIS Scores																			
	Global Physical					Global Mental					Pain Interference					Physical Function				
	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y
Age				X					X					X						
Gender																				X
Employment					X					X									X	X
Income					X										X					
Race/ethnicity																				X
Education																X	X			

X = significance level, P < 0.05; 2 weeks = 2w, 6 weeks = 6w, 3 months = 3m, 6 months = 6m, 1 year = 1y.

p-values of statistically significant variables are listed in Table 3. With regards to basic demographics, of the bivariate survey questions, males had better physical function (PF) at one-year post-surgery than females (p = 0.033). Of the multivariate survey questions, patients ≥60 years old trended better in global physical scores (GP) (p = <0.001), global mental scores (GM) (p = 0.044), and pain interference (PI) (p = 0.007) at six months. Black and Hispanic patients trended worse in PF at one year (p = 0.009). Patients who were employed full-time, part-time, or who cared for family members trended better while patients who were unable to work trended worse in PF at six months (p = <0.001) and in GP (p = 0.015), GM (p = 0.014), and PF (p = 0.004) at one year. Patients with <$10,000 in annual income trended worse in GP (p = 0.015) and PI (p = 0.037) at one year.

With regards to education, no statistically significant differences were found between the lower education and higher education groups for GP, GM, and PI. In comparing the mean GM scores, the higher education groups yielded higher scores at three months, six months, and one year; however, these were not statistically significant. In comparing the mean PI scores, the lower education groups yielded higher scores at two weeks, six weeks, three months, and one year; however, these were not statistically significant. With regards to PF, the lower education group reported better physical function at two weeks (p = 0.05) and six weeks (p = 0.015) postoperatively as compared to the higher education group. This trend continued at the three-month and six-month time points; however, these differences were not statistically significant.

Discussion

Health disparities stemming from SDOH are an inherent aspect of medicine. Although advancements in surgical techniques, implant technology, and sub-specialty surgical training continue to evolve, surgeons must remember that sociodemographic factors such as race/ethnicity, an individual's SES, and SDOH such as education level also play a significant role in determining patient outcomes.

Consistent with prior studies on minority outcomes following orthopaedic surgery, this study found that Black and Hispanic patients reported worse long-term physical function outcomes as compared to Caucasian adults.[16–18] Furthermore, patients with lower SES, such as those earning less than $10,000, trended worse in long-term global physical function and pain interference and those who were unable to work trended worse in global physical function, global mental health, and physical function. Such findings are consistent with the current literature, indicating that SES is a major risk factor for poor long-term health outcomes and further reinforcing the fact that surgeons should be mindful of these patient-related factors when devising a treatment plan.[5]

This study also found that the lower education group reported better physical function in the early postoperative period (two weeks and six weeks) while there were no significant differences found in pain interference, global physical, or global mental health scores. Based on prior studies that have been conducted, it was expected that patients with lower education levels would report worse outcome scores.[5–12] For example, Greene et al. found that patients with higher education statuses had better health-related quality of life and less pain one year after total hip arthroplasty.[7] They concluded that patients with medium to lower education statuses needed to be supported and educated more to achieve better outcomes. Kugelman et al. had similar findings, with patients who had lower education levels having worse outcomes at three months, six months, and long-term follow-ups when compared to patients with higher education levels.[5]

In this study, it is not known why patients with lower education levels reported improved physical function at two weeks and six weeks. It is possible that this significance is due to small sample size or due the nature of PROs; however, this association has not been identified in past studies. Another possible explanation may be related to health literacy. The physical function score is based on the Physical Function PROMIS survey that is administered to patients. Patients with lower education levels have been associated with decreased health literacy, which could lead to decreased understanding of activity and weight-bearing restrictions.[19–20] It is possible that these individuals were more physically active in the first six weeks compared to individuals with higher education and health literacy who were following restrictions that were put in place. This in turn would lead to patients with lower educational levels reporting they

Table 3. Outcome Data and p-Values of Statistically Significant Variables

Classification Variable	N	Mean	StdDev	p-Value
GP, 6 Months, Age				<.001
18–39	22	39.3	8.8	
40–59	21	39.8	5.5	
≥60	14	48.6	7.5	
GM, 6 Months, Age				0.044
18–39	22	43.2	11.5	
40–59	21	43.3	7.6	
≥60	14	51.2	10.6	
PI, 6 Months, Age				0.007
18–39	22	63.1	6.8	
40–59	21	62.3	5.2	
≥60	14	55.3	10.4	
PF, 1 Year, Gender				0.033
Female	8	33.5	3.7	
Male	9	43.2	11.1	
GP, 1 Year, Employment				0.005
Unemployed and seeking work	3	44.0	1.5	
Unemployed and not seeking work	6	42.1	10.4	
Employed (full, part, or family care)	3	52.2	6.6	
Unable to work	7	31.7	5.1	
GM, 1 Year, Employment				0.014
Unemployed and seeking work	3	49.2	5.9	
Unemployed and not seeking work	6	43.9	5.8	
Employed (full, part, or family care)	3	62.0	5.8	
Unable to work	7	39.7	11.7	
PF, 6 Months, Employment				<.001
Unemployed and seeking work	11	36.0	6.1	
Unemployed and not seeking work	11	38.5	9.6	
Employed (full, part, or family care)	14	46.8	6.4	
Unable to work	19	33.3	6.4	
PF, 1 Year, Employment				0.004
Unemployed and seeking work	3	34.4	3.0	
Unemployed and not seeking work	6	41.2	8.4	
Employed (full, part, or family care)	3	52.0	8.4	
Unable to work	6	32.0	4.0	
GP, 1 Year, Income				0.015
<$10,000	4	32.2	4.4	
$10,000 to $20,000	2	54.3	4.9	
$20,000 to $34,999	1	44.9	—	
$35,000 to $74,999	1	54.1	—	
≥$75,000	1	57.7	—	
PI, 1 Year, Income				0.037
<$10,000	4	67.4	4.3	
$10,000 to $20,000	2	56.1	0.1	
$20,000 to $34,999	1	55.5	—	
$35,000 to $74,999	1	58.3	—	
≥$75,000	1	47.2	—	
PF, 1 Year, Race/Ethnicity				0.009
Asian	2	49.0	14.6	
Black or African American	7	33.0	5.2	
Hispanic-origin (solely)	6	36.8	3.4	
White	3	49.5	10.6	
PF, 2 Weeks, Education (Binary)				0.050
High School or Less	41	32.6	9.3	
Some College (or VoTech) or Higher	16	27.4	7.6	
PF, 6 Weeks, Education (Binary)				0.015
High School or Less	25	37.9	8.2	
Some College (or VoTech) or Higher	22	31.2	9.9	

are doing more physically and thus reporting better PF scores. However, because this study did not stratify patients based on type of injury, types of activity, or weight-bearing restrictions, it cannot be determined whether health literacy is associated with the better PF scores reported by the lower education group. Additional questions should be built into future studies to further elucidate this point.

In comparing the mean scores for global mental health and pain interference, two trends were noted. The higher education group reported a higher mean score for global mental health and a lower mean score for pain interference, indicating that the higher education group reported better mental health and less pain interference in their daily lives compared to the lower education group. However, no definitive association can be made due to lack of statistically significant results.

The major limitation of this study is sample size. While 120 individuals completed the cross-sectional survey, not every patient surveyed had PROMIS data at each time point. On average, there were only 45 patients in each time point, which further shrinks the sample size within each group. This limitation may have the effect of either leading to statistical significance among groups that would otherwise not have any difference or leading to a lack of significance when it would otherwise be found to be statistically significant. There is also the possibility of errors and bias from patient reporting. PROMIS scores and the cross-sectional survey were all gathered from questions posed directly to patients, which poses some risk for bias.

Nevertheless, there are some promising insights with regards to education level and its association with patient-reported outcomes following orthopaedic trauma surgery. This is something that should be further investigated so that definitive associations can be made.

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Medical Student Research Project

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The Effects of Access to Transportation on Patient Outcomes After Orthopaedic Trauma Surgery

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Abstract

Lack of transportation is a commonly cited barrier to health care access in the United States. However, the impact of transportation access on patient outcomes after orthopaedic trauma surgery is not known. The purpose of this study is to determine how transportation patterns of patients who underwent orthopaedic trauma surgery at an urban academic medical center affect those patients' reported outcomes. Patients who had undergone orthopaedic trauma surgery and who completed at least one set of Patient Reported Outcome Measurement Information System (PROMIS) surveys between two weeks and one year post-operatively were given a cross-sectional survey about their transportation access. Patients' cross-sectional survey answers were correlated with their PROMIS outcome scores. Demographics and differences in PROMIS scores based on transportation access are summarized in Tables 1 and 2 respectively. Analysis using t-tests and ANOVA found statistically significant differences in PROMIS scores among several transportation variables at various timepoints. Travel modalities before and after surgery, missing and rescheduling appointments, and distance to the hospital were all found to affect patient outcomes in some way, in line with existing literature. The major limitation of the study is sample size, but the initial trends warrant further investigation.

Introduction

Lack of transportation is a commonly cited barrier to health care access in the United States. Several studies have demonstrated that a lack of transportation access can lead to delayed or missed appointments and medication use, leading to a lack of appropriate treatment.[1] Transportation barriers to health care access are also associated with worse population health[2] and higher health care use and costs.[3] Other studies have shown that not having access to a vehicle is associated with lower health care utilization, missed appointments, and delayed or irregular care especially in people of lower socioeconomic status (SES) and minorities, who face greater transportation barriers in general.[1] This is of particular relevance in Philadelphia, where 31% of households have no vehicle available, 25% are below the poverty line, and 66% are minorities, with these percentages concentrated even higher in North Philadelphia.[4, 5]

However, while studies on transportation barriers to health care access have focused on delayed or missed appointments, medication use, population health, and health care use and costs, there is a lack of research on the effects of transportation access on patient outcomes, particularly after orthopaedic trauma surgery in urban areas. Studies have demonstrated how to measure transportation barriers in urban areas,[6] and the effects of these barriers on doctors' appointments and prescription fill rates in urban areas,[1] but not on patient outcomes. Other studies have explored the effects of transportation barriers on some patient outcomes such as poor glycemic control,[1] or lower mental and general health in older adults,[7] but not on orthopaedic outcomes. Some orthopaedic and orthopaedic trauma surgery-specific studies have shown that transportation barriers are associated with less compliance with follow-up and less health care utilization,[8–10] but did not study patient outcomes. There is a dearth of research on the effects of a lack of transportation access on patient outcomes after orthopaedic trauma surgery.

This study investigates how the transportation patterns of patients who underwent orthopaedic trauma surgery at an urban academic medical center affect those patients' reported outcomes. We hypothesized that a lack of transportation access leads to worse patient outcomes. By showing how transportation barriers affect patient outcomes after orthopaedic trauma surgery, it allows future studies to explore how addressing those transportation barriers may improve orthopaedic trauma surgery outcomes.

Methods

This study was conducted as part of a larger study investigating how education level, access to transportation, and the home environment impact patient outcomes after orthopaedic trauma surgery.

Approval was obtained from our University's Institutional Review Board (IRB) to conduct a retrospective cohort study on patients who underwent orthopaedic trauma surgery and who completed Patient Reported Outcome Measurement Information System (PROMIS) surveys at an urban academic medical center clinic in North Philadelphia between April 16, 2019 and June 18, 2020. Surveys on these patients' access to transportation were conducted between July 8, 2020 and July 17, 2020.

Patients were included in the study if they had undergone orthopaedic trauma surgery, had previously completed at least one set of PROMIS surveys in the trauma clinic between two weeks and one year post-operatively, were between the ages of 18 and 89, and were English-speaking. Type, mechanism, and location of injury were not considered inclusion criteria. Patients with severe Alzheimer's, dementia, or other severe mental conditions that prevented them from completing the survey were excluded from the study. Individuals who were not able to consent, including infants, children, teenagers, and prisoners, were also excluded from this study. Two hundred seventy-three patients fulfilled inclusion criteria.

A cross-sectional survey was created and conducted to collect data on patients' access to and modes of transportation. The survey was administered by three student researchers via email or by telephone, using REDCap to ensure all data was collected in a HIPAA-compliant manner. Informed consent was obtained from each patient prior to all data collection, and patient confidentiality was maintained throughout the study. The survey consisted of questions on if the patient had access to a vehicle they could drive, if someone else could drive them if they needed a ride, their most common mode of travel (walk, bike, public transit, personal car, borrowed car, ask someone else to drive them, Uber/Lyft, UberPool/LyftPool, or other), their most common mode of travel to follow-up appointments after their surgery, their travel time to follow-up appointments after their surgery, and if they had missed or rescheduled an appointment due to lack of transportation, as well as questions on education, home environment, and some demographic information (employment status and type, income level, zip code, gender, race, and ethnicity).

Patient reported outcome (PRO) data from PROMIS surveys after orthopaedic trauma surgery was retrospectively evaluated. PROMIS was created by the National Institutes of Health (NIH) to provide validated and standardized measures of PROs.[11] Three PROMIS surveys were administered by physician extenders via iPad at the orthopaedic trauma clinic just prior to the patient seeing their orthopaedic surgeon between two weeks to one year post-operatively. The PROMIS-10 SF Global Health survey assessed patients' overall physical and mental health, the PROMIS Bank v1.1 – Pain Interference survey assessed how much pain interferes with patients' daily lives, and the PROMIS Bank v2.0 – Physical Function survey assessed patients' self-reported physical performance capabilities.[12] From these three surveys, four composite outcome scores were generated (global physical score (GP), global mental score (GM), pain interference score (PI), and physical function score (PF)), where for each score, 50 represented the mean score for the United States general population with a standard deviation of 10.[11] The Global Health survey generated the GP and GM scores, where higher scores indicated better physical and mental health. The Pain Interference and Physical Function surveys generated the PI and PF scores, respectively. For the Pain Interference survey, a higher score indicated that pain interfered with their daily life to a greater extent. For the Physical Function survey, a higher score indicated better physical function.[12]

Patients' cross-sectional survey answers were correlated with their PRO scores. Statistical analysis was conducted using parametric methods that compared the mean values for the different groups analyzed. In survey questions in which there were two possible answers, means were compared using a two-sample t-test. Means for three or more groups were compared using ANOVA. P-values of less than 0.05 were considered to be statistically significant.

Results

One hundred twenty patients completed the cross-sectional survey and were included in final analysis. However, data availability for the various PROMIS scores varied depending on specific outcome reporting time (i.e., two weeks, six weeks, three months, six months, and one year). Data availability at each of the five reporting times are as follows: two weeks (n = 59), six weeks (n = 47), three months (n = 44), six months (n = 57), one year (n = 19). The mean (SD) age of the patients was 47 (18) years old. Other basic demographics are displayed in Table 1.

Statistically significant differences in PROMIS scores were found based on demographics and access to transportation as described in Table 2. Travel time to the hospital and access to a vehicle the patient can drive were not found to lead to a significant difference in PROMIS scores.

With regards to basic demographics, of the bivariate survey questions, males had better physical function (PF) at one year post-surgery than females. Of the multivariate survey questions, patients ≥60 years old trended better in global physical scores (GP), global mental scores (GM), and pain interference (PI) at six months. Black and Hispanic patients trended worse in PF at one year. Patients who were employed full-time, part-time, or who cared for family members trended better while patients who were unable to work trended worse in PF at six months and in GP, GM, and PF at one year. Patients with <$10,000 in annual income trended worse in GP and PI at one year.

With regards to transportation, of the bivariate survey questions, patients who missed an appointment due to lack of transportation had worse PF at three months, patients who

Table 1. Patient Demographics

Criteria	Value
Age Group	
18–39	49 (40.8%)
40–59	36 (30.0%)
60+	35 (29.2%)
Gender	
Female	44 (37.9%)
Male	72 (62.1%)
Race/Ethnicity	
Asian	6 (5.2%)
Black or African American	48 (41.4%)
Hispanic-origin (solely)	27 (23.3%)
White	35 (30.2%)
Work	
Unemployed and seeking work	23 (19.8%)
Unemployed and not seeking work	25 (21.6%)
Employed (full, part, or family care)	30 (25.9%)
Unable to work	38 (32.8%)
Annual Income	
<$10,000	20 (33.9%)
$10,000 to $19,999	12 (20.3%)
$20,000 to $34,999	8 (13.6%)
$35,000 to $74,999	9 (15.3%)
$75,000+	10 (16.9%)

Some patients chose not to answer some survey questions — not all categories will add up to 120.

rescheduled an appointment due to lack of transportation had worse GM at three months, and patients who had no appointment issues and made all their appointments had better GP at three months and better GM at six months.

Of the multivariate survey questions, with regards to the most common mode of travel patients used to get around, patients who used a personal or borrowed car trended better in GP and GM at three months, while patients who had someone else drive them trended worse in PF at six months. With regards to the most common mode of travel patients used to get to follow-up appointments after their surgery, patients who had someone else drive them and those who took Uber/Lyft trended worse in PI at two weeks, and patients who had someone else drive them trended worse in PF at one year. Patients who lived >1 to five miles from the hospital trended worse in PI at two weeks and in GP at three months, while those who lived >3 to five miles from the hospital trended worse in GM at two weeks.

Discussion

This study investigates how the transportation patterns of patients who underwent orthopaedic trauma surgery at an urban academic medical center affect those patients' reported outcomes.

In terms of the basic patient demographics, the results are largely consistent with existing literature in that lower-income and minority patients tend to have worse outcomes.[13–14] The only outcomes based on demographics that differ from previous studies[7, 15] are that older patients (≥60 years old) tended to have better reported outcomes than younger patients in this study. This may be explained by the type of injuries the different age groups were facing, as younger patients in the urban environment this study was conducted in may face more severe traumatic injuries than older patients.

The results on transportation access indicate that missing or rescheduling appointments due to a lack of transportation may lead to worse outcomes compared to patients who had no appointment issues due to transportation. These results are in line with earlier studies both in terms of missed appointments leading to worse outcomes[16] as well as a lack of transportation leading to missed appointments.[8–10]

The results also suggest that patients who normally drive themselves using a personal or borrowed car before surgery tend to fare better, while patients who normally have someone else drive them tend to fare worse. The literature is lacking on the effects of transportation barriers and modalities on post-operative outcomes, but it may be that patients who normally drive themselves are more physically independent at baseline, which could contribute to their better outcomes. The results are not consistent over an extended period of time, and a larger sample size would be useful in identifying clearer trends or a lack thereof.

Table 2. Statistically Significant Differences in PROMIS Scores Based on Demographics and Access to Transportation

Demographics and Access to Transportation	PROMIS Scores																			
	Global Physical					Global Mental					Pain Interference					Physical Function				
	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y	2w	6w	3m	6m	1y
Age				X					X					X						
Gender																				X
Employment					X					X									X	X
Income					X										X					
Race/ethnicity																				X
Travel mode			X					X											X	
Travel mode after surgery											X									X
Ride access								X												
Missed appointment			X															X		
Rescheduled appointment									X											
No appointment issues			X						X											
Distance to hospital			X			X					X									

X = significance level, P < 0.05; 2 weeks = 2w, 6 weeks = 6w, 3 months = 3m, 6 months = 6m, 1 year = 1y.

In addition, the results indicate that individuals who rely on others to drive them or who take Uber/Lyft to follow-up appointments after surgery tend to have worse pain and physical function. It is important to note that directionality cannot be determined here regarding if those transportation modalities are causing them to have worse pain and function or if their pain and function are causing them to utilize those alternative transportation modalities. Additional questions can be built into future studies to elucidate this.

Distance also seems to affect outcomes as patients who live within a mile from the hospital and patients who live >5 miles from the hospital tend to fare better than those in the 1–5 mile range. It may be that living within a mile produces minimal strain on patients getting to follow-up appointments and having access to care. Patients who live >5 miles from this urban medical center likely live in the suburbs, which means they may be more likely to travel by car and are potentially more affluent as well compared to patients living in the low socioeconomic status, urban environment surrounding the hospital. Patients who live in the city but more than one mile away may face additional challenges of the urban environment and may be more likely to travel by public transport or rideshares and thus face a greater physical and financial barrier. The literature has varied results on the topic of distance as Syed et al. found mixed evidence regarding distance and transportation barriers,[1] while Whiting et al. found that living greater than 100 miles from a clinic can lead to non-compliance in post-operative follow-up appointments[8] but had no data on outcomes.

The major limitation of this study is sample size. While 120 individuals ultimately completed the cross-sectional survey, not every patient surveyed has reported outcome data at each time point and there is an average of only 45 patients per time point. This limitation may have the effect of leading to statistical significance among groups that would otherwise not have any difference, or leading to a lack of significance when it would otherwise be found to be statistically significant. There is also the possibility of errors and bias from patient reporting. PROMIS surveys and the cross-sectional survey are all gathered from questions posed directly to patients, which poses some risk of reporting bias. PROMIS scores were also not obtained at discharge, so data on patient outcomes before they first left the hospital is unavailable. The sample used for this study is based around an urban academic trauma center, which may be associated with less generalizability for rural or suburban settings. Finally, this study does not differentiate among patients based on the type of orthopaedic trauma surgery they had. Further studies will need to be conducted using a larger sample size, with patients from different geographical settings, and differentiating patients based on the type of surgery, for example between lower and upper extremity surgeries.

This is one of the first studies to look at the potential impact of transportation access on patient outcomes after orthopaedic trauma surgery, and initial insights indicate it is worth further investigation.

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Medical Student Research Project

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Comparison of Short-Term Clinical Outcomes of the Synthes Femoral Recon Nail (FRN) vs. the Synthes Retrograde/Antegrade Femoral EX Nail (RAFN) for Intramedullary Nailing in Femoral Shaft Fractures

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Abstract

This study compared the short-term clinical outcomes of femoral shaft fracture fixation with either the Depuy Synthes Retrograde/Antegrade Femoral EX Nail (RAFN) or the Depuy Synthes Femoral Recon Nail (FRN). Retrospective analysis of a 30-patient cohort with femoral shaft fracture and antegrade IM nail placement between the dates of January 1, 2017 and April 30, 2019 at a Level 1 trauma center. Short-term clinical outcomes were compared by collecting data including patient characteristics, nature of the fracture, mechanism of injury, blood loss, time until weight bearing, reported pain, rates of infection, reoperation, malalignment, malrotation, delayed union, and any other postoperative complications. Patients treated with the FRN system demonstrated a significant reduction in pain reported at three months post-operation ($p < 0.008$) and reduced overall complications ($p < 0.02$). Treatment with this nailing system was also associated with higher average blood loss ($p < 0.04$) compared to the RAFN system. The newer FRN system seems to yield similar clinical outcomes as its predecessor. Future iterations of this investigation will include both prospective and retrospective data with a larger sample size.

Introduction

Femoral shaft fractures are a common result of major trauma and typically require surgical management with intramedullary nailing.[1] Motor vehicle crashes and accidental falls account for the majority of these injuries in individuals averaging ages of 31 and 70,[2] respectively.

Intramedullary nailing (IMN) has remained the treatment of choice for femoral shaft fractures for several decades with little controversy. Where controversy lies is with the appropriate starting point, surgical approaches, implant design, and reaming. For shaft fractures, entry through either the greater trochanter or the piriformis fossa each provide unique advantages and disadvantages. Entry through the piriformis fossa, for example, provides a collinear trajectory with the long axis of the femur, reducing the risk of varus malalignment and iatrogenic comminution.[3] This is particularly advantageous in certain subtrochanteric fracture patterns. However, there is still damage to the surrounding soft tissues, along with potentially increased risks of femoral neck fracture, avascular necrosis, and septic arthritis.[4] Entry through the trochanteric portal allows for ease of access, reducing operative time and intraoperative fluoroscopy, particularly in obese patients.[5, 6] This technique also encompasses more cancellous bone, reducing hoop stress, and involves minor damage to surrounding soft tissues.[4]

There is currently a lack of consensus regarding which entry portal provides superior clinical outcomes. Subtrochanteric fractures often require very proximal fixation, such as fixation into the femoral head, or from the greater into the lesser trochanter. These injuries are also prone to malreduction, particularly in varus. "Reconstruction nails" typically feature fixation into the femoral head, and modern designs also include other proximal locking options, as well as options for greater trochanteric entry versus piriformis entry designs.

Anterior cortical perforation of the distal femur has been mostly attributed to older nail designs with a larger radius of curvature. More modern designs have worked to reduce the radius of curvature in order to better reproduce normal anatomy and avoid anterior cortical perforation.

With newer implant designs now available for femoral shaft fracture fixation, it is hoped that issues such as malreduction, anterior cortical perforation, other surgical complications, and ultimately patient outcomes can be improved. However, this cannot be assumed and therefore is one of the objectives of this investigation. Whereas some studies report increased rates of nonunion after treatment with reconstruction (recon) nails,[7] other more recent studies indicate adequate clinical outcomes, and even recommend it in case of missed or future femoral neck fractures.[8] Within the use intramedullary nailing with recon nails, there seems to be no reported significant difference between piriformis and tro-

chanteric entry.[9] This data, however, is limited to a single study, and requires further investigation.

The aim of this report is to compare the newer Depuy Synthes Femoral Recon Nail (FRN) with an older nail design, the Depuy Synthes Retrograde/Antegrade Femoral EX Nail (RAFN), with a retrospective analysis of complications, rates of reoperation, patient-reported outcomes, and related secondary measures.

Methods and Materials

Study Design

The data in this report was obtained via IRB-approved retrospective chart review of patients treated between January 1, 2017 and April 30, 2019. During this time frame, intramedullary nailing (IMN) was performed on roughly 385 patients with femoral shaft fractures at a single level 1 trauma center in a metropolitan area. Three hundred fifty-five of these patients were excluded based on the following criteria: intertrochanteric fractures (n = 64), femoral neck fractures (n = 5), retrograde nailing approach (n = 97), other IM nailing equipment (n = 73), prior ipsilateral femur fracture/deformity (n = 11), <3 months of documented follow-up visits (n = 84), age less than 18 or greater than 89 (n = 19), and prisoners (n = 2). A total of 30 patients were identified for study inclusion. Eighteen patients underwent fixation with the RAFN system, and 12 with the FRN system. The choice of trochanteric versus piriformis entry was made at the discretion of the attending surgeon. Charts and radiographs were analyzed retrospectively for patient characteristics, fracture characteristics, and clinical outcomes.

Patient Characteristics

From the selected cohort, the following characteristics were extracted: age, gender, ethnicity, smoking history, mechanism of injury, presence of additional injuries, and comorbidities. Eligible patients were those of ages 18 to 89; pregnant women and prisoners were excluded. Gender was classified as male or female, ethnicity as African American, Hispanic or Non-Hispanic, smoking status as current, never, or quit, and mechanism of injury as low impact (i.e., mechanical fall from standing height) or high impact (i.e., MVC, struck by train, or fall from above standing height). Comorbidities that could impact healing include hypertension (HTN), hyperlipidemia (HLD), diabetes, kidney disease/injury, osteoarthritis, autoimmune disorders, vitamin D deficiency, hypocalcemia, and drug/substance abuse.

Fracture Characteristics

Preoperative radiographs were analyzed for fracture categorization according to the Revised AO/OTA classification system (January 2018).[10] Of the 30 diaphyseal femoral fractures, the majority were classified as 32B3 (Table 1). Use of preliminary external fixation was recorded for its potential role as an extraneous variable. Delayed union and non-union of fractures were determined by the lack of interval callus formation after three and six months, respectively. Fractures were considered healed when patients could bear weight without thigh pain and radiographs showed bridging callus.[11] Presence of malalignment and malrotation was extracted from follow-up data recorded by the attending physician.

Table 1. AO/OTA Femoral Fracture Classifications

Fracture Classification	N
32A1	1
32A2	1
32B3	21
32C2	1
32C3	6

Clinical Outcomes

Clinical outcomes included duration of surgery, estimated blood loss during surgery, postoperative time until able to bear weight, and pain, as well as rates of infection, delayed union, malalignment, malrotation, broken screw(s), reoperation, and any other complications. Pain was recorded as present or absent via chart review for the respective dates at six weeks and three months follow-up.

Data Interpretation

Standard descriptive statistics were used on continuous variables to report mean, median, and standard deviation, and on categorical variables for appropriate classification. Body mass index (BMI), and duration of surgery (minutes) were compared using the Wilcoxon-Mann-Whitney test. Age, blood loss (mL), and post-operative days until weight-bearing as tolerated were compared using the two-sample t-test. Pain at six weeks and three months follow-up, infection, delayed union, malalignment/malrotation, broken screw(s), and reoperation were compared using Fisher's extract test. Sex, smoking status, mechanism of injury, laterality, associated injuries, comorbidities, preliminary external fixation, and entry portal were compared using either Fisher's extract or Chi Square tests. All statistical analyses were conducted using SAS® 9.4 (SAS Institute, cary, NC). Statistical significance was defined as $p < 0.05$. All reported p-values are two-sided where applicable and have not been adjusted for multiple comparisons.

Results

From the included cohort, 26 were male and four were female. The mean age was 34 (range 18 to 88 years). Fifty percent of the cohort was African American, 33% Hispanic, and 17% Non-Hispanic. Roughly half of the patients were classified as current smokers, the other half as either quit smoking or never smoked cigarettes. Nearly all fractures, except for one, were the result of high-energy trauma. The fractures were roughly evenly split in terms of laterality; 16 left-sided and 14 right-sided. Four out of the 30 patients

underwent preliminary external fixation as a means of stabilizing the limb, prior to definitive treatment with intramedullary fixation of their femoral shaft fracture.

Eighteen patients were treated with the RAFN system and 12 with the FRN system. All 18 RAFN implants were inserted via the piriformis fossa; six FRN implants were inserted via the piriformis fossa and six via the greater trochanter. There were no reported operative complications. The RAFN and FRN systems did not differ significantly regarding duration of surgery, amount of postoperative days until able to bear weight as tolerated, pain at six weeks, infection, delayed union, malalignment/malrotation, broken screw(s), or rates of reoperation. There was, however, a statistically significant difference in blood loss during surgery, pain reported at three months, and other complications.

Median blood loss with the RAFN system was 200 mL; with the FRN system median blood loss was 375 mL ($p < 0.04$). Regarding pain, significantly more patients reported pain at three months after having been treated with the RAFN ($p < 0.008$). Rates of other complications were also significantly different between the two groups: seven patients treated with the RAFN system suffered complications, whereas no complications were reported with the FRN system ($p < 0.02$).

Discussion

Intramedullary nailing has been the treatment of choice for femoral fractures for several decades. Over time, improvements have been made in both techniques and equipment used. As of recently, an updated version of a preexisting orthopaedic nail was released by DePuy Synthes, prompting our investigation of its clinical outcomes. Upon retrospective review of a 30-patient cohort at a level 1 trauma center, our results indicate that the new DePuy Synthes Femoral Recon Nail (FRN) shows potential improvement in operative and post-operative outcomes compared to its predecessor, the DePuy Synthes Retrograde/Antegrade Femoral EX Nail (RAFN).

The analysis demonstrates two significant improvements with the use of the FRN system over the RAFN system: decreased pain reported at three months and reduced overall complications. Of the patients who received the FRN, 33.3% reported pain at their three-month follow-up, compared to 83.3% in those who received the RAFN (Table 2). The category 'other complications' was a broad umbrella to cover any complications noted throughout the recovery process that didn't fall under infection, reoperation, malalignment, malrotation, delayed union, or malunion. None of the patients who received the FRN system fell under this category; seven out of the 18 patients who received the RAFN, however, met the criteria for 'other complications.' It is possible that the improvement in outcomes associated with the FRN system are related to the enhanced anatomical fit provided by the smaller radius of curvature (ROC) of 100 cm. Previous investigations have shown improvements in anatomical fit and reduced anterior cortical encroachment with a smaller ROC;[12, 13] others have suggested this as a possible mechanism behind reduction in postoperative pain.[14]

Estimated blood loss was also significantly different between the two groups. Treatment with the FRN was associated with an average blood loss of 130 mL greater than with the RAFN (Table 3). It is likely that the discrepancy in blood loss can be attributed to the fracture pattern being treated. The FRN system, for example, is primarily used for subtrochanteric fractures, which frequently require an open

Table 2. Categorical Postoperative Clinical Outcomes After Treatment of Femoral Fractures with Either the DePuy Synthes Femoral Recon Nail (FRN) or Retrograde/Antegrade Femoral EX Nail (RAFN)

Attribute	Yes	No	P
Pain (6w FU)			0.135
Synthes EX (RAFN)	18 (100%)	0 (0.0%)	
Synthes Recon (FRN)	9 (81.8%)	2 (18.2%)	
Pain (3m FU)			0.008
Synthes EX (RAFN)	15 (83.3%)	3 (16.7%)	
Synthes Recon (FRN)	4 (33.3%)	8 (66.7%)	
Infection			1
Synthes EX (RAFN)	1 (5.6%)	17 (94.4%)	
Synthes Recon (FRN)	0 (0.0%)	12 (100%)	
Delayed union (3m)			0.678
Synthes EX (RAFN)	4 (22.2%)	14 (77.8%)	
Synthes Recon (FRN)	4 (33.3%)	8 (66.7%)	
Malalignment/malrotation			0.48
Synthes EX (RAFN)	0 (0.0%)	18 (100%)	
Synthes Recon (FRN)	1 (8.3%)	11 (91.7%)	
Broken screw			0.503
Synthes EX (RAFN)	2 (11.1%)	16 (88.9%)	
Synthes Recon (FRN)	0 (0.0%)	12 (100%)	
Other complications			0.0242
Synthes EX (RAFN)	7 (38.9%)	11 (61.1%)	
Synthes Recon (FRN)	0 (0.0%)	12 (100%)	
Reoperation			0.5034
Synthes EX (RAFN)	2 (11.1%)	16 (88.9%)	
Synthes Recon (FRN)	0 (0.0%)	12 (100%)	

All values listed were compared using Fisher's extract test.
*FU = follow-up.

Table 3. Continuous Intraoperative and Postoperative Clinical Outcomes After Treatment of Femoral Fractures with Either the DePuy Synthes Femoral Recon Nail (FRN) or Retrograde/Antegrade Femoral EX Nail (RAFN)

Attribute	N	Mean	STDEV	P
Duration of surgery (minutes)				0.14
Synthes EX (RAFN)	8	136	50	
Synthes Recon (FRN)	12	169	46	
Blood loss (mL)				0.04
Synthes EX (RAFN)	16	264	202	
Synthes Recon (FRN)	12	392	158	
PO days for WBAT				0.47
Synthes EX (RAFN)	18	33	41.5	
Synthes Recon (FRN)	12	29	22.1	

Outcomes for 'Duration of surgery' were compared using the Wilcoxon-Mann-Whitney test; 'Blood loss' and 'PO Days for WBAT' were compared using a two-sample t-test.
*WBAT = Weight-bearing as tolerated.

reduction (and therefore entail additional blood loss) far more frequently than midshaft fractures.

This study is not free of limitations. The lack of eligible patients reflects the strict criteria for inclusion, and the recent introduction of the product into procedures at this trauma center. Therefore, the accuracy of certain variables including intraoperative blood loss and pain reported at follow-up must be questioned.

Blood loss can vary immensely based on a long list of things including the type of injury, open vs. closed fractures, whether there were multiple traumas, the complexity of the surgery, and how much time the patient spent in the OR. The amount of blood loss during surgery varies between patients and institutions for a given surgical procedure,[15–17] which limits standardization of reported blood loss. After a procedure, the amount of blood within the suction machine can be recorded accurately, while other blood soaked up in sponges, cloths, or on the table/floor is simply a rough estimate and is subject to high variability between different surgeons. As such, blood loss recorded in an operative report can be variable and inaccurate.

Pain is also a complicated quantitative measurement due to its inherent subjectivity. The charts reviewed for this study did not include any standardized number or value for reported patient pain that was used to directly compare outcomes. The categorization of yes/no for pain was based on the physician's inclusion of the patient's presence/absence of pain in follow-up notes as well as any indication of pain medication refills associated with the clinic visit. The study did not, however, include data on medication type, dose, or frequency. We are planning future studies which will include standardized patient reported outcome scores of pain and function in order to address this deficiency in the current study.

Further research is needed to more accurately determine the short-term clinical outcomes of using the new Depuy Synthes Femoral Recon Nail for fixation of femoral fractures. From what has been gathered, it can be concluded that it is comparable to other products on the market that have been used for years. In this study, there were limited statistically significant differences which indicates that the Recon Nail is performing similarly to the older product.

Conclusion

The DePuy Synthes Femoral Recon Nail (FRN) performs similarly to its predecessor, the Retrograde/Antegrade Femoral Nail (RAFN), in terms of short-term clinical outcomes. However, with such a small sample size, it cannot be concluded that the Recon Nail is the superior product until more data is collected.

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Medical Student Research Project

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Discharge Location and 90-day Outcomes of Smokers vs. Non-smokers Following Total Joint Arthroplasty (TJA)

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Abstract

The primary objective of this paper is to determine if patients who undergo a Total Hip Arthroplasty (THA) or Total Knee Arthroplasty (TKA) and consume nicotine products are more likely to be discharged home rather than to a skilled nursing facility (SNF) as compared to those who do not smoke. Secondarily, we compare the 90-day outcomes of smokers and non-smokers following TJA. This study is a retrospective chart review including all patients who underwent a TKA or THA between January 1, 2015 and December 31, 2019 at Temple University Hospital. Three hundred and seventeen patients met the final inclusion criteria. Statistical significance for an association between 'ever smoker' (current or previous) and 90-day revision rate was determined at $p < 0.05$ using a Chi Square or Fisher Exact Testing. Current smoking status was not statistically significant ($p = 0.182$) regarding a difference in discharge location (SNF vs. home). Therefore, patients classified as being 'ever smokers' are associated with having higher rates of revision surgeries in the 90 days following surgery. Although there is no statistically significant association between smoking status and discharge location following TJA, a larger sample size may show a correlation.

Introduction

The prevalence of smoking has declined over the past several years; however, 13.7% of American adults aged 18 or older currently smoke.[1] Cigarette smoking is the leading cause of preventable disease and death among Americans, accounting for over 480,000 deaths every year, which is one in five of total reported deaths in the US.[1] Cigarettes contain over 600 ingredients including nicotine which is highly addictive.[2] Therefore, it is imperative that we understand effects of nicotine use on surgical outcomes — specifically total hip and knee arthroplasty (THA and TKA). The use of TKA and THA as a cost-effective treatment for symptomatic arthritis has been on the rise over the past few decades, with 650,674 and 374,873 respective procedures performed in 2018.[3] These numbers are expected to continue to rise with anticipated aging trends in the American patient population.[4, 5]

The detrimental effects of nicotine on orthopedic surgical outcomes have been extensively studied and are well documented. Smoking is associated with an increased risk of numerous medical complications including lower respiratory tract infections, myocardial infarction, periprosthetic joint infections, deep infection and higher mortality following THA or TKA.[4, 6, 7] Additionally, nicotine use prior to TKA is associated with decreased arthroplasty survivorship requiring patients who smoke to undergo far more surgical revisions compared with those who do not smoke.[8] Smoking has also been found to be associated with increased use of opioids following total joint arthroplasty.[4] And finally, smoking is associated with less improvement in disability, following single level lumbar microdiscectomy, after one-year post-op.[4]

Despite comprehensive research on the adverse effects of nicotine use on surgical outcomes following TKA and THA, there is no large breadth of knowledge on its effects on discharge location. It has been previously noted that race, age, insurance and comorbidity are the most telling predictors of non-home discharge location following TKA.[9] Similarly, patient demographics such as younger age and lower BMI were predictive of a shorter length of stay in the hospital following THA.[10] Smoking has been shown to be a risk factor for discharge location other than home.[11] Interestingly, studies have shown that there is a correlation between median length of stay in the hospital and smoking status. However, there was no data collected to determine where patients went after the hospital, a data gap which warrants further investigation.[12]

The purpose of this study was to determine if patients who undergo a THA or TKA and smoke are more likely to be discharged to home rather than to a skilled nursing facility as compared to those who do not smoke. Secondarily, we will compare the 90-day outcomes of smokers and non-smokers following TJA. We hypothesize that those who smoke will, regardless of recommended clinical advice or prescription, more likely elect to be discharged to home rather than to a skilled nursing facility so that they can sooner resume their smoking habit. Conversely, we hypothesize that there will be

no difference in the 90-day outcomes between smokers and non-smokers following TJA.

Materials and Methods

Approval was obtained from Temple University's Institutional Review Board to perform a retrospective chart review on all patients who underwent a primary TKA or THA between January 1, 2015 and December 31, 2019. The chart review was conducted using CPT codes searched using an electronic medical record (Epic Systems), as well as a cross-reference with the orthopaedic department's electronic record keeping system. The CPT codes used were 27130 and 27447 for THA and TKA, respectively. History of smoking at or around the time of surgery was the focus of this study. Smoking status was obtained upon questioning the patient during preoperative evaluation and, when available, smoking status was confirmed using urine cotinine levels obtained prior to surgery. Cotinine is a metabolite of nicotine and is indicative of recent exposure to tobacco smoke. A non-smoker cotinine level was considered to be less than 2 μg/mL.[13] The inclusion criteria included all patients between 18 and 89 who had undergone a TKA or THA at Temple University Hospital between January 1, 2015 and December 31, 2019. Patients were excluded if they a revision TKA or THA, had a prior history of septic arthritis or if they had less than 90 days of follow-up. Patients who were pregnant or incarcerated were also excluded. Additionally, charts were excluded if they lacked an operative note or data for the variables being assessed.

An extensive literature review was completed prior to data collection, in which the current understanding of nicotine consumption as it relates to TJA outcomes was examined. Particular attention was given to trends and expectations in discharge location for the various patient populations undergoing joint replacement procedures. Next, the medical records were reviewed for the following pertinent information: gender, age at the time of surgery, smoking status at time of surgery, previous smoking status, years of nicotine usage in packs per day, cotinine level, discharge location, post-operative complications, comorbidities, and whether or not they underwent revision surgery within 90 days or one year following the initial procedure. Additional information collected included BMI, length of stay in the hospital, post-operative day of first ambulation, and whether they received preoperative smoking cessation counseling. Manual chart review and data collection were completed by study authors GL and EJ. Compiled data was then submitted for statistical analysis.

Results

Demographic Information

Three hundred and seventeen patients met the final inclusion criteria. The average age was 64.3 years old (range: 36–89) and average BMI was 31.6 kg/m^2. Females made up 62.1% (n = 197) of the total patients included in the study. The average length of stay in the hospital after surgery was 2.5 days. The most common procedure was TKA at 61.2% (n = 194) followed by THA at 38.8% (n = 123). One hundred percent of patients had a patient history taken in the month leading up to surgery by the nurse practitioner as part of the standard preoperative assessment and an interval patient history taken the day of their procedure by their surgeon. Standard postoperative DVT prophylaxis was administered to all patients for which there was no contraindication.

Numerous medical comorbidities were identified in the patient population of this study, the most common and pertinent to operative risk having been previously listed (see Demographic Data below). 33.8% (n = 107) of patients had Diabetes Mellitus and another 42.3% (n = 134) had anemia as defined by a pre-operative hemoglobin (Hgb) level less than or equal to 14.0 g/dL for males and 12.3 g/dL for females. These studies were routinely obtained prior to surgery for all patients and available for review. 73.5% (n = 233) of patients had clinically diagnosed hypertension and 35.3% (n = 112) had hyperlipidemia. Lastly, 9.5% (n = 30) had a history of coronary artery disease and 3.2% (n = 10) were classified as having a history of congestive heart failure (see Table 1).

24.8% (n = 77) of patients were documented as having ambulated on day 0 following surgery, 69.5% (n = 216) ambulated on day 1, and 5.8% (n = 18) ambulated on what was defined as day 2 or longer.

The patients included in this study also experienced a number of postoperative complications. 2.2% (n = 7) of patients suffered a pulmonary embolism or deep vein thrombosis after surgery. Additionally, 1.9% (n = 6) experienced an infection. 4.4% (n = 14) of patients needed a revision operation within 90 days and 7.2% (n = 20) underwent a

Demographic Data

Total Knee	194 (61.2%)
Total Hip	123 (38.8%)
Female Gender	197 (62.1%)
Male Gender	120 (37.9%)
BMI >30	184 (58.0%)
Age at Surgery >65	156 (49.2%)
Smoker at Time of Surgery	51 (16.1%)
Current or Previous Smoker	188 (59.3%)
Received Preop Smoking Cessation Counseling	45 (83.3%)
Preop Smoking Cessation Reduction	9 (16.4%)
Diabetes	107 (33.8%)
Anemia	134 (42.3%)
HTN	233 (73.5%)
HLD	112 (35.3%)
CAD	30 (9.5%)
CHF	10 (3.2%)
DVT/PE	7 (2.2%)
Postoperative Infection	6 (1.9%)
90-Day Reoperation	14 (4.4%)
1-Year Reoperation	20 (7.2%)
Post-Op Day of First Ambulation (Grouped)	
Day 0	77 (24.8%)
Day 1	216 (69.5%)
Day 2 or Longer	18 (5.8%)
Total	311 (100%)

second procedure within 365 days following surgery (see Table 2 below).

16.1% (n = 51) of patients were identified as smokers at the time of surgery while 59.3% (n = 188) of patients were categorized as current or previous smokers. Of the patients who were current smokers, 83.3% (n = 45) received preoperative smoking cessation counseling. The average nicotine usage in packs per day was 0.73 with a mean cotinine level of 50.9 μg/mL and an average years of usage of 24.1.

Statistical significance for an association between smoking status and 90-day revision rate was achieved at $p < 0.05$ using a Chi Square or Fisher Exact Testing (see Statistical Analysis). This statistical significance held true ($p < 0.05$) when controlling for type of total joint arthroplasty, gender, obesity, age at surgery, diabetes, anemia, HTN, HLD, CAD, CHF, DVT/PE, infection, and post-operative day of first ambulation on univariate and bivariate analysis.

Additionally, there was a statistically significant association ($p < 0.05$) between 90-day revision surgeries and DVT/PE, infection, and discharge location, respectively. More patients who underwent revision surgeries were discharged to an SNF compared to those who did not undergo a revision surgery.

Previous or current smoking status was not statistically significant ($p = 0.342$) regarding a difference in discharge location (SNF vs. home). However, it was found that there is a statistically significant ($p < 0.05$) association between gender and discharge location, with a higher percentage of females being discharged to a SNF. Age at surgery greater than or equal to 65 ($p < 0.05$) was statistically significant for a discharge location other than home when compared to the cohort of patients younger than age 65. Additionally, patient comorbidities: diabetes, anemia, and CAD were statistically significant ($p < 0.05$) for discharge to an SNF when compared to their non-affected counterparts. Patient postoperative complications including infection and 90-day reoperation were statistically significant ($p < 0.05$) for discharge to an SNF when compared to those who did not experience infections or need to have a revision surgery. Lastly, there was a statistically significant association ($p < 0.05$) between patients who took longer to ambulate after surgery (day 2 or longer) and discharge to an SNF when compared to those who ambulated earlier (day 0 or day 1).

A higher percentage of those "never smokers" ambulated on day 0 in contrast to those who were classified as 'current smokers' or 'ever smokers' (current or previous); however, this comparison did not reach statistically significance ($p = 0.278$).

Table 1. Table Summarizing the Comorbidities Experienced by the Patient Cohort

Comorbidity	Percentage of Patients
HTN	73.50%
Anemia	42.30%
DM	33.80%
HLD	35.30%
CAD	9.50%
CHF	3.20%

Table 2. Table Summarizing the Postoperative Complications Experienced by the Patient Cohort

Post Operative Complication	Percentage of Patients
1-Year Revision	7.20%
90-Day Revision	4.40%
Infection	1.90%
DVT/PE	2.20%

Discussion

The main purpose of this study was to determine if smokers were more likely to be discharged home rather than to SNF following a TJA, with the rationale being that a patient who was recommended for SNF may be more prone to decline in order to return home to resume their smoking habit. Our results do not support the hypothesis that smokers are more likely to go home following surgery. However, the p-value was 0.182 with more non-smokers discharged to SNF when compared to smokers. Although this finding did not reach statistical significance, there is potential for future investigation here with a larger sample size and by expanding the patient population outside of a single academic medical center.

Secondarily, this study aimed to compare the 90-day outcomes of smokers and non-smokers following a TJA. The results suggest that current or previous smokers experienced higher rates of revisions in the 90 days following surgery. This is consistent with previous research that suggests patients who smoke experience an increased number of postoperative complications after surgery. Specifically, a study done by Martharu et al. in 2019 showed that smoking is associated with increased analgesic use, medical complications and increased mortality following TJA.[4] This can partially be attributed to the fact that smoking interferes with the healing process by reducing the availability of oxygen in the blood.[13]

Additionally, it was found that infection and 90-day reoperation are associated with a discharge location other than home. These results are in line with a previous study that found that patient adverse events are associated with discharge to SNF or an Inpatient Rehab Facility (IRF) instead of home.[11] Interestingly, there was a statistically significant association between females being discharged to SNF rather than home when compared to males. This is consistent with prior findings which showed that gender was among one of the most influential determining factors in a patient being discharged to a location other than home.[14] The reasoning behind this trend may be a product of clinician bias or multifaceted socioeconomic factors and is an area of potential future research.

As discussed, there was a statistically significant difference in the discharge locations of patients who first ambulated on or after post-operative day two and those who did so

Statistical Analysis

Ever Smoker (i.e., Current or Previous)	**Reoperation**	**No Reoperation**	**Total**	**P-Value**
Yes	13 (6.9%)	175 (93.1%)	188 (100.0%)	0.009
No	1 (0.8%)	128 (99.2%)	129 (100.0%)	
Total	14 (4.4%)	303 (95.6%)	317 (100.0%)	
Ever Smoker (i.e., Current or Previous)	**SNF**	**Home**	**Total**	**P-Value**
Yes	71 (37.8%)	117 (62.2%)	188 (100.0%)	0.342
No	42 (32.6%)	87 (67.4%)	129 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Gender	**SNF**	**Home**	**Total**	**P-Value**
F	84 (42.6%)	113 (57.4%)	197 (100.0%)	<0.001
M	29 (24.2%)	91 (75.8%)	120 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Age at Surgery	**SNF**	**Home**	**Total**	**P-Value**
Age at Surgery >65	79 (50.6%)	77 (49.4%)	156 (100.0%)	<0.001
Age at Surgery <65	34 (21.1%)	127 (78.9%)	161 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Diabetes	**SNF**	**Home**	**Total**	**P-Value**
Yes	49 (45.8%)	58 (54.2%)	107 (100.0%)	0.007
No	64 (30.5%)	146 (69.5%)	210 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Anemia	**SNF**	**Home**	**Total**	**P-Value**
Yes	61 (45.5%)	73 (54.5%)	134 (100.0%)	0.002
No	52 (28.4%)	131 (71.6%)	183 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
CAD	**SNF**	**Home**	**Total**	**P-Value**
Yes	16 (53.3%)	14 (46.7%)	30 (100.0%)	0.034
No	97 (33.8%)	190 (66.2%)	287 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Infection	**SNF**	**Home**	**Total**	**P-Value**
Yes	5 (83.3%)	1 (16.7%)	6 (100.0%)	0.023
No	108 (34.7%)	203 (65.3%)	311 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Post-op Day of First Ambulation (Grouped)	**SNF**	**Home**	**Total**	**P-Value**
Day 0	19 (24.7%)	58 (75.3%)	77 (100.0%)	0.011
Day 1	77 (35.6%)	139 (64.4%)	216 (100.0%)	
Day 2 or Longer	11 (61.1%)	7 (38.9%)	18 (100.0%)	
Total	107 (34.4%)	204 (65.6%)	311 (100.0%)	
Ever Smoker (Current or Previous)	**Day 0**	**Day 1 or Longer**	**Total**	**P-Value**
Yes	42 (22.6%)	144 (77.4%)	186 (100%)	0.278
No	35 (28.0%)	90 (72.0%)	125 (100%)	
Total	77 (24.8%)	234 (75.2%)	311 (100%)	
Smoker at Time of Surgery	**SNF**	**Home**	**Total**	**P-Value**
Yes	14 (27.5%)	37 (72.5%)	51 (100.0%)	
No	99 (37.2%)	167 (62.8%)	266 (100.0%)	0.182
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
DVT/PE	**Reoperation**	**No Reoperation**	**Total**	**P-Value**
Yes	3 (42.9%)	4 (57.1%)	7 (100.0%)	0.002
No	11 (3.5%)	299 (96.5%)	310 (100.0%)	
Total	14 (4.4%)	303 (95.6%)	317 (100.0%)	
90 Day Reoperation	**SNF**	**Home**	**Total**	**P-Value**
Yes	9 (64.3%)	5 (35.7%)	14 (100.0%)	0.041
No	104 (34.3%)	199 (65.7%)	303 (100.0%)	
Total	113 (35.6%)	204 (64.4%)	317 (100.0%)	
Infection	**Reoperation**	**No Reoperation**	**Total**	**P-Value**
Yes	4 (66.7%)	2 (33.3%)	6 (100.0%)	
No	10 (3.2%)	301 (96.8%)	311 (100.0%)	<0.001
Total	14 (4.4%)	303 (95.6%)	317 (100.0%)	
Discharge Location	**Reoperation**	**No Reoperation**	**Total**	**P-Value**
SNF	9 (8.0%)	104 (92.0%)	113 (100.0%)	0.041
Home	5 (2.5%)	199 (97.5%)	204 (100.0%)	
Total	14 (4.4%)	303 (95.6%)	317 (100.0%)	

sooner, with the latter group more likely to be discharged to home. However, a statistically significant difference was not found in day of first post-operative ambulation and smoking status, which may suggest that smoking is not a strong motivating factor for early mobility in the post-operative period.

It is important to acknowledge the limitations of this study. Confinement of the population under examination to a single hospital system during a defined time period could impact the generalizability of this study. Additionally, urine cotinine levels were not available for all patients included in this study. As smoking status was determined through subjective assessment, the additional verification from a laboratory value would strengthen the validity of the results. And lastly, as for all retrospective studies, a limitation exists in the veracity of the data, as charting errors, mistakes in categorization, or stringent exclusion criteria all serve to weaken the findings compared with a higher evidence level study.

There is potential for future research regarding how long before surgery patients must quit smoking in order for it to make a positive difference in their postoperative outcomes. It would also be helpful to explore the different routes of preoperative smoking cessation counseling methods that surgeons are using to advise their patients to quit before surgery. Determining the method of preoperative smoking cessation counseling that is the most efficacious would increase overall patient safety and experiences following orthopaedic surgery.

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Medical Student Research Project

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Are Obese Patients with a BMI Greater than 30 at Higher Risk for Open Tibial Shaft Fractures than Patients with Average BMI?

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Abstract

Introduction: Obesity has been seen as protective against osteoporotic fractures, like hip and pelvic fractures. Recent studies suggest that it may be site specific. This relationship has not been evaluated regarding tibial fractures. The purpose of this study is to determine if obese patients are at higher risk for open tibial shaft fractures compared to non-obese patients.

Methods: A retrospective chart review of patients treated for a tibial shaft fracture sustained via a high-energy mechanism at a level-one tertiary care center was conducted. Patients were divided into obese and non-obese groups. General and surgical demographic information was collected. T-tests and Wilcoxon tests were conducted.

Results: There was no statistical significance in open tibial fracture rates between obese and non-obese groups ($p = .9304$) or the rate of post-surgical complications. Fifty percent of obese patients and 25% of non-obese patients suffered a tibial shaft fracture via fall ($p = .022$).

Conclusion: There was no difference in rate of open tibial shaft fractures between obese and non-obese groups; however, obese patients were more likely to sustain an open tibial fracture via a fall. Further studies should be conducted on the rates between open tibial shaft fractures in obese and non-obese cohort sustained via a fall.

Introduction

Tibia fractures are the most common long bone fracture, with 25% characterized as an open tibia fracture.[1, 13] An open fracture is an injury where the fractured bone violates the soft tissue and skin and makes contact with the external environment.[18] Open tibial shaft fractures usually occur from high-energy trauma such as road accidents, falls from heights, sports, and blunt force trauma. Due to minimal soft tissue covering around the anteromedial portions of the tibia and poor vascularization, tibial shaft fractures are associated with severe bone and soft tissue damage as well as complications, like infection and non-union.[1, 13] These fractures are classified with the Gustilo-Anderson classification system, the AO/OTA system, or the Tscherne classification system which indicates the severity of the fracture and soft tissue injury.[1] Gustilo-Anderson system describes fractures based on the severity of soft tissue injury and the size of the skin wound. The least severe fracture is a type I and the most severe is type IIIC that always has vascular injury requiring repair associated with it.[1] The AO/OTA classification system is based on which long bone was fractured and the description of the fracture.[20] The Tscherne classification system has two main subgroups, open and closed fractures that are further subdivided.[19]

Obesity is a growing global health crisis, affecting millions of people each year. In the year 2017–2018, 42.4% of Americans were obese and 9.2% were severely obese.[3] A BMI of 30 or greater is classified as obese, while a BMI between 25 and 30 is overweight.[16] As obesity rates continue to climb in the United States, it is vital to continue to counsel patients appropriately about their health.

Obesity has been seen as protective against osteoporotic fractures, like the hip and pelvis, due to the increased bone mineral density, BMD, and the increase in adipose tissue acting as a cushion.[8, 11, 12] However, recent studies have shown that the protective measure may be site-specific due to the increased risk of humerus, distal radius, and ankle fractures seen in obese patients.[4, 17] Some studies have indicated that BMD is not proportional to the weight gained and may not be as protective in some fractures, such as the tibia.[6] Other factors besides BMD may influence the likelihood of fractures, like increased fall risk, impaired muscle function, and fall force.[6] Obese patients have increased length of stay in the hospital, increased ICU admittance and longer stays, higher rates of complications, difficulty with stabilization, risk of implant removal, and non-union when compared to non-obese patients with the same fracture.[5, 9, 10] Obese

patients also have more severe tibial and femoral fractures, characterized as type III B or C based on the Gustilo-Anderson system, when compared to non-obese patients when the mechanism of injury is controlled.[9] However, what is unclear is whether obese patients are at a higher risk for open tibial shaft fractures.

The purpose of this study is to determine if obese patients with a BMI of 30 or above are at higher risk for open tibial shaft fracture in comparison to patients with an average BMI, between 18.5–24.9.

Material and Methods

Approval was obtained from the University's Institutional Review Board to perform a retrospective chart review of patients treated for a tibial shaft fracture, sustained via a high-energy mechanism, between January 1st, 2015, to December 31st, 2019, at Temple University Hospital, a level one tertiary care center. The chart review was conducted using electronic medical records.

The inclusion criteria included patients between the age of 18–65 who presented to Temple University Hospital with a tibial shaft fracture sustained by a high-energy mechanism, like falls, motor vehicle/motorcycle crashes or assault, that had a BMI greater than 30 or a BMI between 18.5 and 24.9. The exclusion criteria were patients younger than 18 years of age or older than 65, patients with connective tissue disorders such as Ehlers Danlos or Marfan's Syndrome, patients who sustained the injuries from low-energy mechanisms or gunshot wounds, and patients who had a BMI less than 18.5 or a BMI between 25 and 30. One hundred fifteen patients were identified with tibial shaft fractures. Eighty-nine patients fit the inclusion criteria and 26 fit the exclusion criteria. Additional data obtained included: age, gender, race/ethnicity, BMI, smoking status, comorbidities (diabetes, peripheral vascular disease, coronary artery disease, venous stasis, hepatitis C, and HIV), mechanism of injury, open/closed fracture status, AO/OTA fracture classification, Gustilo-Anderson grade, Tscherne classification, time to irrigation and debridement and time to definitive fixation. Also noted was whether a skin graft, free flap, or local flap were used, whether there was hardware failure, wound complication or revision surgery, as well as duration of clinical follow-up, pain score, and ambulation. Statistical analysis was performed by the Department of Clinical Sciences at the Temple University School of Medicine. A p-value of .05 or less was deemed statistically significant. A t-test was performed for continuous variables, and for continuous variables that were not normally distributed, a Wilcoxon test was performed. For categorical variables, a chi square test was used.

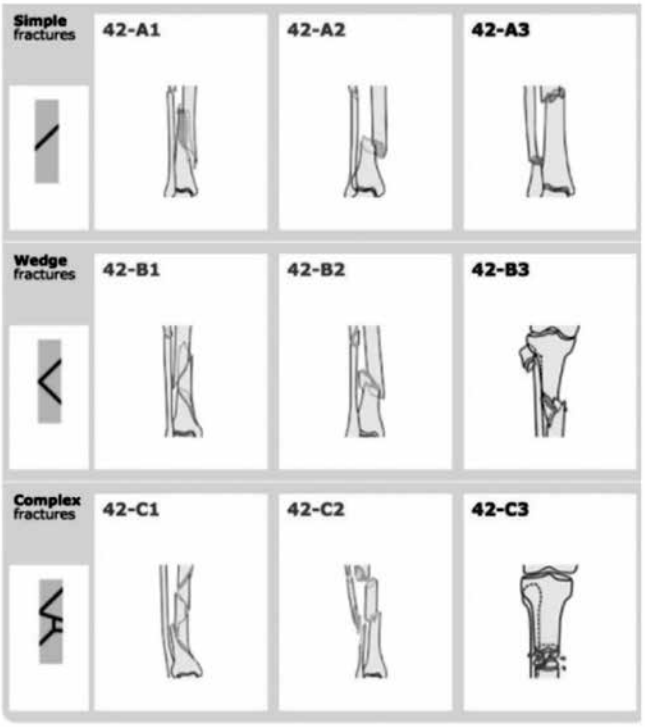
Results

One hundred fifteen patients were identified with tibial shaft fractures. Eighty-nine patients fit the inclusion criteria.

Tscherne Classification for Open Fractures[19]

Grade	Typical Fracture Patterns/Injuries	Typical Soft Tissue Damage
O1	Fractures resulting from indirect trauma (e.g., AO A1-2)	Skin laceration; none to minimal
O2	Fractures resulting from direct trauma (e.g., AO A3; B, C)	Skin laceration; circumferential contusions; moderate contamination
O3	Comminuted fractures; farming injuries; high-velocity gunshot wounds	Extensive; major vascular and/or nerve damage; compartment syndrome
O4	Subtotal and complete amputations	Extensive; major vascular and/or nerve damage

AO/OTA Classification System[20]



Of the 89 patients that were included: 64 were male and 25 were female, 45 were not obese and 44 were obese. The average age was 42.59 ± 11.29 in the obese cohort (Table 1) and 40.06 ± 14.61 in the non-obese cohort (Table 2). 59.09% of patients were African American, 22.72% were Caucasian,13.63% were Hispanic, and 4.5% were other in the obese cohort (Table 1). 44.44% of patients were African American, 26.67% were Caucasian, 26.67% were Hispanic, and 2.2% were other in the non-obese cohort (Table 2).The average BMI in the obese group was 36.7 ± 6.9 (Table 1) while the average BMI in the non-obese group was 23.03 ± 1.46 (Table 2). There were 53 closed fractures and 36 open fractures. The most common mechanisms of injury were falls, auto vs. pedestrian, and motorcycle accidents. All the motorcycle accidents were male, 85% of the auto vs. pedestrian-sustained fractures were male, and 72% of the fractures among women were caused by falls.

Table 1. Obese Demographics

Variable	Number	Frequency/Percentage
Age	44	42.59 ± 11.29 (mean)
Sex		
Male	31	70.45%
Female	13	29.54%
Race		
African American	26	59.09%
Caucsian	10	22.72%
Hispanic	6	13.63%
Other	2	4.5%
Ethnicity		
Hispanic	6	13.63%
Non-Hispanic	37	84.09%
Unknown	1	1%
Smoking Status		
Smoker	22	50%
Non-smoker	22	50%
Average BMI	44	36.7 ± 6.9 (mean)
Fracture Status		
Closed	26	60%
Open	18	40%
Mechanism of Injury		
Fall	22	50%
MCC	7	15.9%
MVC	3	6.8%
Auto vs. Pedestrian	6	13.63%
Assault	N/A	0%
Golf cart/ATV	N/A	0%
Other	1	1%
Comorbidities		
Diabetes	8	18.18%
PVD	0	0%
CAD	0	0%
Venous Stasis	0	0%
HepC	3	6.8%
HIV	2	4.54%
Gustilo-Anderson Grade	18	
I	7	38.88%
II	3	16.67%
I/II	2	11.11%
III	3	16.67%
IIIa	1	5.55%
IIIb	2	11.11%

Table 2. Non-Obese Demographics

Variable	Number	Frequency/Percentage
Age	45	40.06 ± 14.61 (mean)
Sex		
Male	33	73.33%
Female	12	26.67%
Race		
African American	20	44.44%
Caucsian	12	26.67%
Hispanic	12	26.67%
Other	1	2.2%
Ethnicity		
Hispanic	13	28.88%
Non-Hispanic	32	71.11%
Smoking Status		
Smoker	27	60%
Non-smoker	18	40%
Average BMI	45	23.03 ± 1.46 (mean)
Fracture Status		
Closed	27	60%
Open	18	40%
Mechanism of Injury		
Fall	11	25%
MCC	5	11.36%
MVC	2	4.5%
Auto vs. Pedestrian	15	34.09%
Assault	3	6.81%
Golf cart/ATV	3	6.81%
Other	5	11.13%
Comorbidities		
Diabetes	1	2.2%
PVD	1	2.2%
CAD	2	4.44%
Venous Stasis	0	0%
HepC	3	6.7%
HIV	3	6.7%
Gustilo-Anderson Grade	18	
I	4	22.22%
II	3	16.67%
I/II	5	27.78%
III	3	16.67%
IIIa	2	11.11%
IIIb	1	5.55%

Table 3. Time Points

Variable	Mean/Median
Time to I&D (days)	
Obese	.31 ± .716 (mean)
Non-obese	2.55 ± 7.08 (mean)
Time to Definitive Fixation (days)	
Obese	5.74 ± 10.23 (mean)
Non-obese	5.72 ± 7.98 (mean)
Duration of Clinical Follow-up (months)	
Obese	10.74 ± 11.34 (mean)
Non-obese	10.58 ± 14.04 (mean)

The average time for an Irrigation & Debridement (I&D) for obese chort was .31 ± .716 days and the non-obese cohort was 2.55 ± 7.08 days (Table 3). The average time for time to definitive fixation was 5.74 ± 10.23 days for the obese cohort and 5.72 ± 7.98 days for the non-obese cohort (Table 3). The average duration of clinical follow-up was 10.74 ± 11.34 months for the obese chort and 10.58 ± 14.04 months for the non-obese cohort. In the non-obese cohort, a total of nine patients had a wound complication, four patients had hardware failure, nine patients had revision surgery and three patients had an infection requiring surgical treatment (Table 4a). Thirty-six patients' wounds were primarily closed, three patients had a skin graft, three patients had a free flap, and one patient had a local flap (Table 4a). In the obese cohort, a total of 11 patients had a wound complication, five patients had hardware failure, 14 patients had revision surgery and four patients had an infection requiring surgical treatment (Table 4b). Thirty-seven patients' wounds were primarily closed, four patients had a skin graft, three patients had a free flap, and one patient had a local flap (Table 4b).

There was no statistical significance in open fracture rates or time to definitive fixation between the obese and non-

Table 4a. Surgical and Fracture Demographics (Non-Obese)

Variable	Number	Frequency/Percentage
Complications	Total: 9	
Irritation/Erythema	2	22.22%
Wound Breakdown/Dehiscence	0	0%
Other	8	88.89%
Hardware Failure	Total: 4	
Broken/Loose Screws	3	75%
Infected Hardware	2	50%
Revision Surgery	9	20%
Infection Requiring Surgery	3	6.66%
Primarily Closed	Total: 45	
Yes	36	80%
No	3	6.66%
Non-operative	6	13.33%
Skin Graft	3	6.66%
Free Flap	3	6.66%
Local Flap	1	2.2%

Table 4b. Surgical and Fracture Demographics (Obese)

Variable	Number	Frequency/Percentage
Complications	Total: 11	
Irritation/Erythema	4	36.36%
Wound Breakdown/Dehiscence	3	27.27%
Other	7	63.63%
Hardware Failure	Total: 5	
Broken/Loose Screws	3	60%
Infected Hardware	2	40%
Revision Surgery	14	31.81%
Infection Requiring Surgery	4	9.09%
Primarily Closed	Total: 44	
Yes	37	84.09%
No	6	13.63%
Non-operative	1	2.27%
Skin Graft	4	9.09%
Free Flap	3	6.81%
Local Flap	1	2.27%

obese groups (Table 5). There was also no statistical significance between obese and non-obese patients and the rate of complications, infections, hardware failure, or revision surgery (Table 5). Fifty percent of obese patients suffered a tibial shaft fracture via fall, while only 25% of non-obese patients suffered a tibial shaft fracture via fall (p-value = 0.022). There was statistical significance between increased age and patients needing revision surgery (p-value = .0357), having wound complications (p-value = .0463).

Discussion/Conclusion

Obesity is a growing health issue in the United States and globally, thus it is vital to continue to counsel patients appropriately about their health and risk factors. The purpose of this study was to determine if obese patients (BMI greater than 30) had a higher risk of open tibial shaft fractures sustained by a high-energy mechanism than patients with a normal BMI (between 18.5–24.9). The results indicate that there were no differences in the rate of open tibial shaft fractures between both cohorts. This is neither supported nor

Table 5. Relationship Between Obesity and Fractures

Variable	Mean/Frequency	p-Value
Open Fracture	Total: 36 fractures	.9304
Obese	18	
Non-obese	18	
Closed Fracture	Total: 53 fracture	
Obese	26	
Non-obese	27	
Time to Definitive Fixation		.994
Obese	5.74 ± 7.98 days	
Non-obese	5.72 ± 10.23 days	
Revision Surgery		.223
Obese	14	
Non-obese	9	
Fracture Via Fall	Total: 33 patients	.0222
Obese	22 patients	
Non-obese	11 patients	
Hardware Failure		.7247
Obese	5 patients	
Non-obese	4 patients	
Wound Complication		.423
Obese	11 patients	
Non-obese	9 patients	
Infection Requiring Surgery		.6932
Obese	4 patients	
Non-obese	3 patients	

refuted by other studies since there has not been a study focused on the rate of open tibial shaft fractures in obese patients. There was also no difference between the time to I&D, time to definitive fixation, rate of complications, infections, hardware failure, or revision surgery. This is refuted by some studies that suggest obese patients have higher rates of complications, longer hospital stays, and a higher risk of non-union.[5, 9, 10] There are limitations to the data collected on these factors because not all patients continued to follow up with the orthopedic department at Temple until the fracture was healed. Also, how long the patients were in the hospital until they were discharged was not a time data point collected. However, 50% of obese patients, in comparison to 25% of non-obese patients, suffered a tibial shaft fracture via fall, which was statistically significant (p = .02). This may be since obese patients have an increased fall risk and increased fall force making it more likely to sustain a tibial shaft fracture via this mechanism.[6]

There was marginal significance between patients who smoked and increased time to definitive fixation and infection requiring surgical treatment in comparison to patients who didn't smoke. This is supported by other studies that state smokers have a higher risk of complications, delayed union, longer healing times, and more infections of post-operative or traumatic wounds when compared to non-smokers.[21, 22] There are limitations to the data collected on smoking status since this is usually self-reported.

There was statistical significance between increased age and patients needing revision surgery and having wound complications as well as marginal significance between increased age and hardware failure. This may be because with increased age, patients can develop osteoporosis spe-

Table 6. Relationship Between Smoking and Fractures

Variable	Mean/Frequency	p-Value
Time to Definitive Fixation		.0551
Smoker	7.925 days ± 11.24	
Non-smoker	3 days ± 4.61	
Infection Requiring Surgical Treatment	Total: 7 patients	.059
Smoker	6 patients	
Non-smoker	1 patient	

Table 7. Relationship Between Age and Fractures

Variable	Mean/Frequency	p-Value
Hardware Failure		.0728
Yes	47.1 years ± 9.5	
No	40.58 years ± 13.31	
Revision Surgery		.0357
Yes	45.95 years ± 11.62	
No	39.6 years ± 13.3	
Wound Complication		.0463
Yes	46.05 years ± 11.3	
No	39.85 years ± 13.37	

cifically in post-menopausal women as well as the fracture repair components; cells, vascularization, extracellular matrix, and signaling molecules, are impacted by age thus suggesting difficulty with fracture repair and healing.[23, 24]

One of the limitations of this study was how the type of fracture was coded into the electronic medical record. When the fracture is classified, sometimes the wrong code is used, thus patients who should be included are not due to the use of the wrong code. Also, when the Gustilo-Anderson fracture grade was inputted into the system, many patients had type I/II instead of specifying which fracture grade. Another limitation is that before 2016, the patient records are paper and scanned into the system thus some handwritings are difficult to read or they are not scanned in chronological order making it possible that some data points are missed. In regards to BMI, the height and weight of the patient taken at the time of the fracture are usually estimations, thus some of the patients included may be overweight instead of obese or patients excluded may have been obese but were categorized as overweight.

Further studies should be conducted on the rates between open tibial shaft fractures in obese and non-obese cohort, specifically with the mechanism of injury being falls, with a greater sample size and more accurate BMI. Given that it is difficult to get an accurate height and weight at time of the fracture it might be beneficial post surgery to measure height and weight.

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Medical Student Research Project

Supported by The John Lachman Orthopedic Research Fund and Supervised by the Orthopedic Department's Office of Clinical Trials

The Impact of Hip Fractures Presenting During On Call: Patient Outcomes of a Level I Trauma Center

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Abstract

Objective: Delay to surgery is known to be a risk factor for poorer hip fracture surgery outcomes. The aim of this study is to assess how delay to surgery is impacted by patients presenting with hip fracture on-call vs during the week and whether designation to a trauma surgeon confers an advantage to the OR.

Methods: In this retrospective chart review, hip fracture patients were categorized into presenting on call, or during the weekday and within the on call-group being assigned a trauma or non-trauma orthopaedic surgeon. Comparisons of delay to surgery and post-op outcomes were made.

Results: Fifty-seven patients met inclusion criteria. There is a significant correlation between delay to surgery and length of stay (LOS) in the hospital $r = 0.4$ $p = 0.001$. There is no significant difference between on-call and weekday presentation or between trauma and non-trauma surgeons. However, presenting on-call to a trauma surgeon trends towards getting to the OR with <24 hour delay to surgery more often than a non-trauma surgeon.

Conclusion: Delay to surgery after a hip fracture is an important factor that can affect patient outcomes. Assessing hospital-related factors that can make the transition to the OR more efficient is an important process. Trauma surgeons trends towards a shorter delay to surgery during on-call.

Introduction

Over 300,000 older adults are hospitalized for hip fractures every year.[1] These hip surgeries can result in mortality rates between 14–58%[2] and multiple complications. These poor outcomes are exacerbated by increased delay times to surgery.[3] Furthermore, ultra-early surgery after hip fractures (<12 hours) has been shown to reduce in-hospital mortality rate.[4] However, ultra-early surgery is not possible for every patient or every hospital system. Protocols require x-rays, EKGs, urine analysis etc. before clearance to surgery. Factors related to individual patients, such as cardiovascular health upon admittance to the ER and infection can contribute to these delays. However, hospital-related factors such as waiting for results and preoperative risk stratification OR availability, and nonoperative management also contribute to delay to surgery and subsequently poorer outcomes.[5–7] Specifically, delays are more likely to occur during weekends and overnight.[8] Administration records can be used to uncover these obstacles in the system.[9] Better understanding where protocol breaks down and when add-on trauma surgeries are pushed back to further than 24 hours after admission is crucial in addressing delayed surgery, and can potentially lead to changes within the system to improve outcomes.[10, 11] The purpose of this study is to use medical records to systematically review hospital centered reasons for delay and more specifically, to address whether presentation to ED during on-call periods has an impact on delay to surgery and outcomes of patients in the Temple University Health System. We hypothesize that an addressable and identifiable break in the system occurs when non-trauma surgeons are on call to facilitate add-on trauma cases, and that on these occasions, there is an increased delay to surgery, and subsequent increase of in-patient length of stay (LOS) and 30-day post-operative complications.

Methods

IRB approval from the Temple Institutional Review Board was obtained for retrospective review of charts for all hip fracture surgery from 2018–2019. Conformation of hip fracture surgery was done by individual inspection of electronic medical records. We collected the time of day that patients were admitted to the ER. Institutional protocol dictates that based on time of admittance, patients will be under the care of an on-call orthopedic surgeon who may or may not be a trauma surgeon. At Temple, trauma surgery holds an additional OR during the day that allows these cases to be integrated into a surgeon's operative schedule. Orthopedic surgeons without a trauma designation who take these cases do not have that extra OR availability and thus add these cases to the end of a typical workload. This scheduling leads to the potential that these cases get pushed back an additional day. Inclusion criteria was determined that patients must be adults (18+) admitted to the Temple University Emergency

Room with a presentation of closed hip fracture in need of surgical intervention. Exclusion criteria include pregnant women, children, patients who needed pulmonary or cardiac clearances, have suffered from gunshot wounds, taking certain medication, or require multiple surgeries. Data collected included description variables that help to gain a picture of the patient's health before presenting to the ER and surgical variables describing the specifics of surgical timings to capture potential delays and outcome variables to capture how these patients fared. Description variables include age, gender, American Society for Anesthesiologist (ASA) score[12] and number of comorbidities.

Comorbidities were defined as chronic kidney disease, hypertension, coronary artery disease, stroke, arrhythmias, obesity, alcoholism, liver disease, arthritis, or osteoporosis. These variables are potentially confounding variables that are accounted for in further analysis. Surgical variables include time of admittance, time until surgery, surgeon type, delay of ED admission to surgical fixation, and surgical start to end. Outcome variables include length of stay and post-op complications (myocardial infarction, deep vein thrombosis, pulmonary embolism, UTI, stroke, readmission, and pneumonia). Demographic characteristics were summarized using descriptive statistics and a t-test was performed to compare surgical and outcome variables between patients who were admitted to the ER during the weekday, and on-call times to determine if the time of the week in which patients presented with a hip fracture coincided with longer delays to surgery and subsequently poorer outcome measures. A subsequent analysis is performed of only patients who presented during on-call times to indicate whether the on-call surgeon having a trauma designation allowed them to get to the OR more quickly with these patients instead of having to delay them to the next day. Grouping of admittance time is illustrated in Figure 1.

Results

Of the 102 patients presenting hip fractures to TUHS from 2018–2019, a retrospective chart review indicated 57 met inclusion criteria. Patients were excluded for undergoing a procedure that required advanced surgical training. Patients were excluded for not presenting to the emergency room, and for coming in with trauma that would require multiple surgeries, including gunshot wound victims. Thirty-five percent of patients presented to the ED during the weekday between 6 am–6 pm; 65% percent of patients presented to the ED over the weekend, overnight, or during a holiday. As expected, within this sample, LOS is significantly correlated with delay to surgery and shown *rho* = 0.4 *p* = 0.001 (Figure 2). Our main variables of interest are surgical delay and time from ED presentation to surgery. Additionally, within the subset of patients who present to the ED during times that are on call, our main variable of interest is the surgeon trauma/non-trauma designation. Outcome variables are presented in Table 1 describing differences in regards to time of presentation to the ED. We see no statistically significant differences between presenting on call and presenting during the week in any outcome variables. We note that 42% of patients were able to reach the OR in <24 hours, generally associated with gold standard of care. Analysis of outcomes within the subset of patients who present to the ED during on-call times depending on trauma status of the surgeon is presented in Table 2. Within this subset of patients, we see no statistically significant differences in delay to surgery, LOS, and post-op complications between patients with trauma vs non-trauma orthopaedic surgeons. However, there is a trend towards getting patients to the OR faster with the trauma designation. This is thought to be a result of trauma surgery having an extra designated OR to facilitate add-on cases and presenting on call. Seventy-one percent of these

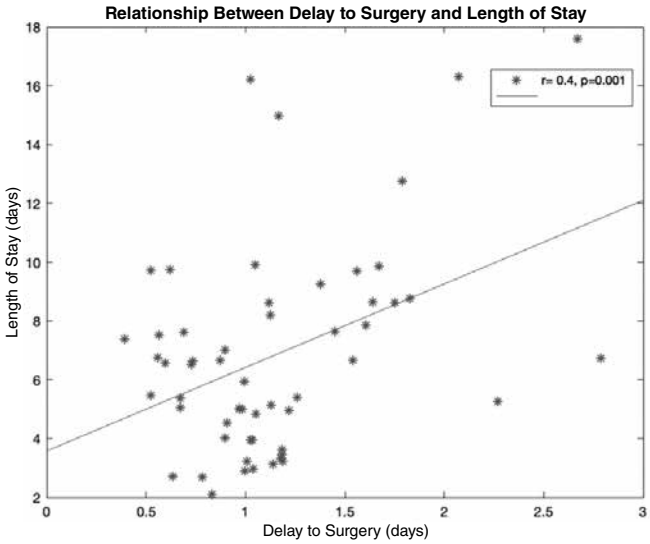

Figure 2. Significant correlation between Delay to Surgery and Length of Stay *Rho* = 0.4 *p* = 0.001.

Figure 1. Example of calendar week describing how time of admittance is grouped.

patients were able to get to the OR in under 24 hours, compared to the 30% of patients not attended by a trauma surgeon, and the 42% of all patients in this cohort. Descriptive subject information is presented in Table 1.

Table 1. Descriptive Statistics of Patients Presenting to the ED with Hip Fractures Either During On Call or Weekday

	On Call n = 37	Weekday n = 20	*p*
Age (m ± sd)	74.05 ± 11.22	79.95 ± 11.98	0.06
Gender (% M)	3%	40%	0.53
Comorbities (m ± sd)	1.7 ± 1.6	2.2 ± 1.5	0.24
BMI (m ± sd)	25.7 ± 6.8	25.5 ± 4.7	0.9
ASA score (m ± sd)	3.2 ± 0.4	2.9 ± 0.4	0.06
Surgeon type (% trauma)	24%	35%	0.53
Surgical duration (m ± sd hrs)	1.5 ± 0.85	1.3 ± 0.59	0.3
Delay to surgery (m ± sd days)	1.17 ± 0.6	1.11 ± 0.23	0.67
% Under 24 hrs	48%	30%	0.26
Post-op complication (%)	35%	50%	0.39
LOS (m ± sd days)	6.57 ± 3.4	7.34 ± 3.8	0.44

There are no significant differences between patient or outcome variables.

Table 2. Descriptive Statistics of Patients Presenting to the ED with Hip Fractures On Call to an Orthopaedic Trauma Surgeon or a Non-trauma Orthopaedic Surgeon

	Trauma n = 7	Non Trauma n = 30	*p*
Delay to surgery (m ± sd days)	0.89 ± 0.32	1.22 ± 0.64	0.1
% Under 24 hrs	71%	43%	0.2
Post-op complication (%)	0%	43%	0.2
LOS (m ± sd days)	5.2 ± 3.9	7 ± 3.6	0.2

There are no significant differences between outcome variables.

Discussion

Hip fractures are a common and potentially deadly injury in the US, particularly for the elderly population. As a level 1 Trauma center, Temple University Health System sees a high volume of hip fracture patients requiring surgery and are well equipped to handle such. New hip fracture protocol has been utilized in 2018 and 2019 in an attempt to streamline care, yet has not been systematically reviewed. It has been well documented that delays to surgery >24 hours are associated with poorer outcomes in these patients. These delays can be caused by either hospital related or by patient-centered reasons and are shown to be increased during the weekend or overnight. It is the purpose of this study to assess whether being admitted to the ED during these times is associated with a greater delay to surgery and subsequent poorer outcomes. Our findings suggest that patients presenting during on-call times do not have a significantly increased delay to surgery or poorer outcomes. This indicates that on-call protocol for hip fractures is allowing patients to get to the OR just as quickly as during the weekday and with positive outcomes.

Within this system at TUHS, trauma on-call surgeons will have access to an extra OR during the day. Of the patients who present during on call, do trauma surgeons confer an advantage in getting patients to the OR with less of a delay? Our results did not indicate that trauma surgeon designation confers a statistically significant advantage in any of our metrics, however, did show trends of having a faster time to the OR, a greater percent of patients in under 24 hours, which has been noted as a critical time point, and less post-operative complications. These findings suggest that the hip fracture protocol in place may benefit from having an extra OR available to get patients to surgery in <24 hours. Overall, this work lends support to the efficacy of the Temple hip fracture protocol and suggests that access to another OR for the orthopedic team during the day to incorporate these patients that are typically add-on surgeries might decrease the delay until surgery and improve patient outcomes. Follow-up research is needed to better understand how the hip fracture protocol can be adjusted to ensure that hip fracture patients are brought to the OR in <24 hours, as is the gold standard of care, and whether access to an additional OR, as trauma surgeons do, may serve that purpose.

Limitations to this study include the lack of comparison to before the hip fracture protocol was implemented. This information could indicate whether these outcomes have improved. Further research to compare these metrics to before the protocol would be helpful to assess whether positive changes have been implemented. Additional limitations include lack of being able to include patients who underwent partial or total hip arthroplasty. Due to additional training needed in performing this type of surgery, not all on-call surgeons are available, and these cases will potentially need to be transferred to another surgeon. Additional follow-up of these patients past 30 days would be helpful in gaining a more complete picture of their health after surgery and could be addressed by further research.

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Medical Student Research Project

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The Effect of the Philadelphia Sugar Tax on BMI

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Abstract

Obesity, defined as a body mass index (BMI) of greater than 30, is an epidemic in the United States that continues to rise over the years. This condition has been shown to have negative impacts on the health and success of surgery on patients. Various strategies have been employed to combat this rising trend; one such example is that of the Sugar Tax. The Sugar Tax, which was implemented in the city of Philadelphia in 2017, was put into effect to try to lower the purchasing and consumption of Sugar Sweetened Beverages (SSBs) in the area in hopes that this would be a way to reduce the local BMI. This specific study examined the effectiveness of the Sugar Tax on BMI. The results of this study showed that in the first year of the tax, BMIs decreased significantly from the year before across race, ethnicity, age, and other factors. However, in the following year, BMIs began to rise in above said groups. This would suggest that the Sugar Tax was unsuccessful after the first year or that it is not the real deterrent for the trend of rising BMIs. Moreover, when examining zip codes outside of Philadelphia, one can see that those zip codes also experienced a decrease in 2017 after the implementation of the Sugar Tax even though they were unaffected by the rising cost of SSBs. The conclusions of this study include that the Sugar Tax has in some way been able to decrease BMI in the first year it took effect, but after that time frame, was ineffective — allowing for an increase in BMIs to continue just as it had before the tax was ever put into place. Further studies should look at the continuation of this increase in BMI, while also examining the role that media coverage has played into the effectiveness and ineffectiveness of the tax.

Introduction

The United States of America is facing an obesity epidemic. Thirty-five percent of adults and 17% of children in 2015 were found to be obese by the Center of Disease Control (CDC).[1] Obesity is defined as having a body mass index (BMI) of 30 or over. These widespread obesity diagnoses have occurred in part due to a favoring of positive energy balance where patients are taking in more calories and expending less resulting in weight gain over the past several decades. In addition, per capita food supplies have increased, thus consumption has also increased, particularly that of high-calorie, palatable foods that are often served in large portions. Furthermore, a decrease in the time spent participating in physical activities, as well as a transition from leisure-time physical activities to sedentary activities, such as television watching and the use of electronic devices, has also contributed to this epidemic.[2]

A number of studies have shown that the obesity epidemic tends to favor particular populations. Obesity rates in the Hispanic population have been found to be 43%, while the non-Hispanic black population obesity rate has been found to be 48%.[3] A link has also been illustrated between lower income and obesity.[4] Education level in previous studies has been shown to correlate with obesity with the two variables being inversely proportional.[5] Other less obvious factors leading to obesity include food insecurity and living in a food desert. Food insecurity is defined as an individual who does not have adequate access to food, which can lead to binge eating whenever food is available. During this binge, the person will typically eat non-essential foods accompanied with sugar sweetened beverages (SSBs), as these are energy dense meals.[6] A food desert is defined as an area where it is hard for the population to receive adequate fresh groceries; this again can lead to an increase in the consumption of non-essential foods and SSBs.[6] Food deserts have also been associated with more unsafe places for residents to be active, as well as being an increased stress area, both of which have links to obesity.[6]

It is well known that obesity is linked to many diseases. For example, obesity causes an increase in adipokines, which can lead to osteoarthritis. Obesity has been strongly associated with diabetes.[7] Furthermore, obesity either complicates or predisposes to other diseases such as coronary heart disease, other heart complications, respiratory problems, and linkage to certain forms of cancer.[8] From the years 2002 to 2009, the amount of obese patients receiving total knee athroplasties (TKAs) rose from 15% to 30%, thus concluding that the population base in this specific demographic has increased.[9] It was also found that a BMI >40 is associ-

ated with greater rates of reoperation and superficial infection in TKAs. Another complication from obesity in the orthopedic field is that in an operation, a five-point increase in BMI resulted in a 15% increase in length of stay, as well as a seven-minute increase in operating time.[9] One other previous study found that obesity increases the duration of anesthesia, the amount of bleeding, thromboembolism, and an increase in the dislocation rates during hip surgery.[7]

One other consideration with regards to obesity is the economics of the disease. Patients have been found to have a 2% decrease in income, a 3% increase in social transfer payments, and a 4% increase in healthcare costs per BMI point above 30.[10] A study conducted in 2014 found that obesity has accounted for $149.4 billion in spending money at the national level.[11] Due to the complications and the cost of healthcare for patients with obesity, interventions were needed. The two main target areas were non-essential foods and sugar sweetened beverages, which are primarily sodas. SSBs specifically have been linked to excess weight gain, Type 2 Diabetes,[12] and coronary heart disease.[13] This link has proven important for interventions aimed at decreasing obesity. In Mexico, a tax on non-essential foods and SSBs was passed and according to an economic study, since being put in place, the purchasing of these two items have in fact decreased steadily over two years.[14] In the United States, the city of Philadelphia intervened by passing an SSB tax. Specifically, this tax is 1.5 cents per ounce of a sugar sweetened beverage, with the profits being marketed as a way to pay for Pre-K schooling in the city.[15] This tax is very intriguing due to the fact that Philadelphia's population, according to census data, would include those who are most susceptible to obesity: African Americans, Hispanics, low-income individuals, and lower-education individuals. There has also been a correlation between excess SSB consumption and obesity in these populations.[12] During the voting period to pass the tax, the government showed the projected health benefits which included the prevention of 36,000 cases of obesity, which would avert 730 deaths due to the disease, while also saving $84 of healthcare per every $1 spent on in the intervention, among other things.[16] An economic study here in the city has shown that the passing of the tax has decreased the intake of added sugars by 14.7 grams per day, or 22% for children who consumed 67 grams of added sugars daily, which is almost equivalent to one 20-ounce bottle of regular soda each day.[17] Unfortunately, there is hardly any health-related data related to what impact the sugar tax has had regarding BMI in Philadelphia. This study looks at patient data from the Temple orthopedics department to assess whether this SSB tax has affected the BMI of these patients.

Materials and Methods

A list of all patients seen at Temple Orthopaedics and Sports Medicine between February 1, 2018 to February 1, 2019 was obtained. A total of 53,797 patients were identified. The following demographics were obtained from this data: age, race, ethnic group, BMI, department seen at, zip code, insurance, financial class and provider. The primary variable being looked at was BMI and how BMI is impacted by the other variables. This data was then compiled and compared with data from two previous patient lists from Temple Orthopaedics and Sports Medicine from two studies from previous years involving the Philadelphia Sugar Tax that collected the same variables. A statistical analysis was then performed by an institutional statistician.

Discussion

In a study based on the effects of the Philadelphia Sugar Tax, it was found that in the years preceding the Sugar Tax — 2014, 2015 and 2016 — there was an increase in BMI each year for the total population of patients. Then immediately after the Sugar Tax was introduced, there was a significant drop in BMI (Figure 1). This drop is seen across all races. The most profound drop came in the Caucasian group followed by Hispanics, African Americans, and Asians in that order. This would seem encouraging for the Sugar Tax reducing BMI. However, in 2018, the year following the first year of the Sugar Tax, the BMI has increased or stayed very close to the 2017 BMI. This is seen in Hispanics and African Americans in which BMI has stayed around the 2017 level while the BMIs of Caucasians and Asians have actually increased. In terms of ethnicity, the same trend was observed across Hispanics and Non-Hispanics (Figure 2).

The patient population at Temple Hospital (Boyer) specifically observed the same decrease immediately following the implementation of the Sugar Tax followed by the increase in BMI the following years (Figure 3). When looking at financial class determined by insurance type, the same trends in the data apply. When looking at age groups, we also see the same basic trend that BMI was increasing up until 2017, at which point the Sugar Tax took effect and the BMI

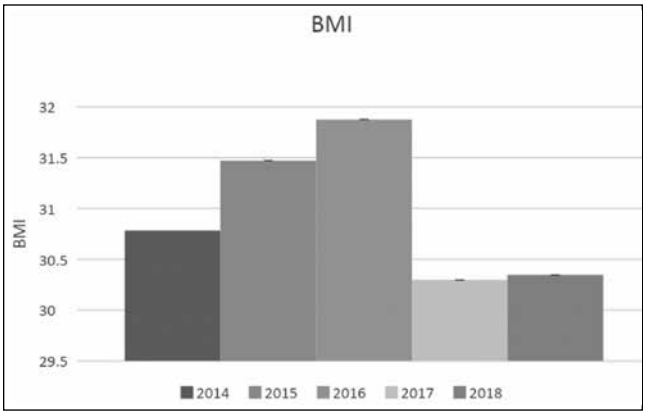

Figure 1. This figure shows the trend in BMI for all patients at Temple Orthopedics from 2014 to 2018. The BMI steadily increased from 2014 to 2016 with a sharp decline 2017. This corresponds to the timeline of the Sugar Tax. In 2018, the BMI slightly increased.

Table 1. The Change in BMI from Year to Year

	Year			
	2015	**2016**	**2017**	**2018**
Change in BMI	+0.687462 (0.000)	+0.404882 (0.000)	–1.57923 (0.000)	+0.050489 (1.000)

This table shows the change in BMI from year to year. For example, in 2016, it increased by +0.404882 from 2015. The p-value for that change is listed in parentheses.

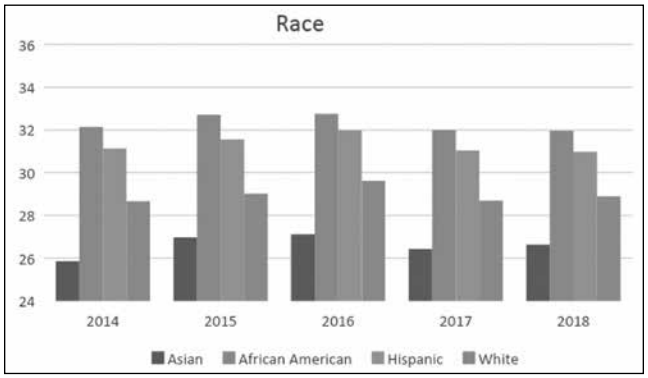

Figure 2. This figure shows the trends in BMI based on race. All races increased until the year 2017 when the BMI decreased. This also shows that for our patient population that the highest BMIs are consistently from African Americans, then Hispanics, then Caucasians and finally Asians.

Table 2. Change in BMI

Race	2017	2018
Asian	–0.734855 (0.103)	0.202082 (1.000)
Black	–0.75278 (0.000)	–0.038897 (1.000)
Hispanic	–0.955672 (0.000)	–0.059785 (1.000)
Caucasian	–0.927096 (0.000)	0.198938 (0.012)

The biggest decrease occurred in the Hispanic and Caucasian patients, but all patients did decrease. Then in the second year of the tax, the results were variable.

Table 3. Change in BMI from the Previous Year

Department	2017	2018
CAA	–0.152262 (0.142)	0.056629 (1.000)

The BMI did not fluctuate very much in either year of the tax.

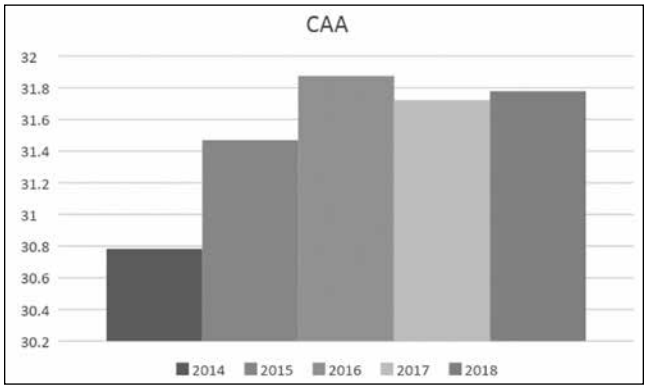

Figure 3. This figure shows patient data from the Boyer Clinic at Temple Hospital. This figure shows how patients at this location responded to the Sugar Tax in terms of BMI. They did have a decrease in BMI; however, it was not very much and their BMI increased in the second year of the tax.

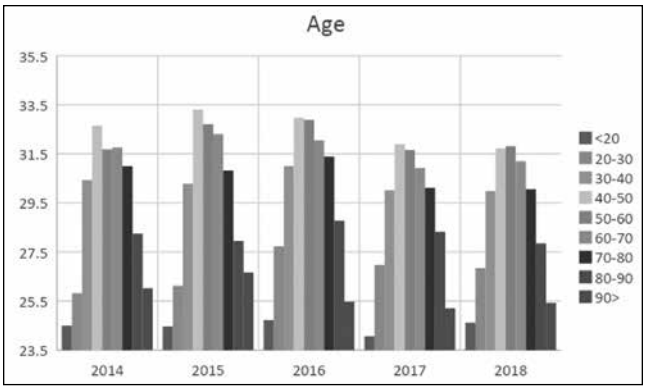

Figure 4. This figure shows how age groups responded to the Sugar Tax. Again, we can see the trend of increasing BMI until the year 2017 and then a decline and then variable results in the second year of the tax.

Table 4. Change in BMI Based on the Previous Year's Data

Age	2017	2018
<20	–0.660723 (0.250)	0.55442 (0.001)
20–30	–0.75498 (0.000)	–0.127631 (1.000)
30–40	–0.988325 (0.000)	–0.036004 (1.000)
40–50	–1.07546 (0.000)	–0.178331 (1.000)
50–60	–1.23611 (0.000)	0.15481 (1.000)
60–70	–1.12331 (0.000)	0.27939 (0.009)
70–80	–1.27289 (0.000)	–0.056588 (1.000)
80–90	–0.452088 (0.427)	–0.477555 (0.032)
>90	–0.272882 (1.000)	0.222825 (1.000)

In almost all cases, the decline in the first year of the tax was significant. In an interesting development, the decreases occurred in a bell curve fashion with the most decrease occurring in the middle aged groups. However, in the second year of the tax, the results were again variable.

dropped. However, an interesting trend is seen in the under 20 age group, in which the BMI decreased the least compared with other age brackets following the Sugar Tax and then increased a statistically significant amount the following year — being the only age group to do so. Beyond that, however, it appears as though the age groups follow a bell curve model with the middle ages having the largest decrease in BMI following the Sugar Tax and the extremes of ages decreasing the least. With regards to Philadelphia versus non-Philadelphia zip codes, the same trend applies where BMI was increasing until 2017, but then took a downturn after the tax was passed, and similarly increased one year post tax in 2018. It is interesting, however, that non-Philadelphia zip codes also decreased given that the tax was not implemented in these zip codes (Figure 5).

The data has largely followed an obvious trend that can be seen across almost all data sets, with few exceptions. First, BMI continued to increase in the Philadelphia region until the Sugar Tax was put into place. After it was implemented, there was a steep drop-off in BMI in the area, in most cases by a full point. Unfortunately, when looking at the years following the Sugar Tax, the BMI returned to the trend of steadily increasing like it had before it was passed.

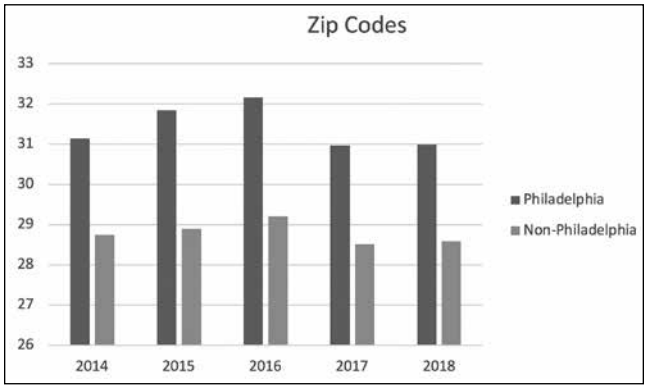

Figure 5. This figure shows how Philadelphia and non-Philadelphia zip codes responded to the Sugar Tax. Again, we can see the trend of increasing BMI until the year 2017 and then a decline and then small increase in the year after. We can also see the difference between the two groups.

Table 5. BMI Based on Zip Codes

Year	BMI in Philadelphia Zip Codes	BMI in Non-Philadelphia Zip Codes	Difference	Standard Error
2014	31.134165	28.741692	2.392473	0.1217018
2015	31.848424	28.886132	2.962292	0.1436995
2016	32.161265	29.207094	2.954171	0.1446855
2017	30.968655	28.503512	2.465143	0.0509623
2018	30.325455	28.584975	2.410649	0.0771473

This shows the BMI based on zip codes. Also it is showing the difference between the two zip codes and the standard error associated with that difference. It follows the trend of increasing up until the tax is implemented and then decreasing. This table also shows that this trend applied in non-Philadelphia zip codes outside of where the tax took place.

Conclusion

The Philadelphia Sugar Tax was successful in lowering BMI the first year it was implemented. Following that year, the impact of the Sugar Tax has been lessened, to nonexistent. While this study only looked at data following the implementation of the Sugar Tax for a little over a year, an increase in BMI can be seen in that time frame. This would point out that the efficacy of the Sugar Tax is not working as well as hoped by the local government. Future studies should continue to monitor this trend as well as investigate possible causes. A new direction would look at the effect that the media played in the decline seen following the Sugar Tax. The Sugar Tax, since it was a widely covered and debated topic, had most people aware of how it was going to affect their daily lives. However, as coverage of the tax waned, the trend of an increase in BMI repeated itself — making one wonder if there could be a correlation between media coverage and the effectiveness of the tax. Making this theory even more intriguing is the fact that non-Philadelphia zip codes also show the same trend in BMI, even though there was no tax imposed in those areas. This would speak to the tax itself not being a deterrent, but rather something else. In any instance, the effect on BMI that the tax set out to achieve has not consistently shown the results wanted, so some other factor must be playing a part in that correlation and hopefully future studies can try to find that association.

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Medical Student Research Project

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Are Open Femur Fractures More Common in Obese Patients?

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Abstract

Objective: Obesity is associated with a decreased risk of pelvic and hip fractures but an increased risk of distal femur fractures. However, this relation has not been thoroughly explored in the context of open femur fractures. This study compares various outcome variables between obese and non-obese groups with a primary focus on incidence of open fractures.

Methods: Sixty-nine patients with femur fractures at an urban level one trauma center were divided into obese (BMI > 30) and non-obese (BMI 18.5–24.9) groups. Pertinent demographic variables, injury characteristics, surgery outcomes, and post-operative clinical outcomes were collected.

Results: There was no significant difference in incidence of open femur fractures between the obese and non-obese groups (p = .208). There were trends toward both longer duration of clinical follow-up (p = .286) and time from injury until definitive fixation (p = .084) in the obese group. Fracture sites differed by mechanism of injury across both groups (p = .013).

Conclusions: There were similar rates of open fractures in obese and non-obese groups. However, due to the overall low incidence of open fractures, further investigation with a larger sample size may yield more nuanced results, specifically by fracture site.

Introduction

Obesity is a growing public health concern, with a prevalence of approximately 42.4% in the United States.[1] It is associated with an increased risk of musculoskeletal injuries and disproportionately affects the lower extremities in site-specific ways, particularly more distal parts like the femur.[2, 3] Additionally, an increased body mass index (BMI) negatively impacts the diagnosis, prognosis, and treatment of closed femur fractures but this relation has not been extensively studied for open femur fractures.[4] Open femur fractures typically occur due to high-energy trauma, particularly road traffic accidents, and less than half are isolated injuries.[5] Due to the severity these injuries, open femur fractures are associated with increased risk of complications such as complex fractures, soft-tissue damage, and longer hospitalizations.[6] Hence, it is important to better understand the role of obesity in the context of open femur fractures and how this can guide clinical management.

The direction and magnitude of the relation between obesity and fractures are inconsistent across the literature. It is commonly believed that obesity serves as a protective factor because the adiposity confers a cushioning effect and sturdier hip geometry. Additionally, a larger body mass translates to increased mechanical load on the femur, which would promote an increase in bone mineral density (BMD) to accommodate the load. Due to these factors, studies show that obesity is correlated with lower rates of pelvic and hip fractures.[2, 3]

Recent studies have challenged this notion and instead discuss how obesity is also associated with an increased risk of fractures. While a higher BMI is associated with lower rates of pelvic and hip fractures, it is also correlated with more complex fractures in the distal radius and open ankle fractures.[7–9] This divergent effect can be attributed to various factors. BMI and BMD are positively correlated with each other, but this is largely dependent on lean mass rather than fat mass.[10] As BMI increases, the percentage of lean mass becomes progressively smaller so respective increases in BMD of the femur may not be as profound.[2, 3] This suggests that the protective effects of increased adiposity may be offset by the decrease in bone strength, particularly in areas of the body with less padding. This may also be further offset by its associated increase in impact force.[2] Road traffic-related accidents and falls from standing are common mechanisms of injuries for femur fractures.[11] When comparing obese and non-obese populations, road traffic-related accidents occur at a similar rate for both but a significantly higher proportion of femur fractures in obese patients is attributed to falls, which suggests that low-energy trauma is sufficient enough to cause injury.[12]

These studies primarily focus on closed fractures; fewer studies analyze the effects of obesity on open fractures. One study found that obese patients had 1.45 times the risk of

developing open fractures after a higher-energy injury compared to non-obese patients, likely due to a greater impact force as a result of increased BMI.[9] Other studies have reported a nonsignificant relation between open fractures and obesity.[12, 13] Of note, some of these studies did not focus on open fractures exclusively, and open fractures have a relatively low incidence rate in comparison.[14] Additionally, some studies included overweight patients (commonly defined as BMI of 25–29.9) in their non-obese group, which can potentially dilute the differences between obese and non-obese groups. However, it is critical to better understand the relation between obesity and open fractures. Studies demonstrate that diagnosis and treatment of fractures are more complicated in obese patients.[4, 15] Obesity was also a strong predictor of developing osteomyelitis following open fractures of the lower extremity, which can prolong hospitalizations and healing time.[16]

In summary, obesity has a protective effect for hip and pelvis fractures but also increases the risk of more distal injuries. Interestingly, both effects manifest in femur fractures due to the unique position of the femur. Obese patients have a lower risk of sustaining proximal femur fractures and a higher risk of sustaining femoral shaft and distal femur fractures in both motorcycle accidents and falls.[17, 18] However, these studies focused on closed fractures, not open fractures. The complexities of the role of obesity in open femur fractures have not been studied extensively, and it is unclear how obesity can affect the incidence of open femur fractures. The purpose of our study is to determine if the incidence rate of open femur fractures occur at a higher frequency among obese populations compared to non-obese populations when accounting for energy level and mechanism of injury. Various characteristics between obese and non-obese groups will also be compared.

Materials and Methods

Approval and waiver consent were obtained from our university's Institutional Review Board (IRB) to conduct a retrospective chart review on femur fractures at an urban level one trauma center from January 1, 2015 to December 31, 2019. The pertinent ICD9 and ICD10 codes for femur fractures were queried in our hospital's electronic medical record. Inclusion criteria consisted of patients aged 18–65 years old who sustained femur fractures during this time frame. They were further divided into an obese group (BMI of greater than 30) and a non-obese group (BMI of 18.5–24.9). Patients who were younger than 18 years of age, older than 65 years of age, had a BMI of less than 18.5, had a BMI of 25–30, had connective tissue disorders (e.g., Ehlers Danlos, Marfan's syndrome), sustained injuries from low-energy mechanisms or gunshot wounds, were pregnant, or were prisoners were excluded from this study.

The electronic health records of eligible patients were reviewed for pertinent variables including: age, gender, race, ethnicity, BMI, smoking status, comorbidities (i.e., diabetes mellitus, peripheral vascular disease, coronary artery disease, venous stasis, hepatitis C, HIV), mechanism of injury, open/closed fracture status, fracture site, and Gustilo-Anderson grade. Information regarding surgery and clinical outcomes were also recorded, such as: time until irrigation and debridement; time until definitive fixation; if there were post-operative complications (e.g., hardware failure, malunion, length discrepancy). Furthermore, details about the final follow-up visit were recorded, including duration of clinical follow-up, presence of pain, and ambulation status.

Data analysis was performed using JMP statistical software. Primarily, data were compared between the obese and non-obese groups. Pearson χ^2 tests and Fisher's exact tests were conducted with categorical variables when applicable while two-sample t tests were conducted with continuous variables. Statistical significance was determined by an alpha level of 0.05 in all tests.

Results

Sixty-nine patients met the inclusion criteria of the study — 35 in the obese group and 34 in the non-obese group. Comparisons of demographic variables between the two groups are summarized in Table 1. The obese group had an average BMI of 36.87, and the non-obese group had an average BMI of 22.76. The average age of the non-obese group

Table 1. Demographic Data

Variables	Obese (n = 35)	Non-obese (n = 34)	p-Value
Age, mean ± st. dev.	42.57 ± 12.02	31.47 ± 10.80	<.001*
BMI (kg/m^2), mean ± st. dev.	36.87 ± 6.33	22.76 ± 1.35	
Gender			.184
M	24 (68.6)	28 (82.4)	
F	11 (31.4)	6 (17.6)	
Race			.950
African American/Black	17 (48.6)	13 (38.2)	
Caucasian/White	8 (22.9)	8 (23.5)	
Hispanic/Other	6 (17.1)	6 (17.6)	
Hispanic/Unknown	0 (0)	1 (2.9)	
Hispanic/White	0 (0)	1 (2.9)	
Other	3 (8.6)	3 (8.8)	
Unknown	1 (2.9)	2 (5.9)	
Ethnicity			.913
Hispanic	8 (22.9)	8 (23.5)	
Non-Hispanic	26 (74.3)	24 (70.6)	
Unknown	1 (2.9)	2 (5.9)	
Smoker			.005*
Yes	8 (22.9)	18 (52.9)	
No	26 (74.3)	13 (38.2)	
Unknown	1 (2.9)	3 (8.8)	
Comorbidities			
Diabetes mellitus	10 (28.6)	1 (2.9)	.004*
PVD	3 (8.6)	0 (0)	.081
CAD	2 (5.7)	0 (0)	.153
Venous stasis	1 (2.9)	0 (0)	.131
Hepatitis C	1 (2.9)	7 (20.6)	.024*
HIV	0 (0)	1 (2.9)	.284

st. dev. = standard deviation
* = denotes statistical significance
Values reported in columns as "n (%)" unless otherwise stated.

was significantly younger than the average age of the obese group (31.47 vs. 42.57 years old; p < .001). In addition, there was a higher prevalence of diabetes mellitus in the obese group (28.6% vs. 2.9%; p = .004). However, the opposite was seen with hepatitis C as patients in the non-obese group were diagnosed at higher rates (20.6% vs. 2.9%; p = .024). Patients in the non-obese group were also more likely to be current smokers at the time of injury (52.9% vs. 22.9%; p = .005). Otherwise, there were no significant differences between the obese and non-obese group in regard to gender (p = .184), race (p = .950), ethnicity (p = .913), or comorbidities with the exception of diabetes mellitus and hepatitis C (p > .081).

Over half the injuries in the obese group (54.3%) were secondary to motor vehicle collisions (MVC; Table 2). The next most common mechanism of injury was falls (20.0%). The most common mechanisms of injury in the non-obese group were MVC (38.2%) and motorcycle accidents (26.5%). There were no significant differences between the groups with respect to mechanism of injury (p = .256). The fractures were subcategorized as femoral shaft and distal femur, but there were no differences in incidence between the two groups (p = .733). There was a total of nine open fractures (26.5%) in the non-obese group and five open fractures (14.3%) in the obese group; there was no statistically significant difference between the groups (p = .208).

Table 2. Summary of Injury Characteristics and Clinical Outcomesa

Variables	Obese (n = 35)	Non-obese (n = 34)	p-Value
Mechanism of injury			.256
Fall	7 (20.0)	4 (11.8)	
Motorcycle accident	6 (17.1)	9 (26.5)	
MVC	19 (54.3)	13 (38.2)	
Other auto accident	1 (2.9)	5 (14.7)	
Other	2 (5.7)	3 (8.8)	
Fracture site			.733
Distal femur	10 (28.6)	11 (32.4)	
Femoral shaft	25 (71.4)	23 (67.6)	
Type of fracture			.208
Closed	30 (85.7)	25 (73.5)	
Open	5 (14.3)	9 (26.5)	
Time until I&D (days), mean ± st. dev.	.83 ± 1.17	0.33 ± 0.71	.377
Time until definitive fixation (days), mean ± st. dev.	3.97 ± 4.01	2.43 ± 2.69	.084
Duration of follow-up (months), mean ± st. dev.	8.49 ± 9.92	6.04 ± 8.95	.286
Post-operative complications (≥1)	11 (31.4)	9 (26.5)	.650
Presence of pain at final follow-up			.896
Yes	22 (62.9)	13 (38.2)	
No	2 (5.7)	1 (2.9)	
Unknown	11 (31.4)	20 (58.8)	
Ambulation at final follow-up			.661
Yes	26 (74.3)	22 (64.7)	
No	5 (14.3)	3 (8.8)	
Unknown	4 (11.4)	9 (26.5)	

st. dev. = standard deviation
* = denotes statistical significance
Values reported in columns as "n (%)" unless otherwise stated.

Perioperative outcomes did not differ significantly between the two groups (Table 2). The average time until I&D of the obese and non-obese groups were .83 and .33 days, respectively (p = .377). The average number of days from the injury until definitive fixation was higher for the obese group compared to the non-obese group, but this did not reach statistical significance (3.97 vs. 2.43 days; p = .084). Post-operative clinical outcomes are also summarized in Table 2. The average duration of clinical follow-up was longer for patients in the obese group compared to their non-obese counterpart (8.49 vs. 6.04 months), but this trend was also not statistically significant (p = .286). Additionally, around one-third of patients from both groups experienced at least one post-operative complication (p = .650). The most common complications in the obese group were nonunion and quadriceps weakness while the most common complication in the non-obese group was quadriceps weakness. Other clinical outcomes included presence of pain and ability to ambulate at the patient's final follow-up visit. There was a trend toward increased reports of pain in the obese group, but there were no statistically significant differences between the two groups (62.9% vs. 38.2%; p = .896). By the last follow-up visit, a majority of patients from both groups were able to ambulate (74.3% vs. 64.7%; p = .661).

Discussion

Obesity continues to be a concerning public health problem and has been correlated to several comorbidities including musculoskeletal injuries.[1, 2] Research studies have demonstrated the nuances in the relation between obesity and femur fractures, such that obesity can be a protective factor for proximal femur injuries due to increased adiposity around the pelvic region but increase the risk of distal femur injuries due to decreased femur BMD and increased impact force secondary to obesity.[2, 3] However, this relation has not been adequately explored in the context of open femur fractures specifically. Furthermore, obesity is correlated with a more complicated diagnosis, prognosis, and treatment of fractures so identifying differing characteristics between obese and non-obese patients can help guide clinical decision-making.[6, 15]

The primary aim of this study was to determine if there was a difference in the incidence of open fractures between obese and non-obese populations. Based on the collected data, there was no statistically significant relation between fracture status and BMI. This can be attributed to several reasons. First, there were disproportionately fewer open fractures in both groups; this reflects what is seen in the general population, as open fractures are less common than closed fractures. Hence, the sample size may not have had adequate statistical power for the purposes of this study.

Second, the severity and details of the mechanism of injury are largely unknown. Although the mechanisms of injury were all high-energy, many non-obese patients with open fractures were involved in polytrauma accidents and were more likely to have been involved in motorcycle accidents. Lastly, some of the femoral shaft fractures were more proximal (i.e., in the subtrochanteric region). As mentioned previously, the literature has shown that obese patients have a lower risk of sustaining hip and pelvic fractures. Subtrochanteric fractures are on the more proximal end of the femur, so this may have potentially diluted the results. Additionally, our data showed that distal femur fractures were more likely to be associated with falls while femoral shaft fractures were primarily associated with MVC and motorcycle accidents ($p = .013$). The sample size was too small to further assess this but stratifying by fracture type may have revealed more nuanced results.

However, there were other trends observed in the data. The average time until definitive fixation was 63% longer for obese patients compared to non-obese patients, which is consistent with findings from studies focusing on closed femur fractures. This may be attributed to factors such as difficulty stabilizing fractures in patients with a larger body habitus.[4, 18] In addition, the duration of clinical follow-up for patients in the obese group was approximately 41% longer than those in the non-obese group. There was a slightly higher proportion of obese patients experiencing post-operative complications which may have influenced this trend. Additionally, a majority of obese patients reported pain at their final follow-up visit, which may have also influenced their decision to continue following up with their physician.

There are some limitations to this study. First, the incidence of open fractures in the general population is much lower than that of closed fractures, as demonstrated in our sample. Further exploration of this topic would benefit from a larger sample size in order to increase the power of the study. Second, because this is a retrospective chart review, data collection for certain variables was limited by what was documented during follow-up visits. For example, a pain score was not routinely documented in the chart so only explicit mentions of pain or lack of pain were noted in the data, which resulted in missing data for this variable (Table 2). Third, some demographic variables (i.e., age, smoker status, diabetes mellitus, hepatitis C) differed between the obese and non-obese groups. These variables were inputted into a nominal logistic regression model and were found to not be significant predictors of open or closed fracture status. However, because of the small sample size, there was not enough statistical power to derive any meaningful conclusions from the multivariate model.

In summary, there was no statistically significant difference in the rates of open fractures between obese and non-obese patients in this study. However, this study demonstrated both longer clinical follow-up duration and time until definitive fixation for obese patients. The mechanisms of injury also significantly differed between distal femur fractures and femoral shaft fractures. Conducting this study with a larger sample size that is further subdivided by fracture type may reveal further trends and clinically significant results in this patient population.

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The Impact of Structural Racism on Black Americans During the COVID-19 Pandemic: A Review

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Abstract

America's history of anti-Black racism has greatly contributed to racial health disparities. This review completes a historical examination of the origins of these health disparities, starting from slavery, and connects them to the increased COVID-19 infection and mortality rates present among the Black population. Slavery, segregation, and the implementation of discriminatory policies have led to inequalities in wealth, employment, living conditions, healthcare access, and healthcare quality that currently affects the health of the Black population. Due to limited employment, income, and educational opportunities available to Black Americans for most of America's history, they are more likely to be uninsured and unemployed, which serves as a barrier to affording healthcare. They are also more likely to work in essential industries, such as service and transportation, which increases their contact with others and their risk of exposure to COVID-19. Predominantly Black neighborhoods also tend to have poorer living conditions, which increases their risk of common COVID-19 comorbidities, and less access to healthcare services and COVID-19 testing, placing them at a greater risk of infection and mortality. Overall, the Black population has been disproportionately affected by COVID-19, largely due to the presence of racial health disparities that have been present since America's inception.

Introduction

Slavery, Jim Crow Laws, and Lynch Law are part of America's dark history of anti-Black racism. Black Americans have consistently experienced discrimination and oppression since the country's inception and continue to face the consequences of this history, particularly with regards to health. Currently, the novel coronavirus is rapidly spreading across the United States with over 32 million cases and over 580,000 deaths from the resulting coronavirus disease of 2019 (COVID-19) (World Health Organization 2020b). Data suggests that Black Americans are disproportionately impacted by COVID-19, with significantly higher hospitalization and mortality rates than White Americans (CDC 2020c). In cases where racial information is reported, Black Americans account for approximately 19% of American COVID-19 cases and 22% of American COVID-19 deaths, even though they represent 13% of the population. In comparison, White Americans account for approximately 40% of COVID-19 cases and 51% of COVID-19 deaths, despite being 60% of the US population (CDC 2020a). Generally, counties with a higher Black population experience higher rates of COVID-19 diagnoses and deaths (Millett et al. 2020).

The COVID-19 pandemic is highlighting health disparities that have been present for centuries as a result of racism and systemic oppression, which have historically limited the opportunities and resources available to Black Americans. Since the establishment of America's healthcare system, Black individuals have not had an equal opportunity to be as healthy as their White counterparts. They generally have higher incidence and mortality rates for cardiovascular disease, diabetes, and cancer, higher infant mortality rates, and higher hospital admission rates than White Americans (Cunningham et al. 2017, 444–456; Manuel 2018, 1407–1429; Landrine 2009, 179–184; Ferdinand and Nasser 2020, 2746–2748). They also tend to receive a lower quality of healthcare and are more likely to be uninsured (CDC 2020b; Manuel 2018, 1407–1429; Landrine 2009, 179–184; Yearby 2018, 1113–1152; Bailey et al. 2017, 1453–1463).

There is currently an abundance of research on health disparities between Black and White Americans; however, much of the research fails to adequately address the root causes of these disparities, especially with regards to COVID-19. The purpose of this paper is to explore the origins of health disparities between Black and White Americans and discuss how these factors relate to the current COVID-19 pandemic.

Methods

The literature review was completed using PubMed, Google Scholar, and EBSCOhost databases. The included

literature consisted of reviews, qualitative studies, quantitative studies, and expert opinions. Information from the Centers for Disease Control (CDC), World Health Organization (WHO), the United States Bureau of Labor Statistics (BLS), the Federal Reserve, the United States Census Bureau, the National Archives, and the National Association of the Advancement of Colored People (NAACP) was also included. Search terms included: 'structural racism and healthcare,' 'racial health disparities,' 'history of health disparities and African Americans,' 'health disparities and slavery,' 'healthcare and the Jim Crow Era,' 'healthcare and civil rights,' 'residential segregation and health disparities,' 'COVID-19 and health disparities,' 'COVID-19 and African Americans,' 'pollution and COVID-19' and 'increased risk of COVID-19.' Searches were restricted to papers that were published in English, released following 2000, and were specifically focused on the history of health disparities in the United States, the general effects of those disparities, and the impact on the COVID-19 incidence and mortality rates. Papers that were specific to children and adolescents, focused on a region outside of the United States, and focused on groups besides Black and White Americans were excluded. Additional papers were included from the bibliographies of the articles found through the database searches.

Seven hundred forty of the most relevant papers (according to the database searches) were reviewed. After the removal of duplicates and application of the exclusion and inclusion criteria through title, abstract, and article review, 21 papers remained. Twelve articles were added from the bibliographies of these papers and 16 sources were added from the CDC, WHO, BLS, the Federal Reserve, the National Archives, the National Association for the Advancement of Colored People (NAACP) and the United States Census Bureau. In total, 49 sources were used in this review.

Historical Context

For hundreds of years, race was considered to be a concept that established a biological hierarchy, with Whites at the top and Blacks at the bottom. Blacks were often considered to be a separate species and were viewed as the "missing link" between apes and humans (Byrd and Clayton 2001, 11S–34S). These false beliefs were corroborated by numerous scientists and served as justification for the enslavement of Africans for labor (Byrd and Clayton 2001, 11S–34S; Hammonds and Reverby 2019, 1348–1349).

Beginning in 1619, Africans were brought to America, where they were separated from their families, overworked, and subjected to abject living conditions, abuse, rape, and violence (Hammonds and Reverby 2019, 1348–1349). Slaves rarely received any healthcare and if they did, it was low in quality. There was no legal obligation or expectation of keeping slaves in good health; they only received care if the slaveowner viewed it as necessary (Byrd and Clayton 2001, 11S–34S). Physicians during this time had little concern for the health of Black individuals and believed they were physiologically different from Whites, unable to feel pain, and predisposed to certain "Negro Diseases" (Byrd and Clayton 2001, 11S–34S). Slaves were also consistently the victims of medical experimentation and exploitation (Byrd and Clayton 2001, 11S–34S; Hammonds and Reverby 2019, 1348–1349; Williams and Rucker 2000, 75–90). By the time slavery was made illegal, Black individuals had the poorest health of any group in America (Byrd and Clayton 2001, 11S–34S).

Following the signing of the Emancipation Proclamation in 1863 and the creation of the 13th amendment of the Constitution in 1865, the institution of slavery was made illegal (National Archives 2015; National Archives 2016). Although Black Americans were given their freedom in writing, in reality they continued to face barriers in every aspect of life, including health. As racial tensions increased following emancipation, they were often subjected to brutality in the form of mob violence and lynching (National Association for the Advancement of Colored People). Lynch Law was an unwritten rule that allowed mobs to punish Black individuals by murder for accusations of any type of crime. Between 1882 and 1968, 3,446 Blacks were lynched and those responsible faced no repercussions (National Association for the Advancement of Colored People). Illness and death also rose among the Black population as they struggled to access healthcare (Hammonds and Reverby 2019, 1348–1349). Although a few predominantly Black medical schools were created, such as Meharry Medical College and Howard University School of Medicine, Black individuals were mostly shut out of the medical profession and white physicians continued to neglect the health of the Black population (Byrd and Clayton 2001, 11S–34S; Hammonds and Reverby 2019, 1348–1349).

Starting in 1877, Jim Crow Laws were implemented by federal, state, and local governments, causing racial segregation of society and explicitly placing Blacks at a disadvantage (Yearby 2018, 1113–1152; Smith 2003, 37–60). These laws, which lasted until 1964, forced Black individuals to use lower-quality public facilities, including hospitals, which resulted in them receiving worse quality healthcare than their White counterparts (Smith 2003, 37–60).

Blacks also continued to be victims of medical experimentation and exploitation, with the Tuskegee Syphilis Study serving as one of the most poignant examples (Byrd and Clayton 2001, 11S–34S; CDC 2020d). Beginning in 1932, the United States Public Health Service sanctioned a study which withheld syphilis treatment from hundreds of rural, impoverished, Black men, in order to document the negative effects of the disease until their deaths. These men were deliberately denied treatment that could have saved their lives and were misinformed about the study's true purpose. This study lasted until 1972 and demonstrates the fact that at this time, Black health was not a priority and Black lives were viewed as expendable (Byrd and Clayton 2001, 11S-34S; CDC 2020).

In addition to disadvantages in healthcare quality and access, Jim Crow laws had other devastating consequences. The federal government made it exceedingly difficult for Black Americans to own homes, stunting their ability to accumulate wealth. Starting in 1934, the Federal Housing Administration refused to provide Black families with housing loans and encouraged housing contractors to only sell homes to White Americans. This process, known as redlining, created predominantly White suburbs and forced Black Americans into overcrowded inner-city housing projects (Yearby 2018, 1113–1152).

In 1964, President Lyndon B. Johnson passed the Civil Rights Act, which led to the desegregation of public facilities, such as hospitals and clinics. One year later, Johnson established Medicare and Medicaid, which provided health insurance to many, often for the first time, and significantly improved the accessibility of healthcare (Yearby 2018, 1113–1152). Additionally, the Fair Housing Act was passed in 1968, making housing discrimination illegal (Yearby 2018, 1113–1152). These three pieces of legislation improved the quality of life and health of the Black population, but were not enough to have a lasting effect. Following the passage of Medicare and Medicaid, the health of the Black population continued to improve; however, after approximately a decade, it began to stagnate and worsen (Byrd and Clayton 2001, 11S–34S). Although racist and discriminatory legislation was removed from law, their legacy continues to negatively impact the lives and health of Black Americans.

Legacy of Racial Health Disparities and COVID-19

Wealth and Occupation

There remains a severe gap in wealth between Black and White households. In 2016, White families had a mean wealth of $933,700 and a median wealth of $171,000. In contrast, Black families had a mean wealth of $138,200 and a median wealth of $17,600 (Dettling et al. 2017). Between 2007 and 2011, the national rate of poverty in the United States was 14.3%, but for Black Americans it was nearly twice that at 25.8%. However, White Americans had the lowest poverty rate of any racial group at 11.6% (Macartney, Bishaw, and Fontenot 2013).

Table 1. Important Dates in the History of Racial Health Disparities

Historical Dates	Significance
1619	Beginning of slavery in the American colonies
1863	Signing of the Emancipation Proclamation which granted enslaved Americans their freedom
1865	Creation of the Thirteenth Amendment of the Constitution, which made slavery illegal
1877	Beginning of the Jim Crow Era and racial segregation of public facilities which subjected Black Americans to poorer-quality health facilities and healthcare
1934	Establishment of the Federal Housing Administration and the implementation of discriminatory housing policies that made it extremely difficult for Black Americans to own homes
1964	Passage of the Civil Rights Act which made segregation of public facilities illegal
1965	Passage of Medicaid and Medicare, providing medical insurance to many Americans and increasing the accessibility of healthcare
1968	Passage of the Fair Housing Act, which made housing discrimination illegal

Researchers have shown that approximately 66% of this wealth gap can be attributed to racism and discrimination, which have prevented Blacks from obtaining the same homeownership, income, educational, and employment opportunities as Whites (Yearby 2018, 1113–1152). They are less likely to be in management and professional occupations, but are more likely to be in transportation, healthcare, and service (U.S Bureau of Labor Statistics 2018, U.S Bureau of Labor Statistics 2020). They are also more likely to have jobs that are considered essential during the COVID-19 pandemic, especially those that require close proximity to others and involve frequent exposure to infections, such as nurses and personal care aids (Hawkins 2020). This combined with the fact that fewer Black Americans are able to work from home, makes it more difficult for them to reduce contact with others, placing them at a greater risk of infection (U.S. Bureau of Labor Statistics 2019).

Additionally, Black Americans are more likely to be unemployed or in low-wage jobs that do not provide employer-sponsored health insurance, which can have detrimental effects to their health (Manuel 2018, 1407–1429; Yearby 2018, 1113–1152; Bailey et al. 2017, 1453–1463; Copeland 2005, 265–270). For all medical conditions, adult patients who are uninsured typically have a 25 percent greater mortality rate than those who are insured (Yearby 2018, 1113–1152). As the COVID-19 pandemic progresses, those who are uninsured may be reluctant to seek treatment out of concern for the cost, which can consequently result in more severe outcomes.

Living Conditions

As a result of discriminatory redlining policies and their legacy, American society remains fairly segregated by race. In 2000, approximately 70% of the Black population lived in segregated, predominantly Black neighborhoods (Landrine 2009, 179–184). While the degree of Black-White segregation has decreased over the past 20 years, many Black Americans remain clustered in metropolitan areas, which tends to increase the risk of COVID-19 infection due to the large population density (Rastogi et al. 2011, 1–10; World Health Organization 2020a; Mein 2020, 1).

These predominantly Black neighborhoods tend to have worse living conditions than predominantly White neighborhoods, which increases susceptibility to COVID-19. Predominantly Black neighborhoods tend to have increased exposure to pollution, which makes individuals more susceptible to certain medical conditions, such as asthma, car-

diovascular disease, hypertension, and diabetes. Studies have shown that polluting factories and toxic waste dumps are often intentionally placed in predominantly minority neighborhoods because they have less representation in government and industry and are unable to successfully oppose the placement of these pollutants (Landrine 2009, 179–184; Mohai, Pellow, and Roberts 2009, 405–430). These neighborhoods consequently tend to experience 5–20 times more pollution than White neighborhoods, which has been associated with more severe COVID-19 outcomes (Landrine 2009, 179–184).

Segregated Black neighborhoods also have less access to healthy foods and activities than White neighborhoods (Landrine 2009, 179–184; Block, Scribner, and DeSalvo 2004, 211–217; Walker, Keane, and Burke 2010, 876–884; Powell et al. 2007, 189–195; Morland et al. 2002, 23–29). Black neighborhoods typically have significantly greater amounts of fast-food restaurants and fewer supermarkets than White neighborhoods, limiting access to fresh healthy foods (Block, Scribner, and DeSalvo 2004, 211–217; Walker, Keane, and Burke 2010, 876–884; Powell et al. 2007, 189–195; Morland et al. 2002, 23–29). These neighborhoods also have fewer recreational facilities, such as gyms and pools, which reduces the ability to be physically active (Landrine 2009, 179–184). These factors contribute to higher rates of obesity and diabetes among the Black population, which are both associated with more severe COVID-19 outcomes and increased COVID-19 mortality (Lighter et al. 2020; Sattar, McInnes, and McMurray 2020, 4–6; Stokes 2020; Wang et al. 2020, 6049–6057).

Healthcare Quality

The racial segregation of neighborhoods results in differences in the healthcare facilities and physicians that are available to Black and White Americans. Healthcare facilities in predominantly Black neighborhoods have fewer specialists, fewer technological resources and lower-quality physicians (Landrine 2009, 179–184). Physicians in these areas are less likely to be board certified, typically less knowledgeable about cancer prevention, less likely to follow the recommendations regarding screening for cancer and chronic diseases, provide poorer management of diabetes and hypertension and are less likely to recommend behavioral modifications for patients such as changes in diet or smoking cessation. This subpar medical care likely contributes to the worse health outcomes and the increased prevalence of comorbidities for COVID-19 among the Black population (Landrine 2009, 179–184; Bach et al. 2004, 575–584; Ashford et al. 2000, 59–62).

Black individuals also experience discrimination in healthcare settings. Physicians have been shown to subconsciously prefer White patients and to view Black patients as less intelligent, educated, and medically compliant (Green et al. 2007, 1231–1238; van Ryn, M. and Burke 2000, 813–828). These views impact clinical decision-making and lead physicians to provide Black patients with substandard healthcare (van Ryn, Michelle et al. 2006, 351–357). This bias against Black patients also results in mistrust of healthcare professionals, delays in seeking treatment, and avoidance of the healthcare system, all of which negatively impact the health of Black patients. This bias against Black patients may also affect the way limited resources are allocated during the COVID-19 pandemic (Copeland 2005, 265–270; Milam et al. 2020, 139–141; Sabin et al. 2009, 896–913; Wheeler and Bryant 2017, 1–11).

Healthcare Access

In addition to receiving poorer-quality healthcare, many Black Americans face barriers to accessing healthcare. As previously mentioned, they are more likely to be uninsured, often resulting in delays in treatment and ultimately worse health outcomes (Manuel 2018, 1407–1429; Yearby 2018, 1113–1152; Bailey et al. 2017, 1453–1463; Copeland 2005, 265–270). Predominantly Black neighborhoods also experience higher rates of hospital closures, limiting the availability of health services. In fact, as the Black population increases in a neighborhood, hospitals in that area are more likely to close down and relocate (Sager and Socolar 2006, 1–48). The closing of hospitals results in shortages of healthcare services in these neighborhoods and overcrowding of other healthcare facilities, lowering both the access and quality of services in these facilities. Preliminary information also suggests that members of minority and underserved communities have reduced access to COVID-19 testing sites, due to factors, such as lack of reliable transportation or physician referral (Fouad, Ruffin, and Vickers 2020). Without access to testing, members of these communities may be put at an even greater risk of mortality due to delays in seeking medical attention and unknowingly spreading the virus to their loved ones.

Conclusion

The purpose of this paper is to explore the causes of racial health disparities between the Black and White populations through an investigation of America's history. After reviewing the relevant literature, it is clear that America's history of slavery, segregation, violence, and systemic oppression of Black Americans has led to inequality that significantly impacts their health and increases the risk of COVID-19 infection and mortality.

Differences in wealth, occupation, living conditions, healthcare quality, and healthcare access between Black and White Americans contribute to the occurrence of worse COVID-19 outcomes among Black patients. Because Black Americans have had significantly fewer opportunities for homeownership, education, and employment, they have significantly less wealth than White Americans and are more likely to be unemployed and uninsured, causing them to struggle to afford healthcare (Manuel 2018, 1407–1429;

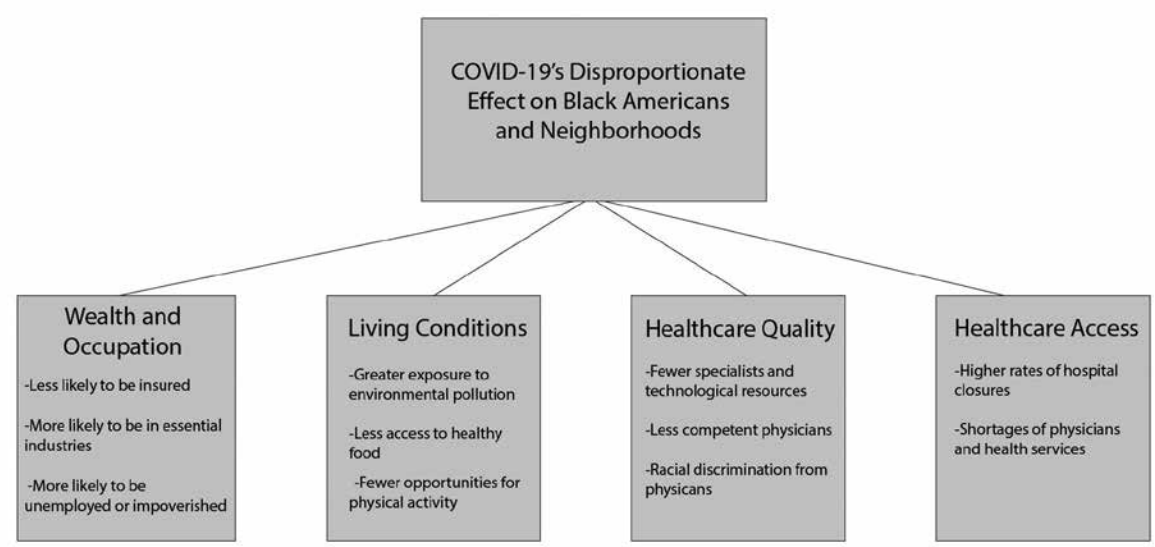

Figure 1. Factors contributing to COVID-19's disproportionate impact on Black Americans and predominantly Black neighborhoods.

Dettling et al. 2017; Yearby 2018, 1113–1152; Bailey et al. 2017, 1453–1463). They are also more likely to be in jobs that cannot be done from home, require close contact with others, and have frequent exposure to infections, increasing their risk of COVID-19 infection (Hawkins 2020; U.S. Bureau of Labor Statistics 2019). Predominantly Black neighborhoods tend to have worse healthcare facilities, fewer board-certified physicians, fewer specialists, and greater rates of hospital closures, than predominantly White neighborhoods (Landrine 2009, 179–184; CDC 2020b; Powell et al. 2007, 189–195; Morland et al. 2002, 23–29). These neighborhoods also tend to have large amounts of pollution and less access to healthy foods and activities, placing the members of these neighborhoods at a greater risk for common COVID-19 comorbidities, such as cardiovascular disease, hypertension, diabetes, and obesity (Landrine 2009, 179–184; Mein 2020, 1; Mohai, Pellow, and Roberts 2009, 405–430; Wang et al. 2020, 6049−6057; Stokes 2020; Block, Scribner, and DeSalvo 2004, 211–217; Walker, Keane, and Burke 2010, 876–884; Powell et al. 2007, 189–195; Morland et al. 2002, 23–29; Lighter et al. 2020; Sattar, McInnes, and McMurray 2020, 4–6).

America's legacy of discrimination against Black individuals has also resulted in implicit bias and discrimination against Black patients. Physicians have been shown to have subconscious preferences for White patients and have biases against Black patients, which impact clinical decision-making and have led to a worse quality of care, mistrust, and worse health outcomes among Black patients (Green et al. 2007, 1231–1238; van Ryn and Burke 2000, 813−828; van Ryn et al. 2006, 351–357; Sabin et al. 2009, 896–913).

Limitations and Further Research

The data and statistics used in this paper are only representative of the COVID-19 information available up to this point. Additionally, cities and states have varying mechanisms for reporting COVID-19 cases and deaths and not all available data contains racial information.

More research regarding race, health outcomes, and COVID-19 should be completed as the pandemic continues. This research could further investigate the following: 1) the accessibility of COVID-19 testing in predominantly Black neighborhoods, 2) implicit racial bias and whether it has played a role in the allocation of medical resources such as ventilators during the pandemic and 3) the impact that COVID-19 has had on other racial minority groups. Although more research needs to be completed, the COVID-19 pandemic has highlighted the persistent racial health disparities present throughout American society. Differences in health outcomes between Black and White Americans will only be reduced if the presence of racism and discrimination is addressed in all areas of American society.

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Original Research

Reliability of the Sterility of Surgical Instruments in the Operating Room: Do We Have a Problem?

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Abstract

Background: Prevention of surgical site infections is an important goal in orthopaedic surgery. The aim of this study was to determine how operating room traffic and covering trays affect bacterial contamination rates of surgical instruments.

Methods: An empty operating room with simulated personnel traffic was used weekly over six weeks. Twelve trays were randomly assigned to one of four groups. Group 1 and 2 consisted of uncovered or covered trays in a low traffic OR while Groups 3 and 4 were exposed to high traffic. Instruments and trays were cultured at zero, one, two, and four hours.

Results: Bacteria grew, at low colony count from three of 12 instrument sets. Six of seven positive cultures occurred during high-traffic simulation, and six of seven occurred in uncovered trays. Neither traffic nor tray coverage reached statistical significance ($p = 0.130$). When considering time for samples ($n = 48$) to be contaminated, 25% of the samples were contaminated at the four-hour mark, but this was not statistically significant ($p = 0.173$).

Conclusions: Bacterial contamination of operating room trays and instruments is not common, but when it does occur, it appears to be in the setting of high operating room traffic, and in uncovered trays. We also observe that contamination is time-dependent over a four-hour time period.

Introduction

The sterility of operating-room instruments throughout a surgery, barring any known irregularities, is an assumption currently made by surgeons. However, little is actually known about the validity of this assumption once the trays are opened. Infections are an important complication in orthopedic surgery and having adequate sterile techniques and instruments helps prevent such infections. Prosthetic joint infection (PJI, also periprosthetic joint infection) is a major concern following total join replacement.[1] Current methods to decrease risk of PJI during surgery include specific operating-room conditions such as laminar airflow and ultraviolet radiation.[2, 3] Perioperative antibiotics are given to prevent wound infections.[4] Risk factors for PJI include advanced age, medical comorbidities, high BMI, immunosuppression, and poor nutrition. The ASA score is used to assess preoperative risk.[5] *Staphylococcus aureus* is the most common pathogen for post-operative orthopedic infections.[6]

While operating room (OR) conditions are standardized and tightly controlled in order to decrease bacterial wound contamination, some common surgical practices may affect these conditions and allow contamination of surgical instruments. For example, opening operating room doors multiple times during a surgery will affect airflow and airborne particulates despite air filtration and adequate air exchanges.[7] The impact of high-volume health care worker traffic on instrument sterility is also a concern. Operating room traffic can lead to an increased risk of contamination of the sterile field during surgery and thus could lead to increased rates of infection post-surgery. Every time an operating door is open, laminar air flow is disturbed, turbulent flow increases, and microbes can contaminate the surgical field by convection.[7] Bacterial air content in the operating room can be calculated by measuring bacterial colony-forming units (CFU)/m^3 of filtered air. It is currently recommended that colony counts be less than 10 CFU/m^3 during implant surgery, with lowest infection risk when colony counts are <1 CFU/m^3.[8] High rates of door opening have been correlated with high levels of bacterial CFU/m^3.[9]

In addition, increasing numbers of persons in an operating room and increasing pedestrian movement increase the chances of compromising the integrity of the sterile field. There are no currently agreed upon methods to regulate operating room traffic during surgeries.[10]

A recent study found that the average number of door openings was 60 in cases of initial total joint arthroplasty and 135 in revision cases.[11] The authors found that 23% of door openings were to obtain supplies, 12% to communicate information about the case, and 47% were unexplained. Most of the doors were opened by circulating nurses and the equipment representatives (26% and 20% respectively). Another study found that only 7% of door openings were "necessary;" they allowed entry of expert consultants.[9]

Ritter and colleagues found that the number of people in an operating room had a stronger effect on air contamination

(measured by microbiological counts) than did leaving the door of an operating room open.[12] Pryor and colleagues found that infection rates were higher as numbers of people in the operating room during surgery increased.[13]

Researchers have found that bacterial contamination of instrument trays is time-dependent and that it can be decreased by covering trays.[14] However, they found that operating room traffic did not influence tray sterility. There are no current recommendations concerning the timing of setting up a sterile field and opening surgical trays in relation to room preparation and patient entry and preparation. These practices vary based upon hospital, surgeon and nursing preferences.[15, 16] If surgical trays are opened but not used right away, current practice in the operating room generally is to cover the instrument table with disposable non-woven surgical drapes.[17]

The purpose of this study was to examine 1) how long it takes for trays to become bacterially contaminated once opened, 2) how this time-dependent contamination is affected by operating-room traffic and 3) if covering opened surgical trays with drapes delays time-dependent contamination of surgical instruments. Our hypothesis was that 1) contamination is time-dependent, 2) contamination will occur most quickly when there is high operating room traffic and 3) bacterial tray contamination will be delayed when opened trays are covered by surgical drapes.

Materials and Methods

Two sterile orthopaedic surgical instrument trays were opened in a positive-air-flow operating room each week for six consecutive weeks (12 opened trays during the study period). The study was performed during routine daytime operating hours in operating rooms which were not in use at the time of the study; rooms were cleaned the night before the study, and not used again until cleaned after the study. Trays were randomly assigned to one of four groups and were opened using standard sterile technique. Each week, two new sterile trays were randomly assigned to either the covered or uncovered groups. Each tray was set up on a separate table. One tray was covered with two sterile surgical drapes immediately after opening (OR Table A), while the other was left uncovered (OR Table B).

Personnel in the study operating rooms were medical students who followed prearranged door opening and OR movement protocols. A single person was responsible for the traffic flow into and out of the operating room from a non-sterile corridor. A door opening was defined to be complete inward door movement of a single-entry door. Room traffic alternated between high and low traffic each week. High traffic was defined as 60 door openings, whereas low traffic was deemed 30 openings over the four-hour study period. A third of door openings occurred within the first and last 30 minutes of the "case" in order to best recreate workflow traffic during procedures.

At hours 0 (control) and 4, two separate sterile swab cultures were obtained from OR Tables A and B — one of the tray surfaces only, and one of the instrument surfaces only. At hours 1 and 2, one swab was used to sample the tray and instruments together. Specimens were plated on blood agar immediately after swabbing and cultures were read daily for five days. Cultures were reported as having "No growth," or by the number of colonies, recorded as total CFUs. Organisms were identified to the species level. Control swabs of freshly opened sterile instruments had no growth.

Statistical Analysis

Total CFU values of bacterial growth were recorded for each sample. Total CFU data were analyzed using negative binomial regression: the two independent variables were the presence or absence of tray coverage and high versus low room traffic.

Results

Specimens taken during the 12 sampling events yielded positive cultures in three swabs of trays (25% of all trays), three swabs of instruments (25% of all instrument sets) and one combined swab of instruments and tray (Table 1). Of culture positive trays, one was in the covered group and two in uncovered group. Of positive tray cultures, one had four total CFUs, one had three CFU, and one had one CFU (Table 2). There was bacterial growth on samples from week 2 (high-traffic condition) and week 3 (low-traffic condition) but overall 13 CFU of growth (all samples) during the high-traffic week but only one CFU during the low-traffic week. A sample from the covered table (OR Table A) during week

Table 1. Summary of Total CFUs by Sampling Event*

Week	OR Traffic	Tray (Covered or Uncovered)	Total CFUs†	Organism Type
1	Low	Covered	0	—
1	Low	Uncovered	0	—
2	High	Covered	1	1
2	High	Uncovered	12*	1, 2, 3, 4
3	Low	Covered	0	—
3	Low	Uncovered	1	5
4	High	Covered	0	—
4	High	Uncovered	0	—
5	Low	Covered	0	—
5	Low	Uncovered	0	—
6	High	Covered	0	—
6	High	Uncovered	0	—

Organism Type:
1 = *Staphylococcus epidermidis*
2 = *Staphylococcus hominis*
3 = *Micrococcus luteus*
4 = *Staphylococcus lugdunensis*
5 = Bacillus species not anthracis

*One CFU was detected at hour 2 during week 2 — high-traffic environment, uncovered sample; all remaining 11 CFUs were detected at hour 4 samplings.
†Sum of CFUs of all cultures taken under each condition.

Table 2. Characteristics of Positive Sampling Events

Week	OR Traffic	Tray (Covered or Uncovered)	Sample Time	Sample Location	Organism Type	CFU
2	High	Covered	4	Tray	*Staphylococcus epidermidis*	1
2	High	Uncovered	2	Combined	*Staphylococcus epidermidis*	1
2	High	Uncovered	4	Tray	*Staphylococcus hominis*	3
2	High	Uncovered	4	Instrument	*Staphylococcus hominis*	2
2	High	Uncovered	4	Tray	*Micrococcus luteus*	4
2	High	Uncovered	4	Instrument	*Staphylococcuslugdunensis*	2
3	Low	Uncovered	4	Instrument	Bacillus species not anthracis	1

2 (high traffic) grew *S. epidermidis* at four hours. Samples from the uncovered table (OR Table B) showed growth of *S. hominis* and *Micrococcus luteus* from a tray swab at four hours, *S. hominis* and *S. lugdunensis* from an instrument swab at the four hours, and *S. epidermidis* from a tray plus instrument swab at two hours (Table 2). A sample from the uncovered table during week 3 (OR Table B, low traffic) showed growth of Bacillus species, not anthracis, at four hours.

Based on a negative binomial regression of Total CFU (as the dependent variable), neither room traffic ($p = 0.130$) nor tray coverage ($p = 0.130$) reached statistical significance, but it is clear that when growth did occur, it was more likely to happen when trays were uncovered, and when OR traffic was high.

Discussion

We found, overall, that there was increased potential for contamination in the high traffic/uncovered trays. Contamination occurred in 25% of trays sampled (3/12) and more were from trays in the high-traffic condition (2/6) than with low traffic (1/6). However, high-traffic condition was not a statistically significant factor in the contamination of trays ($p = 0.130$).

One of 12 trays showed contamination with four different types of organisms while two other trays showed contamination for with a single organism. With the three contaminated trays, we saw one contamination at the two-hour mark, but most positive cultures were seen on samples at the four-hour mark. Contamination could have occurred any time between two to four hours after tray opening. It is important to note that during surgeries, trays are usually opened before skin incision occurs. Our results suggest that delaying tray opening as close as possible to skin incision could decrease surgical instrument contamination.

Table 4. Negative Binomial Analysis

LR Statistics for Type 3 Analysis			
Source	**DF**	**Chi Square**	**p-Value**
Traffic	1	2.30	0.130
Cover	1	2.30	0.130

Instrument contamination does not always lead to postoperative infection in surgical patients, especially with low levels of contamination and commensal organisms. However, the organisms isolated in this study can certainly cause infections of implanted orthopedic devices, especially those used in total joint replacement surgery, and it is by no means certain that even low levels of instrument and tray contamination are safe.

OR traffic and instrument covering were not statistically significant in multivariate analysis, but this was true because instrument contamination did not occur often under any of our study conditions. But our study suggests that while instrument and tray contamination are not common, they seem mainly to occur with increased operating room traffic (especially door opening), and when instrument trays are uncovered. Our study, therefore, supports practices which minimize operating room traffic, and supports covering sterile instruments when they are not in use.

While our findings are not sufficiently robust to dictate clinical policy, they suggest a need for a substantially larger study.

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Table 3. Analysis of Maximum Likelihood Multivariate Binomial Regression Parameter Estimates

Parameter	DF	Standard Estimate	Wald Error	95% Confidence Limits	Wald Chi-Square	Pr > ChiSq
Intercept	1	–1.2178	1.3762	–3.91511 ; 1.4795	0.78	0.3762
Traffic: High	1	2.6726	1.6885	–0.6367 ; 5.9820	2.51	0.1135
Cover: Covered	1	–2.6726	1.6885	–5.9820 ; 0.6367	2.51	0.1135
Dispersion	1	3.2221	2.8706	0.5621 ; 18.4707		

Note: The negative binomial dispersion parameter was also estimated by maximum likelihood.

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Original Research

Repeat Irrigation and Debridement of Upper Extremity Infections: Do Repeat Cultures Change Antibiotic Treatment Regimens?

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Abstract

Upper extremity infections are frequently treated by hand and upper extremity surgeons. Organism identification and their antibiotic sensitivity profile are critical for successful treatment. Antibiotic treatment for infections is complicated by quickly changing resistance patterns and increasing incidence of polymicrobial infections. While many infections resolve with antibiotics alone, some require one or more surgical procedures in which culture data is obtained. The purpose of this study was to determine if repeat cultures taken at subsequent surgical debridement of upper extremity infections changed antibiotic treatment. A retrospective review was performed using International Classification of Diseases, Ninth Revision (ICD-9) codes to identify all adult patients treated for an upper extremity infection at a single institution with two or more separate culture data over a period of five years. Culture and sensitivity data were comparted to identify changes in antibiotic treatment and associated risk factors. Culture data were categorized as "same" if the repeat culture demonstrated the same organisms and sensitivities, or "different" if the repeat culture demonstrated different organisms or sensitivities compared to the results of the first culture. We further subdivided the group with "different" microorganism composition into same antibiotic treatment and different if there was a change in antibiotic treatment. A total of 183 patients were identified who underwent two or more surgical procedures with repeat culture data. Organisms identified with repeat culture were the same or no growth in 153 patients and different in 30 patients. The antibiotic treatment did not require a change in 170 (92.9%) of the total patients. Of the 30 patients with different repeat cultures, antibiotic treatment changed in only 13 patients (43.3%). Patients who had a change in antibiotic treatment were more likely to have hepatitis C ($p = 0.005$). Cultures are regularly obtained at initial and subsequent surgical debridement's for upper extremity infections. Repeat culture data changed antibiotic treatment in only 7.1% of patients from our cohort.

Introduction

Hand and upper extremity surgeons frequently treat upper extremity soft tissue infections. The severity and complexity of infections varies from simple cellulitis, deep space collections, flexor tenosynovitis, and necrotizing fasciitis. Delayed or inadequate treatment can result in significant loss of function, amputation, or even death. Upper extremity infections most commonly result from blunt or penetrating trauma, but surgery, poor hand hygiene, animal bites, or human bites can all lead to infections.[1–3] The current opioid epidemic and rise in intravenous drug use has also increased the number of upper extremity infections treated by hand and upper extremity surgeons.[4]

Most upper extremity infections can be successfully identified and treated following a thorough history and physical examination. Computerized tomography and magnetic resonance imaging of the infected area can identify deep space collections not appreciated on physical exam. Treatment varies based on infection severity and location. Superficial cellulitis may be treated with oral or intravenous antibiotics while infections with deep space collections, flexor tenosynovitis, and necrotizing fasciitis frequently require one or more surgical procedures.[5] Depending on abscess size and location, irrigation and debridement may be safely performed at the bedside.[6] Cultures are regularly taken during bedside or formal irrigation and debridement to isolate the causative organism. Organism identification and an accurate antibiotic sensitivity profile is essential to direct appropriate antibiotic treatment and reduce the burden of antibiotic resistance. Increasing polymicrobial infections and changing resistance patterns have added an additional level of complexity in treating these infections.[4, 7]

In severe infections, multiple surgical procedures may be required, and cultures are often taken at the time of each procedure. The importance of obtaining initial cultures is well accepted in practice, but the value of obtaining additional cultures and their influence on antibiotic treatment is not well understood.

The purpose of this study was to determine if repeat cultures taken at subsequent surgical procedures resulted in a

different bacteria or antibiotic sensitivity profile and therefore a change in antibiotic therapy. The secondary purpose was to identify risk factors in patients who had a change in antibiotic treatment based on additional culture data. The authors hypothesize that subsequent culture data causes a change in antibiotic treatment in less than 10% of patients.

Materials and Methods

Following Institutional Review Board approval, ICD-9 codes associated with an upper extremity infection were applied to our institutional coding database for all patients admitted to our institution from October 2010 to August 2015. A retrospective chart review was performed to confirm patients had a diagnosed upper extremity infection and to collect clinical data. Inclusion criteria consisted of patients 18 years or older who underwent more than one surgical procedure for an upper extremity infection (bedside or in the operative theater) with cultures obtained at each separate procedure. Culture data, including organism and antibiotic sensitivities, were categorized as "same" if the repeat culture demonstrated the same organisms and sensitivities or no growth, and "different" if the repeat culture demonstrated different organisms or different antibiotic sensitivities compared to the results of the first culture. We further subdivided the group with "different" repeat culture data into "same antibiotic treatment" or "different antibiotic treatment" based on whether there was a change in antibiotic therapy after the second culture result. Patient demographics, comorbidities, and clinical factors were also collected. A P value of less than 0.05 was considered significant.

Results

Over the five-year study period, there were 2,901 patients with an associated ICD-9 code for an upper extremity infection. Of these patients, 183 were included in the study who underwent two or more surgical procedures where cultures were obtained. Repeat culture results were the same in 153 patients (83.6%) and different in 30 patients (16.4%). Antibiotic treatment did not require a change in 170 patients (92.9%). Of the 30 patients with different repeat culture data, antibiotic treatment was changed in only 13 patients (43.3%). No antibiotic changes were made to those patients who had the same culture profile or no growth on repeat culture testing.

Patients who had their antibiotic therapy changed after repeat cultures were significantly more likely to have hepatitis C virus (19.4% vs 4.1%; $P < 0.5$). Patients with a psychiatric history showed a trend towards requiring a change in antibiotic treatment though this did not reach statistical significance.

There was no significant difference in other patient comorbidities such as intravenous drug use, hypertension, diabetes mellitus, human immunodeficiency virus, or smoking. There was also no significant difference in patient demographics including sex, age, and ethnicity. Clinical factors including fever, length of stay, white blood cell count, C-reactive protein, and erythrocyte sedimentation rate also showed no significant difference (Table 1).

There were 163 patients who had positive bacterial growth on their first culture with 38 different organisms identified. Methicillin-resistant Staphylococcus aureus (MRSA) was the most common bacteria, followed by Methicillin-sensitive Staphylococcus aureus and Alpha Hemolytic streptococcus (Table 2). MRSA was present in isolation in 53/163 (32.5%) of cultures and with one or more bacteria in 14/163 (8.6%) of all cultures. Of the 67 MRSA positive cultures, 14 (20.9%) also had growth of one or more additional bacteria. Polymicrobial (two or more bacteria) accounted for 43/163 (26.4%) of all infections in this study. MRSA was present in 14/43 (32.6%) of all polymicrobial infections.

Discussion

Obtaining accurate culture data in upper extremity infections is critical for guiding antibiotic treatment. Repeat cultures are often obtained at the time of subsequent procedures but their usefulness and influence on antibiotic treatment is not well understood. In this study, repeat cultures were different from those obtained at the initial procedure in 16.4% of patients. In these cases, antibiotics required a change in less than half the time. Overall, less than 10% of patients had a change in antibiotic therapy because of second culture data.

Hepatitis C was identified as an independent risk factor for a change in antibiotic treatment. Patients with hepatitis C often develop various cutaneous diseases.[8] Poor soft tissue integrity combined with immunosuppressive treatments may increase the risk of complex infections in patients with hepatitis C. Diabetes mellitus is a known risk factor for upper extremity infections[1, 9] but was not a significant risk factor for a change in antibiotic treatment in this study. Human immunodeficiency virus also increases a patient's risk for developing infections, particularly with MRSA,[10, 11] but was not a significant risk factor for changing antibiotic treatment in our study. Intravenous drug use has also been shown to increases a patient's risk for developing a MRSA infection[12, 13] but was not a significant risk factor for changing antibiotic treatment.

Consistent with previous studies, MRSA was the most prevalent organism isolated in this study, followed by MSSA and Streptococcus species.[4, 7, 14, 15] Polymicrobial infections accounted for 26.4% of all infections in our cohort. This is slightly higher than previous studies which have reported polymicrobial infections in 9.4%, 19.5% and 22% of upper extremity infections.[4, 7, 15] Over one fifth of MRSA positive cultures had growth of one or more additional bacteria while MRSA was present in about one third of polymicrobial infections. This is an increase from the findings of Fowler

Table 1. Demographic and Clinical Variables

Variable	All Cases (%)	Changed Antibiotic Treatment N (%)	Odds Ratio (95% Confidence Interval)	P Value
Sex				
F	71 (38.8%)	6 (8.5%)	1.38 (0.45, 4.30)	0.57
M	112 (61.2%)	7 (6.3%)		
Age, y				
≤45	91 (49.7%)	8 (8.8%)	1.68 (0.53, 5.33)	0.41
>45	92 (50.3%)	5 (5.4%)		
LOS, days				
≤5	97 (53.0%)	9 (9.3%)	2.10 (0.62, 7.07)	0.26
>5	86 (47%)	4 (4.7%)		
Race/Ethnicity				
Caucasian	48 (26.3%)	6 (12.5%)	2.57 (0.69, 9.64)	0.24
Hispanic/Other	59 (32.2%)	3 (5.1%)	0.96 (0.21, 4.49)	
African American	76 (41.5%)	4 (5.3%)		
IVDU				
Y	64 (35.2%)	7 (10.9%)	2.29 (0.74, 7.14)	0.23
N	118 (64.8%)	6 (5.1%)		
Fever				
Y	41 (22.5%)	4 (9.8%)	1.59 (0.46, 5.44)	0.49
N	141 (77.5%)	9 (6.4%)		
HTN				
Y	58 (31.9%)	2 (3.4%)	2.73 (0.58, 12.72)	0.23
N	124 (68.1%)	11 (8.9%)		
HCV				
Y	36 (19.8%)	7 (19.4%)	5.63 (1.76, 17.99)	0.005
N	146 (80.2%)	6 (4.1%)		
Psychiatric History				
Y	26 (14.3%)	4 (15.4%)	2.97 (0.84, 10.47)	0.09
N	156 (85.7%)	9 (5.8%)		
Diabetic				
Y	44 (24.2%)	12 (8.7%)	4.10 (0.52, 32.43)	0.19
N	138 (75.8%)	1 (2.3%)		
HIV				
Y	9 (4.9%)	2 (22.2%)	4.21 (0.78, 22.71)	0.13
N	173 (95.1%)	11 (6.4%)		
Smoker				
Y	112 (61.9%)	9 (8.0%)	1.42 (0.42, 4.80)	0.77
N	69 (38.1%)	4 (5.8%)		
WBC				
≤12	89 (48.9%)	5 (5.6%)	1.58 (0.50, 5.03)	0.57
>12	93 (51.9%)	8 (8.6%)		
CRP (mg/L)				
≤41	74 (50%)	5 (6.8%)	1.44 (0.44, 4.77)	0.76
>41	74 (50%)	7 (9.5%)		
ESR (mm/hr)				
≤32	75 (52.1%)	7 (9.3%)	1.32 (0.40, 4.36)	0.77
>32	69 (47.9%)	5 (7.2%)		

LOS, length of stay; IVDU, intra-venous drug use; HTN, hypertension; HCV, hepatitis C; HIV, human immunodeficiency virus; WBC, white blood cell count; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate.

and colleagues who reported MRSA in only 12.3% of polymicrobial infections in their study.[15]

A weakness of this study was its retrospective nature. As such, the decision to change antibiotic treatment was not standardized and was at the discretion of the treating surgeon or consulting infectious disease service. This decision may have been biased based on their individual experience and treatment practice. The decision to and technique of obtaining culture were not standardized and were also at the discretion of the treating surgeon. We also acknowledge that while bedside procedures are appropriate for some upper extremity infections, there may be a higher risk of contamination from the skin flora that may affect culture results. While this retrospective study is the first to our knowledge to investigate the utility of repeat cultures in upper extremity soft tissue infections, further prospective studies would be helpful

Table 2. Prevalence of Organisms Identified on Initial Culture

MRSA	67 (41.1%)
MSSA	35 (21.5%)
Alpha Hemolytic streptococcus	16 (9.8%)
Streptococcus Pyogenes (Group A)	13
Coagulase-negative Staphylococcus	12
Streptococcus agalactiae (Group B)	10
Proteus mirabilis	6
Streptococcus anginosus	6
Klebsiella pneumoniae	5
Diphtheroid bacilli	4
Microaerophilic streptococci	4
Streptococcus constellatus	4
Group C Streptococcus	4
Enterobacter aerogenes	3
Pasteurella	3
Escherichia coli	3
Eikenella corrodens	3
Enterococcus faecalis	2
Streptococcus intermedius	2
Normal Skin Flora	2
Enterobacter cloacae	2
Group F Streptococcus	2
Group G Streptococcus	2
Prevotella corporis	2
Pseudomonas aeruginosa	2
Ancinetobacter baumannii complex	2
Prevotella bivia	1
Peptostreptococcus prevotii	1
Streptococcus pneumoniae	1
Klebsiela oxytoca	1
Prevotella oralis	1
Bacillus Species	1
Enterobacter gergoviae	1
Citrobacter freundii	1
Haemophilus parainfluenzae	1
Fusobacterium	1
Streptococcus corrodens	1
Bacteroides fragilis	1

in determining which situations would be most appropriate to obtain repeat cultures. Reducing the burden of unnecessary cultures that do not change patient care has the potential to save time and money for health care systems.

Conclusion

The decision to obtain repeat cultures should be at the discretion of the treating surgeon. This study supports obtaining repeat cultures in patients with upper extremity infections who have a history of hepatitis C. A history of diabetes, human immunodeficiency virus, and intravenous drug use were not significant risk factors for a change in antibiotic treatment; however, repeat cultures can be considered in these patients due to their historically high risk of infection complications and complexity.

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Medical Student Research Project

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Patient Perception of Vulnerability While Wearing Sling or Brace

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Abstract

Orthotic devices such as braces and slings are frequently worn following orthopaedic procedures. Patient compliance with prescribed orthotic device wear is often an important component of the postoperative protocol, and failure to wear these devices can lead to delayed recovery or poor outcomes. There are a variety of factors that may contribute to patient noncompliance with orthotic device wear, but to date few studies have evaluated why some patients do not adhere to their prescribed treatment plan. The aim of this study was to examine whether fear of appearing vulnerable while wearing an orthotic device could lead to patient noncompliance with orthotic device wear in an urban, underserved population. A telephone survey was administered to postoperative clinic patients of a single attending surgeon. Patients were eligible for inclusion if they were prescribed an orthotic device or ambulatory assistive device following surgery of the shoulder, knee, or foot between September 2019 and March 2020. Patients under the age of 18 and incarcerated patients were excluded from the study. A total of 23 questions were administered in the study. Thirty-seven of the eligible 55 patients (67%) completed the survey. The frequency of compliance with orthotic device wear outside the home was reported as "always" by 31/37 patients (84%), "often" by 3/37 patients (8%), "sometimes" by 1/37 patients (2.7%), "rarely" by 1/37 patients (2.7%), and "never" by 1/37 patients (2.7%). When asked which factors would be most likely to lead to noncompliant behavior if experienced, 35% of patients (13/37) reported discomfort, followed by 32% (12/37) patients reporting difficulty traveling, 19% (7/37) patients reporting a perception of vulnerability, and 8% (3/37) patients reporting the experience of negative social pressure. Eight out of the 37 respondents (21.6%) reported experiencing any perception of vulnerability while wearing their orthotic devices. Our results suggest that the primary reason for noncompliance in our patient population was discomfort from the device, and that patient perception of vulnerability did not play a large role in deterring patients from orthotic device wear. A high proportion of patients (84%) denied noncompliant behavior entirely, demonstrating their understanding of the importance of compliance for their recovery.

Introduction

Surgeries addressing shoulder and knee injuries are some of the most common procedures performed by orthopedic surgeons. A population-based study reported that annually, surgeries of the knee represent the most common orthopedic procedures at over 40% and shoulder-based surgeries as the third most common procedure at 17%.[1] Of these, about 100,000 ACL reconstructions and 75,000 rotator cuff surgeries alone are performed annually in the United States.[2–4] Given the prevalence of these surgeries, it is important to understand the best method of treatment to ensure maximal recovery.[1]

Braces, slings, and knee braces are frequently worn following the surgical repair of joints and limbs and are designed to immobilize or restrict movement of the injured area with the purpose of protection, alignment, and support during the healing process.[7–13] These devices are collectively referred to as orthotic devices. Ambulatory assistive devices such as crutches are also effective in combination with knee braces by transferring some weight-bearing load from the lower to upper body.[14] Many studies have placed a focus on the most efficient surgical procedures and recovery protocol, but if this recovery protocol is not followed, the benefits of the surgery can be diminished or lost.[5, 6]

Compliance with the recommended treatment is crucial for recovery. Poor adherence is one of the greatest causes of failure to recover.[5, 6] In comparison to the volume of studies focused on treatment efficacy, few studies have evaluated why some patients do not adhere to their prescribed treatment plan.[15] Unfortunately, the limited published research concerning noncompliance does not consider many factors

beyond static descriptors of patient demographics or properties of the injury itself.[5, 16–20] A major gap in current literature exists concerning the dynamic nature of a patient's everyday life experiences and how the use of these devices could affect those experiences. Each patient must evaluate the degree to which their device affects their everyday activity and decide if they can accept this cost to fully recover. A factor that seems to be uninvestigated up until now is a patient's perception of "vulnerability" outside of the home and how this may affect device-wearing compliance.

Skogan et al. defined vulnerability as the "physical condition of individuals and recognition by potential offenders that they can be exploited."[21] Singer et al. found that the physical disabilities of older people greatly increased their vulnerability, particularly in violent urban areas. He posited that these potential victims could limit the possibility of victimization by avoiding the dangerous situation altogether.[22] A later study confirmed that 60% of residents living in high-crime cities reported altering their behavior to avoid victimization. The most common practice was avoiding being outdoors at night, with additional precautionary behavior including driving instead of walking, traveling with company, and avoiding dangerous areas.[21]

Although vulnerability caused by the physical disabilities from old age has been studied, these are conditions not easily hidden from potential offenders. In contrast, wearing an orthotic device or using crutches is a modifiable behavior, like traveling with company or avoiding dangerous areas. We believe that patients presenting from an area high in violent crime may feel that their device poses a risk to their wellbeing by advertising a limited ability to defend themselves. For this reason, it could become a means of street safety to avoid showing this exploitable condition to potential attackers by simply not using their device altogether. The purpose of our study is to determine, using a survey, if patients are using their prescribed device, and if not, if it is due to fear of vulnerability.

Methods

A survey was conducted by telephone to patients of Temple University's Orthopaedic Surgery and Sports Medicine department as part of a quality improvement project designed to improve patient care.

Study participants were patients who were prescribed an orthotic device or ambulatory assistive device following surgery of the shoulder, knee, or foot by a single board certified orthopaedic surgeon between September 2019 and March 2020. The specific types of orthotic devices used by eligible patients included the shoulder abduction sling, hinged knee brace, or CAM walker boot. Patients were also eligible if crutches were prescribed as an ambulatory assistive device. An additional inclusion criterion was an age of 18 or older at the time of surgery. Patients were excluded if incarcerated.

A total of 55 patients were deemed eligible, determined by referencing the orthopedic department's electronic record-keeping system. This number of patients was chosen with the expectation of reaching an 80% response rate, resulting in at least 44 responses. A certain degree of participant non-response was anticipated from declining the survey or not answering the phone. March 2020 was chosen as the end date for study eligibility due to the outbreak of the COVID-19 disease at this time, resulting in a hiatus in surgical procedures and device prescription.

Patients were contacted by telephone by the first author. It was explained to patients that our study was interested in their experience while using these prescribed devices. In the interest of preventing response bias, it was not disclosed that the survey was designed to investigate possible reasons for device-wearing noncompliance. After confirming their understanding of the voluntary, anonymous nature of the survey and its process, a total of 23 questions were given.

The first part of the survey confirmed the surgical location, side, and type of device prescribed. Participants that were provided a device for shoulder recovery were also asked their side of hand dominance.

The next part of the survey utilized a 5-point Likert scale as a means of collecting standardized data. Participants were asked the frequency of device-wearing inside, followed by the frequency of device-wearing outside of the home. Next, questions were presented to measure the degree to which participants felt that they experienced each investigated factor of noncompliance. This was followed by investigating the degree to which it did, or would, affect their decision to wear their device, depending on if it were experienced, or not, respectively. In order, the investigated factors of noncompliance included forgetfulness, low health literacy, device discomfort, travel or public transportation difficulty, negative social interactions, and the perception of vulnerability. An additional question addressing vulnerability asked participants the frequency with which they intentionally hid their device while wearing it.

In the last part of the survey, participants were asked which of the factors they felt contributed the most to not wearing their prescribed device. The survey concluded by requesting participant demographics during the period when the device was prescribed. These included the participant's zip code/neighborhood, level of education, and employment status. These were used as additional factors for analysis as possible predictors of noncompliance.

Results

Thirty-seven of the eligible 55 patients (67%) were able to complete the survey. Shoulder injuries were the more common injury location (n = 20) followed by lower extremity injuries of the knee and/or foot (n = 17). One hundred percent of patients agreed that they were provided and instructed

to use one or more of the following orthotic devices: shoulder abduction sling, hinged knee brace, or walker boot.

Patients responded to the degree they experienced negative factors while using their orthotic device, with difficulty traveling experienced the most by 23/36, followed by a perception of vulnerability experienced by 8/36, and negative social pressure experienced by 2/37 (Figure 1). The physical comfort of the orthotic device was reported to be excellent by 6/37 patients (16%), good by 17/37 patients (46%), and fair by 14/37 patients (38%) (Figure 2). When asked which factors would be most likely to lead to noncompliant behavior if experienced, 13/37 patients reported discomfort, followed by 12/37 patients reporting difficulty traveling, 7/37 patients reporting a perception of vulnerability, and 3/37 patients reporting the experience of negative social pressure (Figure 3). Patients reported the frequency of compliance to wearing their prescribed orthotic device, both in an inside and outside setting. The frequency of compliance outside was reported as always by 31/37 patients (84%), often by 3/37 patients (8%), sometimes by 1/37 patients (2.7%), rarely by 1/37 patients (2.7%), and never by 1/37 patients (2.7%). The frequency of compliance inside was reported as always by 26/37 patients (70%), often by 8/37 patients (22%), sometimes by 2/37 patients (5.4%), and rarely by 1/37 patients (2.7%) (Figure 4).

The main determinant of device noncompliance was discomfort from the device, reported in 11/39 responses (28%),

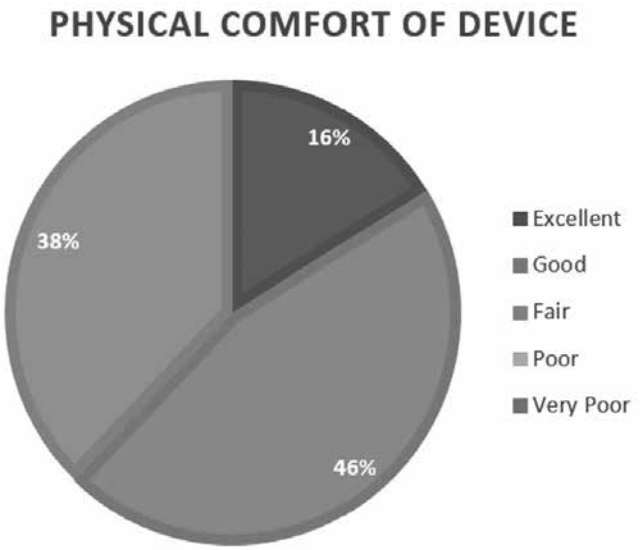

Figure 2. Patient ratings of level of comfort of their orthotic devices.

followed by forgetfulness in 4/39 (10%), difficulty traveling in 3/39 (8%), a perception of vulnerability in 2/39 (5%), and low health literacy in 2/39 (5%). More patients denied noncompliant behavior compared to any individual factor for noncompliance, with a total of 17/39 responses (44%). Due to two patients being unable to decide between two determinants, both options were included in analysis, accounting for the 39 responses (Figure 5).

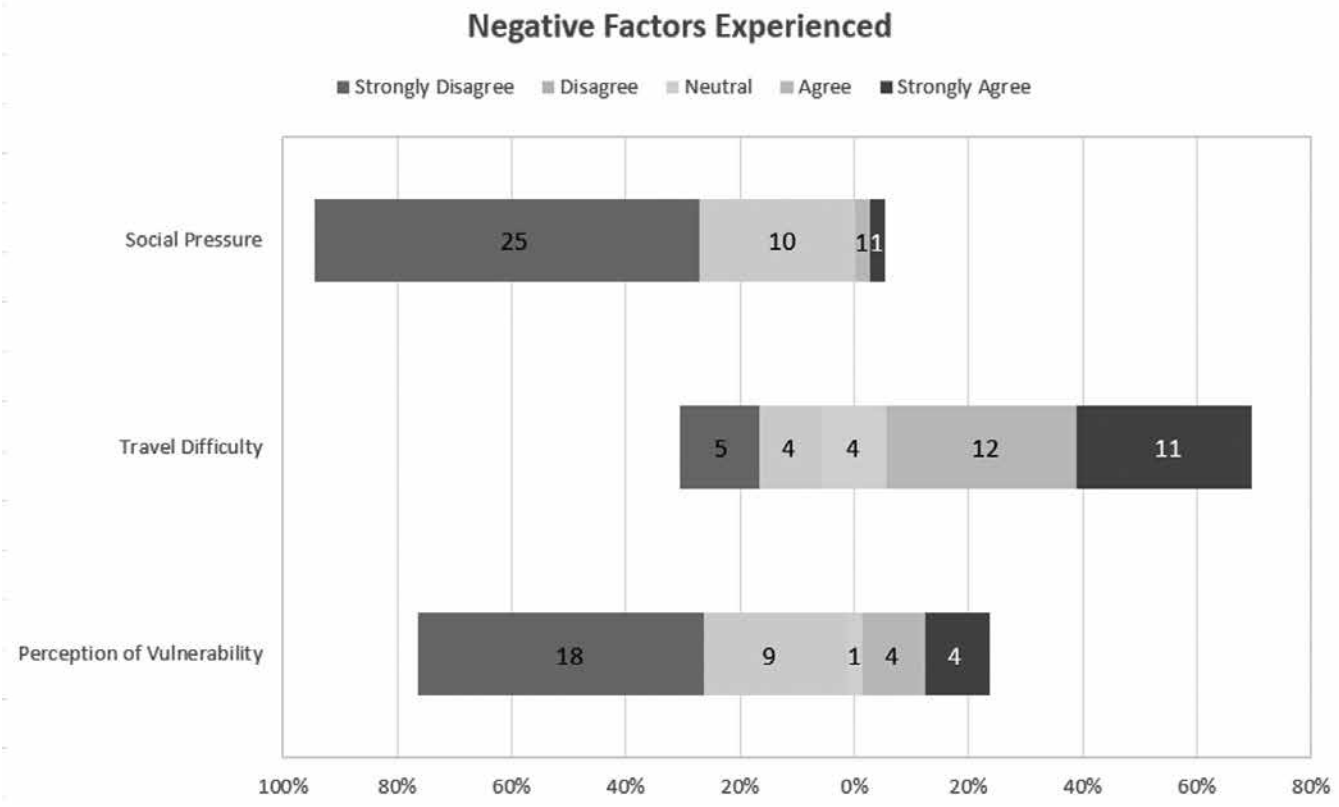

Figure 1. This figure demonstrates patient responses to whether or not they experienced the proposed negative factors while wearing their orthotics outside the home.

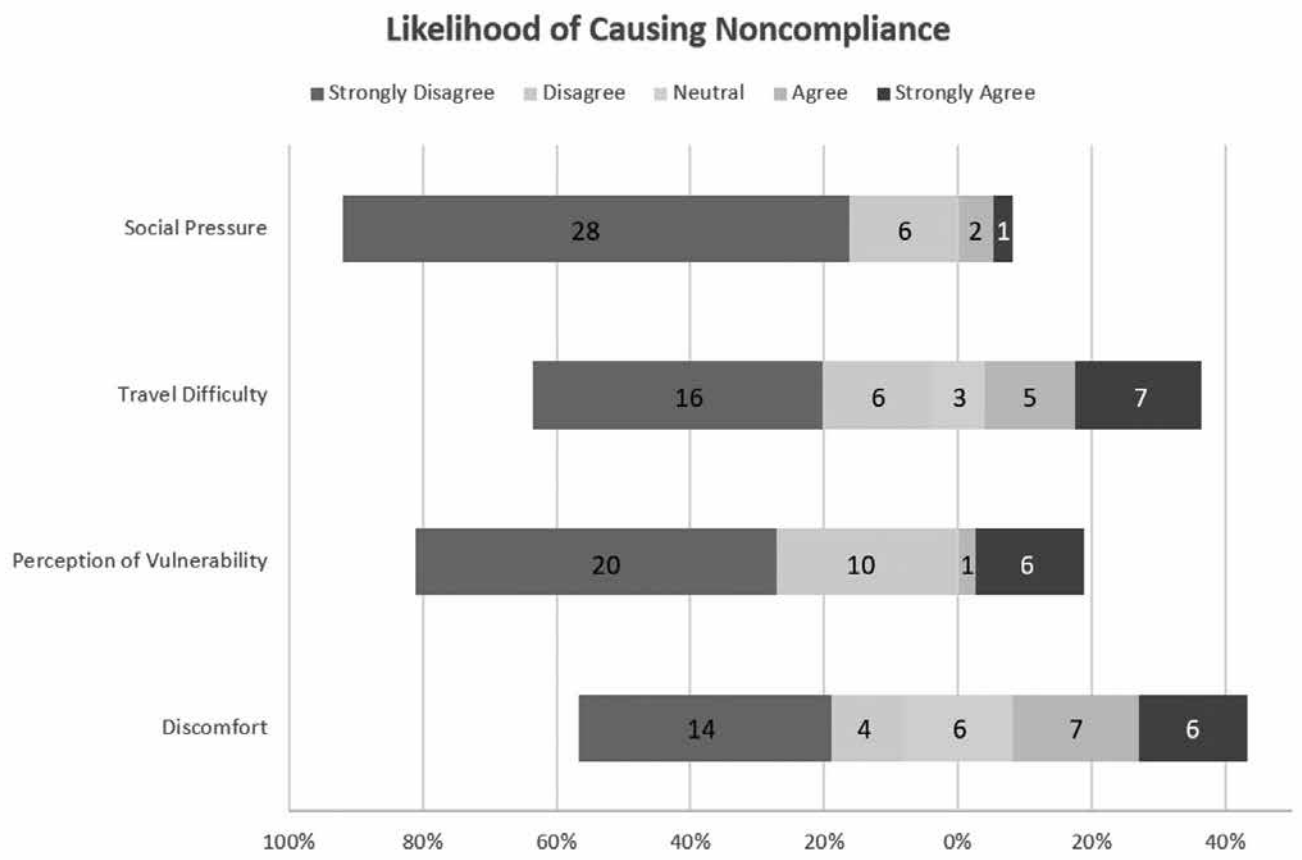

Figure 3. Patient responses to the likelihood that the proposed negative factors could lead to noncompliance with device wear outside of the home.

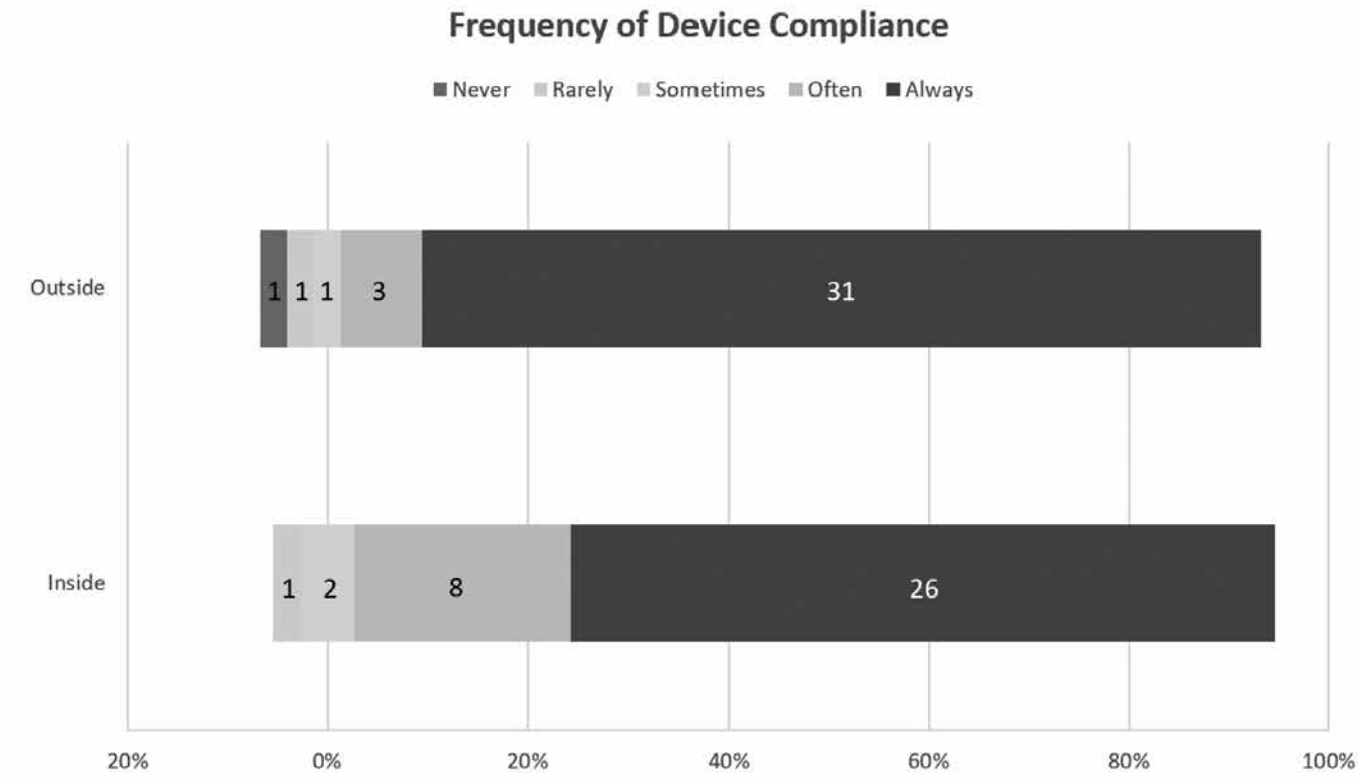

Figure 4. Patient self-reported rates of compliance with device wear both inside and outside of the home.

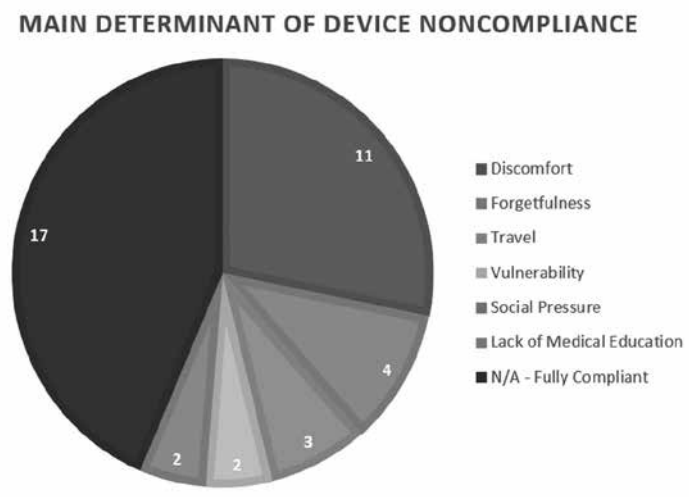

Figure 5. Main determinants of device noncompliance.

Discussion

Our study sought to investigate whether patients felt vulnerable while using their recovery device and if a perception of vulnerability led to noncompliant behavior. Participants in our study were all patients at Temple University. After reviewing the personal zip codes provided by patients, many were living nearby Temple Hospital or in the Philadelphia region at the time they were prescribed their brace. According to the FBI, Philadelphia's violent crime is 139% higher than the national average. In recent years, the city has had the third highest violent crime rate of 10 American cities with populations greater than one million residents.[23] Furthermore, a large proportion of our patient population reside primarily in North Philadelphia, a region known to have some of the highest violent crime rates in the city. The Philadelphia Police report that in the past month, Temple Hospital's neighboring areas of Fairhill and Kensington have had a violent crime rate of 1.76 and 1.73 (per 1,000), respectively, representing the leading neighborhoods of violent crime in an already violent city.[24] As the study set out to observe whether behavior modification occurred due to a perception of vulnerability, this effect was expected to be experienced by these individuals who have a greater potential to be victimized.

Our results suggest that the primary reason for noncompliance was discomfort from the device (28%). However, the greatest proportion of patients (44%) denied noncompliant behavior entirely, emphasizing their understanding of the importance of compliance for their recovery. Contrary to our hypothesis, responses from our survey suggest that a perception of vulnerability does not contribute to noncompliant behavior in orthotic device use. Although several patients felt very strongly about their own personal experiences, the collected data is not strong enough to support a generalizable conclusion.

Travel difficulty was by far the most common negative experience outside of discomfort, although it rarely caused noncompliance (23/36). Factors that were strongly considered when deciding whether or not to engage in noncompliant behavior were travel difficulty (12/37) and discomfort (13/37).

Implications

A review of the literature returned limited results, with no clear study looking into vulnerability as a predictor of noncompliance. Moreover, the handful of previous studies were unable to prove consistent predictors of noncompliance. Davies et al. considered a number of studies that evaluated the measuring and reporting of adherence to be inconsistent and difficult to interpret.[25] Our study was interested in re-exploring some of these factors as well as looking into other uninvestigated areas: forgetfulness, low health literacy, travel or public transportation difficulty, and negative social interactions.

The study of Sandford et al. (2008) reported the most common reasons for brace noncompliance were activities of daily living, such as handwashing, dressing, bathing, or as a result of device discomfort.[16] In agreement with this study, we found that a majority (31/37) of patients did admit that they experienced discomfort with their device. However, only 13 considered noncompliance and 11 admitted noncompliant behavior due to discomfort.

Given the responses of participants, it appears at this stage that travel/public transportation difficulty was the second most common experience (23/36). A total of 12 participants stated that it would be influential to consider noncompliance although only three participants confirmed that it had caused noncompliant behavior. In contrast, most patient noncompliance did not seem to result from forgetfulness, low health literacy, or negative social interactions.

Several other studies concluded that there was no connection between noncompliance and socioeconomic factors such as age, sex, ethnicity, education level, employment status, living status (alone vs. community), family or social dysfunction, or drug or alcohol issues.[18–20] We considered employment status and education level but did not have enough data to reach a conclusion in this area.

Current literature looking at the medical predictors of noncompliance such as comorbidities, injury side, repair complexity, or hand dominance were similarly not observed to have an influence on compliance.[16, 18, 20] Our study was unable to establish a connection between the side of injury and hand dominance to explain noncompliant behavior.

Further literature has reached conflicting conclusions about whether smoking status or worker's compensation were linked to noncompliance.[5, 17, 18] These factors were not considered in this study and may be worth considering in future studies.

Limitations

Some limitations of the study design do need to be acknowledged. Regarding the survey, there were some ques-

tions that could have been re-worded to avoid confusion or more accurately reflect the patient's experiences. One participant reported that they felt safer while using their prescribed crutches. The wording of the related question asked if they felt "less safe" while using crutches compared to baseline, to which a response of "Strongly Disagree" does not clearly reflect that they, in fact, felt safer than baseline. Extreme responses were an expected, but undesirable, effect of using a Likert scale. In these cases, some individuals began with a detailed explanation suggesting a neutral or mild response, but when asked for a response based on the provided Likert scale, they provided an extreme response such as "strongly agree" or "strongly disagree." Bias towards social desirability may have driven other patient responses. Because questions focused on if patients followed the instructions of the doctor, it is possible that they overreported compliance to appear more favorable, even when explained beforehand that their answers were anonymous and would not affect their individual care.

There were other limitations unfortunately experienced as a result of data being collected during the COVID-19 pandemic. The initial goal at the start of the study was to meet an 80% response rate to the survey, which was not met. This could have been due in part to having to change the study design from in-person survey administration in the office to phone calls, perhaps causing patients to be less likely to participate. This could have introduced an element of response bias into the study as well. Eligible participants were 4–10 months post-surgery, which made recall of device-wearing habits more challenging than if a recent patient cohort was used. Another limitation was the restriction of communication to telephone calls due to the COVID-19 pandemic. Because of poor cellular connection or user error, responses were sometimes difficult to understand which led to occasional participant frustration and hastiness to finish the survey. The participant response rate was not helped by telephone-based contact. In comparison to follow-up visits in clinic, it was much easier to decline participation by either not answering the phone or by hanging up if they were not interested.

Recommendations

Although devices have been designed in a way to optimize recovery, some consideration could be given to designing a different device that is less obvious to onlookers to limit the potential for victimization. This may mean a less-efficient design for recovery, but if the current design is not being worn to prevent victimization, meeting in the middle may be the most effective solution. Similarly, with discomfort reported to be one of the most common reasons for brace noncompliance, a change in design to improve comfort may also be worth consideration.[16]

Current protocols for surgical recovery generally call for a period of joint or limb immobilization early in the recovery process, though current literature is divided on the most efficient timelines to wean orthotic device use and increase mobility rehabilitation.[7, 12, 26–29] Further research in this area can give physicians a better sense of how long their patients need to put themselves in a restricted state. If future studies confirm the benefits of a shorter post-surgical immobilization phase, this could lead to a shift in post-operative recovery, resulting in improved patient satisfaction and greater compliance.

Our study investigated many possible explanations of noncompliance, with a focus on patient perception of vulnerability. This was cross-referenced with the participant's provided zip code to see if a positive correlation exists between areas of high crime rates and the perception of vulnerability. Participants surveyed in our study were from a variety of areas with very different rates of crime, although without a significant sample size in each, it was difficult to definitively conclude if a correlation exists between zip code and a perception of vulnerability. Future studies should be conducted with a larger sample size or with participants from a relatively concentrated region.

Although several factors were investigated here, plenty of other reasons for noncompliance remain uninvestigated. Additional studies need to be conducted to examine these perceptions of vulnerability and other factors that might account for noncompliant behavior. In the design of these studies, it should be considered that reported patient adherence is generally higher than actual adherence. Although costly, thermal sensors within the orthotic devices could be considered and have been proven in previous studies to be a more accurate measure of compliance.[20, 30]

For patients that do admit experiencing a sense of vulnerability leading to noncompliance, more work needs to be done to understand measures that can be taken by the patient's care team to alleviate this fear and increase compliant behavior. Until then, we can only hope that each patient prescribed a device does not leave the hospital with the feeling of a target on their back.

In the interim, physicians can do their part by educating their patients on the importance of their treatment, whether it be from orthotic devices, ambulatory assistive devices, medications, or lifestyle modifications. Health literacy cannot be assumed and in part depends on the resources provided by the healthcare system.[31] With lower health literacy, patients report engaging in less-compliant behavior, resulting in worse outcomes.[32] Another equally important measure for physicians is to continue to build rapport with their patients. The importance of a physician-patient partnership is key to improving the patient experience and compliance, ultimately fostering better health outcomes.[33]

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Original Research

Infection Rates and Management of Firearm Injury Tibia Shaft Fractures

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Abstract

Tibia fractures from firearm injuries (FI) are commonly seen in North American urban trauma centers and typically treated without formal surgical debridement. The purpose of this study is to compare infection rates of extra-articular tibia fractures caused by firearm injuries with and without debridement, as well as compare against other open and closed mechanisms. A retrospective chart review was conducted for a 10-year period at an urban level one trauma center. Patients included for this study were 18 years or older and treated operatively for extra-articular tibia fractures with at least three months follow-up. Two hundred twenty-one (221) fractures in 220 patients were included. There was no significant difference between total and deep infection rates between FI and non-FI fractures ($P > 0.05$). Type I FI fractures were never indicated for surgical irrigation and debridement (I&D) emergently but underwent I&D at time of fracture fixation in 14 of 37 cases. All non-FI open fractures, FI Type II and FI type III fractures were indicated for emergent I&D, except for one FI type II fracture which underwent extensive bedside irrigation. FI type I had lower infection rates than FI type II and III, and non-FI type III fractures ($p < 0.05$). There was no significant difference ($p > 0.05$) between deep infection rates in FI type I fractures, closed fractures, non-FI type I, and non-FI type II fractures. FI type II and FI type III fractures had significantly higher infection rate than closed fractures and comparable infection rates to non-FI type II and III open fractures. FI type I open fractures can be safely treated without urgent surgical I&D. FI type II and III fractures have comparable or higher infection rates than their non-FI counterpart and we recommend treating them with urgent surgical I&D.

Introduction

Patients with firearm-related injuries commonly present to American trauma centers and place significant burden on the health care system.[1, 2] These patients often sustain extremity fractures, with tibia fractures among the most common.[1, 3] The thin soft-tissue envelope overlying the tibia results in a higher proclivity for open wounds and associated infections, presenting a unique challenge in the treatment of these injuries.[4]

Though optimal surgical timing and antibiotic regimen is not entirely clear in the literature, open tibia shaft fractures from blunt mechanisms are nearly always treated with immediate antibiotics and emergent irrigation and debridement (I&D).[4–7] Unfortunately, there is far less consensus regarding the treatment of firearm injury (FI) tibia fractures with no clear data demonstrating whether urgent operative debridement results in lower infection rates. Previous publications on this topic make recommendations based on expert opinion, but lack data to guide the treatment of small FI wounds overlying fractures.[8] A recent survey of orthopaedic trauma surgeons showed marked heterogeneity in the way that FI fractures of the lower extremity are treated and a lack of guiding principles in the field.[9] In fact, there is no conclusive evidence demonstrating whether FI fractures should be classified as open fractures; most research attempting to answer this question has done so without specifically focusing on FI tibia fractures.[5, 7, 10–14]

The purpose of this retrospective chart review is to compare infection rates of extra-articular tibia fractures caused by firearm injuries with and without debridement, as well as compare against other open and closed mechanisms with the goal of defining which patients would benefit from I&D. The authors hypothesize that patients with FI tibia fractures will demonstrate comparable rates of infection to patients with open fractures from other mechanisms and should be treated with operative I&D.

Materials and Methods

After obtaining approval from the Institutional Review Board (IRB), a retrospective chart review was conducted for a 10-year period at an urban level one trauma center. Patients were included if they were 18 years or older and treated operatively for an extra-articular tibia fracture (open or closed) sustained by any mechanism. Patients treated non-operatively for an extra-articular FI tibia fracture were also included. All included patients had at least three months follow-up. All FI fractures and non-FI open fractures were classified using the Gustilo-Anderson system. When docu-

mented, Gustilo-Anderson classifications were taken directly from operative reports. If not listed in the operative report, fractures were graded from available documented information including wound description and associated injuries. Whether the patient underwent I&D, total infection rates, and deep infection rates were calculated and compared for all FI fractures, non-FI open fractures, and closed fractures treated operatively. Deep infection was defined as infection requiring operative treatment. Additional injury/treatment characteristics were analyzed for correlation to infection rates including compartment syndrome, vascular injury, nonviable muscle at the time of debridement, bone visible within the wound, timing to antibiotics, decision to perform I&D, timing to I&D, and associated injuries.

Results

Patient and Injury Characteristics

Two hundred twenty-one (221) fractures in 220 patients met inclusion criteria. The average age was 38.7 ± 15.0 years and included 74% males. Cases included 49 fractures caused by FI, 110 closed fractures, and 62 non-FI open fractures. Firearm injury patients were more likely to be younger (32.2 vs 40.6 years, $p < 0.005$) and male (96% vs 67%, $p = 0.001$) compared with non-firearm extra-articular tibia fracture patients.

Additionally, open fractures from FI and non-FI mechanisms were associated with more additional injuries than closed fractures (32% vs 10%, $p < 0.001$). Type III fractures were more commonly associated with additional injuries as well (50% vs 23%, $p = 0.03$). The most common cause of a closed tibia extra-articular fracture was a fall (n = 49), and the most common cause of a non-FI tibia open fracture was an automobile striking a pedestrian (n = 24).

I&D Decisions and Infection Rates

Firearm Injury Type I

Firearm injury Type I fractures never underwent I&D emergently, rarely had I&D as a primary procedure (3%, Table 1), and infrequently developed infections (5%, Table 3). The FI Type I infection rate was not statistically significantly different than operative closed tibia extra-articular fractures (5% vs 7%, $p = 0.7$). The infection rate was lower than FI Type II and III (5% vs 38%, $p < 0.001$), and lower than Type III non-FI fractures (5% vs 35%) (Table 3).

The one FI Type I case that underwent I&D as a primary procedure had a prominent retained bullet fragment threatening the surface of the skin. The patient received I&D 22 hours after presentation as an isolated procedure to remove the prominent retained bullet fragment and the fracture was treated with closed reduction and casting. This patient did not develop an infection. Whether or not patients with FI Type I received I&D while in the operating room for fixation as an adjunct procedure varied (34%). Average time to I&D, when performed, was 17.9 ± 14.2 hours (Table 2). Timing of debridement and decision to debride did not have a statistically significant relationship with infection rates.

Table 1. I&D Decisions for Firearm Injury Tibia Fractures*

	Emergent	P-Value (vs FI Type I
FI Type I (n = 37)	0	
FI Type II (n = 9)	8 (89%)	<0.001
FI Type III (n = 3)	3 (100%)	<0.001
	Primary Procedure	**P-Value (vs FI Type I)**
FI Type I (n = 37)	1 (3%)	
FI Type II (n = 9)	9 (100%)	<0.001
FI Type III (n = 3)	3 (100%)	<0.001
	No I&D	**P-Value (vs FI Type I)**
FI Type I (n = 37)	23 (62%)	
FI Type II (n = 9)	0	<0.001
FI Type III (n = 3)	0	<0.001

*Including break down of whether I&D was carried out emergently, whether it was the primary procedure, and whether no I&D was performed at all.

Table 2. Time from Presentation to Operative I&D

	Time to I&D (hrs)	P-Value	<6 Hours	P-Value
FI Type I (n = 37)	17.9 ± 14.2*	0.04	3 (8%)	0.007
FI Type II (n = 9)	10 ± 8.2		4 (44%)	
FI Type III (n = 3)	1.9 ± 1.0		3 (100%)	

*Timing for FI type 1 fractures includes those cases in which an I&D was performed. There was no I&D performed in 23 FI Type I cases.

The two FI Type I cases that developed infections received I&D while in the operating room for primary indication of fracture fixation. The first case involved a 50-year-old male presenting with a "through and through" FI wound containing palpable bony fragments with a 5 mm bullet hole. The patient underwent surgical fixation with I&D 10 hours after presentation. At one week follow-up, tenderness and erythema around the wound led to a diagnosis of a superficial cellulitis that resolved with oral antibiotics alone. A second case involved a 55-year-old male with an anterior FI wound over a bony right tibia deformity that underwent I&D and surgical fixation two days after presentation. The patient returned with drainage and subjective fevers two weeks after surgery. He underwent debridement of the draining wound which was found to communicate directly with the intramedullary nail (IMN) and cultures from the intramedullary canal were positive. The infection was treated with IMN removal and antibiotic nail with subsequent exchange nailing after the infection resolved.

Firearm Injury Type II and III

Firearm injury Type II and III cases were mostly taken for emergent I&D (92%, Table 1), always as a primary procedure (100%, Table 3), and commonly developed infections (42%, Table 3). One FI Type II fracture was not indicated for emergent surgical I&D, but it did undergo irrigation at bedside in the trauma bay prior to splinting with 6L of normal saline. No statistically significant relationship was found between infection rate and timing to I&D. These FI Type II

Table 3. Infections Rates for Extraarticular Tibia Fractures

	Superficial	Deep	Any Infection	P-Value (vs Non-FI of Same Grade)	P-Value (vs Closed)
FI (n = 49)	2 (4%)	5 (10%)	7 (14%)	0.8	0.2
FI Type I (37)	1 (3%)	1 (3%)	2 (5%)	0.9	0.7
FI Type II (9)	1 (11%)	2 (22%)	3 (33%)	0.03	0.02
FI Type III (3)	0	2 (67%)	2 (67%)	0.3	<0.001
Non FI Open (62)	5 (8%)	6 (10%)	10 (16%)	—	0.07
GA Type I (16)	1 (6%)	0	1 (6%)	—	0.9
GA Type II (23)	1 (4%)	0	1 (4%)	—	0.6
GA Type III (23)	2 (9%)	6 (26%)	8 (35%)	—	<0.001
Closed treated operatively	3 (3%)	5 (5%)	8 (7%)	—	—

and III cases had higher infection rates than FI Type I fractures (42% vs 5%, $p < 0.001$) and closed tibia fractures (42% vs 7%, $p = 0.008$) (Table 3). Infections included one superficial infection (11% Type II) resolving with antibiotics alone, as well as four deep infections (22% Type II, 67% Type III) (Table 3). Each case of deep infection required surgical intervention.

Irrigation and debridement was performed for FI Type II fractures within 10.0 ± 8.2 hours of presentation and for FI Type III fractures within 1.9 ± 1.0 hours of presentation. Eighty-nine percent (89%) of FI Type II and 100% of FI Type III were debrided before definitive fixation. Forty-four percent (44%) of FI Type II and 100% of FI Type III were debrided within six hours (Table 2).

Additional Injury Characteristics vs Infections

None of the additional analyzed characteristics for FI fractures including compartment syndrome, nonviable muscle at time of I&D, vascular injury, need for soft tissue coverage, extent of associated trauma, fixation method, surgical approach, or timing to antibiotics independently correlated to infection rates.

Discussion/Conclusions

Tibia fractures from firearm injuries are common injuries lacking evidence to guide optimal treatment. Previous studies have shown that there is no significant increase in infection risk for FI tibia fractures when compared to open and closed fracture from other mechanisms.[15] In the current study, comparison of all FI fractures to all non-FI open fractures and closed fractures treated operatively also showed no significant difference in infection rates. However, analysis of the FI fractures based on injury severity showed that higher grade fractures with more extensive soft tissue injury are at higher risk of infection and should be treated with emergent I&D.

Firearm injury Type I tibia shaft fractures, although never indicated for emergent I&D in reviewed cases, had infection rates comparable to closed tibia fractures treated operatively and can be safely treated without emergent I&D. Type I fractures generally present with a small entry wound with or without a second small exit wound. Figure 1 shows an example of a FI-type I wound and a FI-type III wound. Although the current series supports the safety of forgoing emergent I&D in FI Type I fractures, the authors are unable to recom-

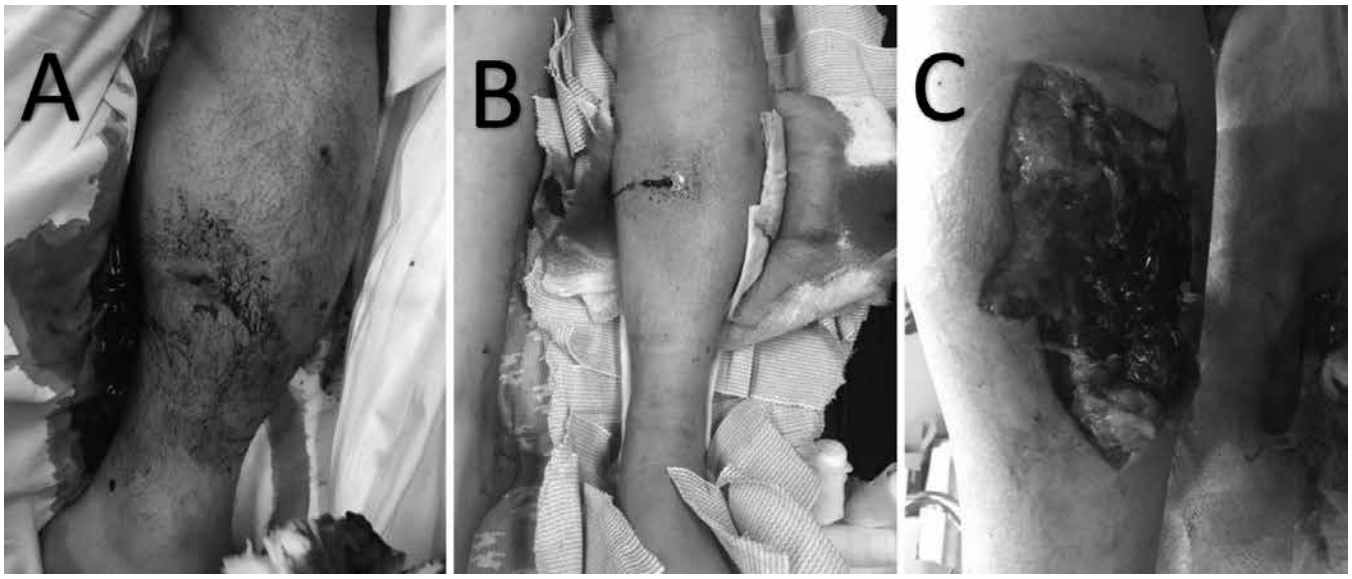

Figure 1. Clinical photos of wounds from firearm injuries overlying tibia fractures. **A** shows a <1 cm entry and exit wound classified as a FI-type I injury. **B** and **C** show a small medial entry wound and a large lateral exit wound with extensive soft tissue injury classified as FI-type III injury.

mend for or against the need for debridement of the FI wound at time of fracture fixation. Fourteen out of 37 patients with FI Type I fractures underwent I&D during external fixation or definitive fracture fixation, and the rate of infection was not significantly different between the two groups. Despite the lack of difference in infection rates, it remains common practice at our institution to debride small bone fragments from the wound and irrigate FI-type I wounds at time of fracture fixation.

Firearm injury Type II and III fractures have similar or higher infection rates to non-FI counterparts and we recommend treating them with emergent I&D. The available data focusing specifically on FI tibia fractures is limited. However, one recent study did examine the outcomes of tibia shaft fractures caused by FI.[15] In that study, the authors considered all FI fractures in one category. It is unclear if any of the patients had more extensive injuries that would have been classified as Type II or III injuries by the system used in the current study. The published findings in that study show no significant difference in infection rates between FI fractures and closed fractures treated operatively, and the authors recommended treatment of FI tibia fractures similar to closed injuries with the addition of local wound care. The results of the current study agree with this recommendation for FI Type I fractures. However, this study finds that FI Type II and III fractures have infection rates comparable to open fractures from other mechanisms.

In this study, timing of antibiotic administration and time to I&D were not predictive of infection risk. Similarly, recent data has called into question the historical view that open fractures should undergo I&D within six hours of presentation, emphasizing instead the importance early antibiotics.[16–18] Further investigation is needed to determine the optimal timing of I&D.

There were several limitations to this study. As a retrospective chart review, it is subject to the limitations inherent to this type of study relying on occasionally limited or inconsistent documentation. There were a number of patients that were excluded due to poor follow-up, which is common at the urban level 1 trauma center where the study was performed. Improved follow-up would have increased the number of patients included and the overall power of the study. Additionally, potential selection bias could affect the results, with less severe cases less likely to meet the follow-up threshold. Finally, the grading of FI fractures was performed based on available documentation when not specifically listed in the operative report which may somewhat limit the accuracy with which the fractures were graded.

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Case Report

Peroneus Quartus Muscle as a Cause of Chronic Lateral Ankle Pain: A Case Report and Review of the Literature

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Abstract

The peroneus quartus is an accessory muscle located in the lateral ankle. Its location in the retromalleolar groove is associated with over-crowding, which may lead to swelling and pain. Injury to the lateral ankle may compound compressive forces in the area. Diagnosis of the accessory muscle may be difficult, as MRI studies of the peroneus quartus may appear as a split peroneus brevis tendon. We present a case report of a peroneus quartus and a review of the literature on the topic.

Introduction

The Peroneus Quartus (PQ) is a variant structure in the lateral ankle with a frequency of 6.6% to 21.7% according to cadaveric studies.[1] It is most prevalent in the African and Indian population[2, 3] and is more frequently found in males.[3] The muscle most commonly arises from the peroneus brevis; however, origination from the peroneus longus has been reported.[4] Insertion points are also variable and include the calcaneus, base of the fifth metatarsal, the peroneus brevis or longus tendons, the inferior extensor retinaculum, and the cuboid bone, but the lateral calcaneal insertion is most common.[1, 4] MRI studies commonly mistake the PQ for a split peroneal tendon. Therefore, sonography or exploratory surgery may be used to differentiate between peroneal tendon disorders and a PQ muscle.[5, 6] The positive predictive value of identifying the PQ on MRI is low as well and reported to be 16.7%.[3] This case report aims to enhance the knowledge of PQ pathology in the setting of ankle injury.

Case

A 47-year-old female with a history of morbid obesity and multiple ankle injuries presented with persistent right ankle pain, which began after her first torsional injury in 2016. She subsequently sustained an avulsion fracture of the distal fibula three years later. In 2020, she experienced a second-degree ankle sprain of the anterior talofibular ligament. Conservative treatment including casting, CAM boot, and physical therapy failed to relieve her constant, achy, moderately severe pain over the lateral ankle, necessitating the use of a cane for ambulation.

Physical exam revealed tenderness, swelling, and ecchymosis along the lateral ligament complex and distal fibula. Eversion reproduced pain in the peroneals and diffusely over the anterior and lateral ankle. Diagnostic radiographs showed a chronic avulsion of the distal fibula along the tip of the lateral malleolus. An MRI of the right ankle showed an apparent split tear of the peroneus brevis tendon.

The patient underwent extensive nonoperative management with immobilization followed by physical therapy but continued to be symptomatic and agreed to proceed with surgical intervention of exploration of the peroneal tendons. A curvilinear incision was made over the posterior lateral aspect of the malleolus. The superior retinaculum was then split longitudinally exposing the peroneal tendons. Both the peroneus longus and brevis tendons were intact. A large accessory PQ muscle and tendon was encountered and was found to insert onto the lateral calcaneus. Excision of the muscle belly and tendon then was performed, significantly improving the space within the retromalleolar groove. The wound was closed in routine fashion and she was placed into a CAM boot and instructed to remain nonweightbearing.

On post-operative day 12, the patient returned for follow-up and had no complaints. The wound was healing well. She was instructed to continue nonweightbearing in the CAM boot for six weeks total. At her six-week follow-up, she noted no pain and was advanced to weightbearing as tolerated. She was transitioned from the CAM boot to an ASO brace, and she started physical therapy.

Discussion

There have been a number of cases describing patients with an accessary PQ who experienced chronic lateral ankle pain refractory to conservative management who then underwent surgical treatment.[5–10] Many of these patients had acute ankle injuries preceding this chronic pain.[6–9] In some cases, overuse injury preceded the chronic pain.[5, 10] Because of the PQ's location, there is a significant propensity to cause overcrowding.[1, 11] The PQ may be found in the retromalleolar groove causing pain due to compressive space-occupation on the nearby peroneal tendons.[7, 9] Furthermore, overcrowding associated with the PQ muscle in the setting of overuse injury has also been implicated with chronic peroneal compartment syndrome.[5] Trauma in this region is known to

cause swelling, avulsion, subluxation, and laxity of tendons.[12] This is associated with rubbing of the tendons on each other, as well as on the fibula, leading to inflammation, tendonitis, and peroneal tendon tears.[12]

Our patient's repetitive trauma to the right ankle may have caused irritation and compression of nearby tendons. In addition, our patient's history of morbid obesity could have correlated with delayed recovery of the ankle sprain injury.[13] A delay in healing may have been associated with prolonged swelling and inflammation, further contributing to the overcrowding in the retromalleolar groove. In our case, MRI failed to distinguish between a split peroneus brevis tendon and an accessory PQ tendon. In addition to ultrasonography and exploratory surgery, MRI can uncover a PQ muscle if it is performed with specific parameters for this indication.[6] The PQ can be best appreciated with axial imaging, where it is usually separated from peroneus brevis by a fat plane. Differentiation of peroneal tendons may be more apparent with 20 degrees of plantar flexion, as this creates a thin fat plane. With a clinical suspicion for an accessory muscle, the PQ tendon can be followed down to its insertion via sequential axial images.[14]

Conclusion

In conclusion, presence of the PQ muscle should be considered in the setting of chronic lateral ankle pain following trauma to the ankle that is refractory to immobilization and physical therapy. MRI of the ankle can erroneously identify the peroneus quartus as a split tear of the peroneal tendon. Treatment includes immobilization and physical therapy. Surgery can be considered if the symptoms persist despite adequate nonoperative treatment.

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Case Report

Acute Bilateral Exertional Compartment Syndrome in a Young Male Athlete

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Abstract

Acute Exertional Compartment syndrome (AECS) is an atraumatic presentation of acute compartment syndrome (ACS) after athletic activity. In this case report, we present a patient with bilateral AECS presenting several years apart, and discuss its presentation, diagnosis, and treatment. The objective of this case report is to bring attention to this rare condition and highlight the devastating consequences of missed or delayed diagnosis.

Introduction

Acute compartment syndrome (ACS) results from an increase in intra-compartmental pressure in a closed fascial space causing decreased perfusion to local tissues. This hypoperfusion can lead to irreversible necrosis of tissues resulting in impaired limb function, loss of limb, and death. Therefore, ACS is a surgical emergency that requires a timely diagnosis for effective treatment.[1] The majority of ACS cases, over 70%, occur secondary to fracture or significant trauma. However, ACS has also been described as secondary to atraumatic etiologies in the lower extremity including post-operative swelling, vascular compromise, insect bites, and exertion.[2]

Acute exertional compartment syndrome (AECS), is defined by acutely elevated compartment pressures after physical exertion and leads to the same sequelae of hypoperfusion as ACS described previously. During strenuous exercise, muscle myofibers are damaged, causing increased swelling. This swelling and subsequent increase in compartment pressure decreases muscle perfusion, which can lead to irreversible muscle injury.[3] AECS tends to occur in young adult and adolescent males. These patients are at higher risk due to growing muscle mass in non-compliant fascial compartments. Similar to ACS, AECS is treated with fasciotomy. Untreated AECS can lead to nerve damage, muscle necrosis, and loss of limb function within four hours of symptom onset.[2] The diagnosis of AECS can often be missed due to decreased suspicion of compartment syndrome with an atraumatic presentation and due to the paucity of reported cases in the literature.[4–8] Here, we present the case of a young adult male with two independent occurrences of AECS, once in the right leg, and once in the left leg separated by over two and a half years.

Case

This case will describe two separate presentations of the same patient for AECS of the lower extremity after playing soccer — the first presentation in the left lower extremity and the second in the right lower extremity.

The patient initially presented as a 26-year-old male with no significant past medical history who was transferred to our institution from an outside hospital. On presentation, the patient was complaining of 24 hours of left lower extremity pain after playing soccer. The patient denied any trauma to the left lower extremity. The pain was in the anterior aspect of his left lower extremity, and the patient complained of numbness and tingling over the dorsum of his foot. On exam, the patient had no open wounds, ecchymosis, or gross deformity of the extremity. The patient had tense but compressible lateral and anterior compartments, and the posterior compartments were soft. Examination was notable for pain with passive movement of the left great toe. The patient was unable to activate extensor hallucis longus and tibialis anterior but had 5/5 strength in the gastrocnemius and flexor hallucis longus. Sensation in the left lower extremity was intact to light touch. However, the patient was complaining of numbness and tingling in the deep peroneal and superficial peroneal distributions. The patient had a palpable dorsalis pedis pulse and stable vital signs.

Plain radiographs of the left lower extremity displayed no acute fracture or dislocation. The patient's creatinine kinase was 9507 (U/L) on admission. The anterior and lateral compartment pressures were measured and found to be 26 and 40 mmHg, as measured by Intra-Compartmental Pressure Monitor System (Stryker). The patient's diastolic blood pressure was 106 mmHg. The patient was taken emergently to the operating room for a four-compartment fasciotomy of the left lower extremity due to clinical suspicion for compartment syndrome. The patient was noted to have dusky musculature of the lateral compartment at the time of the release. Fasciotomy wounds were later closed after a series of debridements. Patient follow-up at eight weeks revealed little to no change in EHL and TA function and an unchanged sensory deficit in deep peroneal and superficial peroneal distributions. EMG at the time confirmed left saphenous, peroneal, and sural neuropathies.

Several years later, the patient presented with similar symptoms in the right lower extremity after playing soccer.

The patient again denied any trauma to the right lower extremity. The patient, age 29 at this presentation, had no interval changes in his medical history; however, on this admission, he presented within four hours of symptom onset. The patient complained of pain in the anterior aspect of his right lower extremity as well as numbness and tingling over the dorsum of his foot. On inspection, there were no open wounds, ecchymosis, or gross deformity of the right lower extremity. On exam, the patient had compressible compartments, but the posterior and anterior compartments were tense compared to the contralateral leg. The patient had decreased strength in ankle dorsiflexion. The remainder of the patient's motor exam in the right lower extremity was normal. Sensation was intact to light touch throughout the right lower extremity. However, the patient complained of numbness and tingling over the dorsum of his great and second toe. The patient had a palpable dorsalis pedis pulse.

Radiographs of the right lower extremity showed no acute fracture or dislocation. The patient's creatinine kinase was 4373 (U/L). Compartment pressures in the anterior, lateral, superficial, and deep posterior compartments were 5, 10, 7, and 14 mmHg, respectively. The patient's diastolic blood pressure was 82 mmHg. Based on the clinical history, the patient was diagnosed with an evolving acute compartment syndrome and taken emergently to the operating room for a four-compartment fasciotomy of the right lower extremity. The patient had healthy and viable muscle in all four compartments. The patient's wounds were later closed after subsequent debridements, and he had no neurologic sequelae post-operatively.

Discussion

When an athlete presents with atraumatic lower extremity pain, the differential diagnosis should include medial tibial stress syndrome, chronic exertional compartment syndrome, stress fracture, tendinopathy, and nerve entrapment. AECS is a rare entity but must also be considered in this scenario due to its devastating consequences if missed. Classically, cases of AECS describe a young male presenting after a running sport with pain in the lateral and anterior compartments of the lower extremity.[2] Even more importantly, these patients will describe pain that does not improve with rest, and associated motor and sensory deficits. On exam, they may have taut and shiny skin overlying the affected compartment. Researchers have hypothesized that the anterior and lateral compartments are at higher risk for AECS because muscle fibers in these compartments have an increased percentage of fast-twitch fibers, which are more prone to ischemic injury and utilized during sporting activity.[9]

The threshold for fasciotomy should be low if one has a clinical suspicion for compartment syndrome. However, AECS is rare and can go undiagnosed. In a case series of patients with AECS, it was noted that the diagnosis was initially missed in four of seven presented cases.[2] Hope et al. noted that patients with an atraumatic presentation of ACS experienced an eight-hour delay in time to fasciotomy compared to patients with ACS attributed to direct trauma. A missed diagnosis of ACS can lead to nerve palsies, compromised extremity function, loss of limb, and rhabdomyolysis with subsequent acute kidney injury. A study comparing early (less than 12 hours) vs. late fasciotomy (greater than 12 hours) showed residual sensory and motor deficits in 32% of patients in the early group vs. 98% in the late group.[10] We present a case of bilateral AECS occurring several years apart. This case is unique to other cases of bilateral atraumatic compartment syndrome because of the time separating both presentations. AECS is a diagnosis that has devastating consequences when missed, as evidenced by the first presentation of our patient that resulted in a persistent foot drop. Heightened suspicion for ACS in our patient on his second presentation led to prompt treatment with no complications. Lower extremity AECS should be considered in any patient presenting with acute lower extremity pain, especially young males presenting after athletic participation.

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Case Report

Humeral Shaft Fractures in Overhead Throwing Athletes

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Abstract

Atraumatic humeral shaft fractures in athletes exposed to repetitive overhead throwing motions are a rare but well-documented phenomenon termed "thrower's fractures." Thrower's fractures are most likely seen in baseball but have also happened during dodgeball, javelin and grenade throwing. This case report examines the treatment and management of three baseball players who suffered thrower's fractures. A retrospective chart review was performed for all patients. A literature review was performed examining all current treatment recommendations and case reports of thrower's fractures. All of the patients examined underwent open reduction and internal fixation with no apparent complications. As the demographic of those with thrower's fractures tends to be young, active males, we advocate for surgical fixation unless underlying medical conditions preclude the patient from surgery.

Introduction/Background

Humeral shaft fractures occurring in athletes exposed to repetitive overhead throwing motions are a rare but recognized phenomenon. The incidence of humerus fractures in the general population is approximately 13 per 100,000 people per year with most being secondary to trauma in young men.[17, 18, 24] The incidence of humerus fractures as a result of throwing is much lower and most of the literature is in the form of case reports. Not surprisingly, Ogawa and Yoshida showed that the most common demographic for thrower's fractures were also young males.[29] Thrower's fractures are frequently seen in the sport of baseball but are also documented in other sports and activities such as javelin and grenade throwing.[25] The goal of this case series is to review the biomechanics leading to fracture, discuss current management principles, address common complications, and examine the author's treatment of these rare cases.

Biomechanics

There are several theories as to why this injury occurs in this demographic. The first theory attributes this type of fracture to the violent biomechanics that come with forcefully throwing an object. The throwing cycle is broken down into five phases: wind-up, early-cocking, late-cocking, arm acceleration and follow-through (Figure 1). During the late-cocking and early acceleration, the humerus is subjected to a significant amount of torsional stress due to internal rotation pull of the subscapularis, latissimus dorsi, and pectoralis major. This force starts proximally and is transmitted down an already externally rotated arm which creates a transition point of opposing forces leading to fracture.[19, 24, 33] This theory, however, fails to explain certain fracture patterns and instances where fractures occur with minimal effort.

An alternative explanation, which accounts for this limitation, faults deconditioning of the humerus as the main cause for fracture. This explanation is compelling as it has been shown that thrower's fractures are more likely to occur in amateur athletes with improper conditioning and a lesser degree of cortical adaptation, compared to those with an increase in bone mass when throwing is performed regularly.[37, 39] In these cases, the torsional force needed to produce a fracture is much less. Patients may present with disuse muscular atrophy or report prodromal arm pain in these instances.

Complications

The primary complication associated with humeral shaft fractures is neurovascular injury. There is a predisposition for injury to the radial nerve with a thrower's fracture because of its anatomical location in the spiral groove. Perturbations in the winding course of the radial nerve as it wraps around the cylindrical shaped humerus makes the nerve susceptible to traction or laceration injuries when the

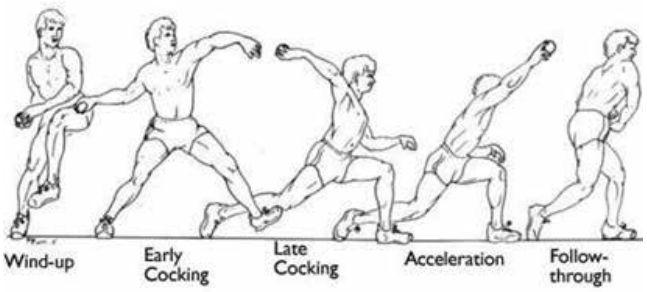

Figure 1. The throwing cycle.

humerus fractures. The prevalence of radial nerve palsy increases as the fracture site moves distally in the humerus, with a prevalence rate of 2% in the proximal third, 15% in the middle third and 24% in the distal third. Though radial nerve injury is a serious sequela of humerus fractures, it is not a contraindication to nonoperative treatment with functional bracing. Surgical exploration is indicated in open fractures and palsies that do not resolve in 3–6 months.

Management

Humeral shaft fractures can be managed both surgically and nonsurgically. The traditional treatment for humeral shaft fracture is functional bracing.[5, 21, 38] Sarmiento et al. demonstrated good functional outcomes with union rates approaching 96% with functional bracing alone. They also proved that there was no statistically significant difference in functional outcomes when compared with surgical treatment groups.[10, 15] Recent publications regarding the nonunion rates after nonsurgical treatment challenge this, ranging from 23–33% as compared to 4–10% for surgical intervention.[43] Nonsurgical treatment is also associated with a high conversion rate to surgery.[38] Surgical management with open reduction internal fixation has increased 13.1% over the last decade, especially in younger patients.[26, 34] Surgical management is preferred if important contraindications to functional bracing exist, including open fractures, vascular injury, unacceptable angulation, or more recently, thrower's fractures. Operative treatment of thrower's fracture has been shown to reduce time to return to sport, at 13.5 in the operative group versus 22.6 weeks in the non-operative group.[1]

Cases

Case 1: 27-year-old right hand dominant male graphic designer presents with right arm pain after he felt a pop while throwing a baseball. He denied any prodromal pain. Post injury radiographs revealed distal third spiral humeral shaft fracture (Figure 2). He was neurovascularly intact on exam with no evidence of radial nerve palsy. Both nonoperative and operative management was discussed with the patient. The patient ultimately underwent open reduction and internal fixation using plate and screws through a posterior, triceps-sparing approach eight days after injury. Postoperative course was uneventful at six weeks and was not seen again until 18 months after surgery for medial arm pain after working out. X-rays at this visit showed radiographic healing of the fracture. He was thought to have triceps tendonitis which was treated with anti-inflammatory medication and activity modification.

Case 2: 26-year-old right hand dominant male who presented to clinic with right arm pain after throwing a baseball and hearing a loud pop. He denied any prodromal arm pain but did start playing baseball a couple of months prior after a long hiatus. Radiographs demonstrated a spiral humeral shaft fracture (Figure 3). The patient was neurovascularly intact on exam. The patient underwent open reduction and internal fixation three days after injury. He did well post operatively and had follow-up of three months. At that time, the fracture was completely healed with no hardware complication on radiographs. The patient developed shoulder soreness with overhead activities following union of his fracture which was treated with steroid injection into the proximal biceps tendon.

Case 3: 26-year-old right hand dominant male barber presented to the emergency department with acute right arm pain after throwing a softball. He was found to have right humeral shaft fracture with a butterfly fragment (Figure 4). He had no neurological deficits and was placed in a coaptation splint. The patient then underwent open reduction and internal fixation of the humeral shaft fracture through a triceps splitting approach 10 days after injury. The patient was observed overnight in the hospital and was discharged postoperative day one in stable condition. He was seen in clinic three weeks postoperatively and was subsequently lost to follow-up. At that visit, the incision was well-approximated and he was neurovascularly intact.

Discussion

Overhead throwing is an uncommon mechanism for humerus fractures. In the cases presented above, all were recreational male athletes in their mid-20s who presented

Figure 2. Post-injury and post-operative radiographs of case 1.

Figure 3. Post-injury and post-operative radiographs of case 2.

Figure 4. Post-injury and post-operative radiographs of case 3.

with a thrower's fracture. None of the patients had prodromal symptoms. All were neurovascularly intact upon presentation and underwent open reduction and internal fixation within two weeks of injury.

As stated previously, a concerning complication associated with humeral shaft fractures is peripheral nerve injury. Though rare, there are case reports of radial nerve palsies secondary to humerus fractures caused by playing tennis, grenade throwing, javelin throwing, and dodgeball.[2, 3, 6, 8, 9, 12–14, 17, 23, 25, 29, 37, 41, 42] The radial nerve has a propensity to be injured after a thrower's fracture because it wraps around the humerus in the spiral groove directly adjacent to the cortex, making it susceptible to traction, laceration, compression, or contusion by fracture fragments.[26, 43] The prevalence of radial nerve palsy in the setting of a humeral shaft fracture increases from proximal to distal, with a prevalence rate of 1.8% in the proximal third, 15.2% in the middle third, and 23.6% in the distal third.[36] Typically, treatment of the fracture itself is generally all that is necessary for proper healing of the nerve. However, in cases of open fracture or where the nerve does not show recovery in 3–6 months, surgical exploration is indicated. In the cases presented in this paper, no radial nerve palsies were observed before or after surgery.

The traditional treatment option for humeral shaft fractures is functional bracing.[5, 21, 38] Sarmiento et al. demonstrated that bracing achieve good functional outcomes, similar to those treated surgically, with union rates approaching 96 percent without significant cosmetic deformity.[10, 15] Recent data has questioned this claim, and over the last decade, surgical management with open reduction and internal fixation has increased 13.1%.[26, 34] Surgical management is indicated in open fractures, vascular injury, or unacceptable alignment. The presence of radial nerve palsy is not an indication for open reduction and internal fixation. Many radial nerve injuries recover with time; however, several current studies have shown that surgical exploration has a higher likelihood of regaining radial nerve function as compared to nonsurgical treatment.[22, 27, 31, 43]

Definitive fracture fixation can be accomplished using external fixation, plates and screws, or intramedullary implants. Utilization of direct compression plates for absolute stability is ideal particularly to avoid a varus deformity.[38] Other methods such as intramedullary nail fixation have been studied but results have shown suboptimal outcomes when compared to plating techniques.[15, 28, 30, 40] Importantly, shoulder pain is often reported following intramedul-

lary fixation due to rotator cuff violation during the procedure. This sequela is less than ideal in patients who participate in activities which require overhead motion.

Despite recent trends towards surgical fixation for humerus fractures in young and active males, operative intervention does not come without risks such as iatrogenic radial nerve palsy.[1, 16, 20, 32] The incidence of iatrogenic nerve palsy has been reported between 6% and 32%.[4, 7, 11] Higher rates are seen during the use of external fixators and the lateral approach during fracture fixation.[7, 35] All of the cases presented underwent open reduction and internal fixation with no apparent complications. We advocate for surgical fixation of thrower's fractures unless there are underlying medical conditions precluding the patient from surgery.

In summary, humeral shaft fractures as a result of overhead throwing can be considered rare stress fractures which are often preceded by prodromal pain. Radial nerve palsy is a potential complication of humeral shaft fractures, although it is not an indication for surgical exploration and fracture fixation in the general population. Because the demographic of those with thrower's fractures tends to be young, active males, we advocate for exploration and fracture fixation in the setting of radial nerve injury. In the absence of radial nerve palsy, conservative treatment with functional bracing can be considered; however, we prefer open reduction and internal fixation in these cases as well.

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Case Report

Watching and Waiting? A Case of Incomplete Glenosphere Seating with Spontaneous Resolution in Reverse Shoulder Arthroplasty

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Abstract

Reverse shoulder arthroplasty is a useful procedure with broadening applications, but it has the best outcomes when used for rotator cuff tear arthropathy. However, this procedure is not without complications. While scapular notching and aseptic loosening are more common complications that have been extensively studied in the literature, dissociation of the glenoid component and incomplete glenosphere seating has not received much attention. Specifically, little research has explored appropriate management of incomplete seating of the glenosphere component, and no gold standard for treatment of this complication has emerged. In the case described here, an elderly patient with an incompletely seated glenosphere component post-operatively opted to pursue conservative management in order to avoid revision surgery if possible. The partially engaged, superiorly directed components in this case exhibited spontaneous complete and symmetric seating of the glenosphere between six and 12 months post-operatively, indicating that conservative management of this complication in low-demand patients may be a viable option to avoid the risks associated with revision surgery. Further research should be pursued to explore what patient and prosthesis design factors may be suited to observation with serial radiographs when incomplete seating of the glenosphere component occurs.

Introduction

Reverse shoulder arthroplasty (RSA) is a well-established procedure to treat rotator cuff tear arthropathy to move the center of rotation of the shoulder inferiorly and medially, thereby engaging the functional capacity of the deltoid to elevate the arm in the absence of a functional rotator cuff.[15] For this indication, 10-year implant survivorship is 89%, with 90% patient satisfaction at a mean of 4.3 years.[6, 7, 19] However, RSA complication rates range from 13–25% after primary arthroplasty surgeries and 37–69% of revisions.[16, 18] Reported complications include scapular notching, aseptic loosening, temporary postoperative neurapraxia, and intraoperative fracture.[3, 16]

Glenosphere dissociation is the third most common mode of failure in reverse total shoulder arthroplasty and has been reported to occur in approximately 1.8% to 5.1% of cases, with reported incidence as high as 12.2%.[1, 17] Glenosphere dissociation has been observed with various implant designs, including designs with a centrally threaded screw for glenosphere fixation as well as designs that rely solely on the Morse taper, for which glenosphere dissociation is the most frequent mode of failure.[17]

Inadequate engagement of the Morse taper has been identified as a cause of acute dissociation.[2, 5, 12, 14] Incomplete seating of the glenosphere on the scapular baseplate can result in suboptimal angulation or poor union of the components, allowing eventual baseplate-glenosphere separation, which has been confirmed by biomechanical, clinical, and retrieval studies.[5, 14] Several mechanisms have been proposed to explain improper engagement of the Morse taper between the baseplate and glenosphere components, including inadequate reaming of the glenoid, inadequately seated baseplate screws, implant design, and interposed soft tissues.[13]

This case report describes a patient with incomplete postoperative glenosphere seating whose implant underwent spontaneous correction with conservative management observed through serial radiological studies. Our case may indicate that superiorly directed, partially engaged glenospheres with a Morse taper alone for fixation, non-operative management and close follow-up with serial x-rays can provide a viable, beneficial course of action by avoiding the morbidity and mortality associated with surgical revision of an RSA implant.

Case Report

Patient Presentation

The patient is a 72-year-old, retired, right hand-dominant, cane-ambulating female with a medical history of hypertension, stage III chronic kidney disease, gout, gastroesophageal reflux disease, and a BMI of 33.1, who presented with persistent left shoulder pain to orthopaedic clinic unimproved by chronic narcotic pain medication use. She described severe pain without paresthesias that was worse

with overhead activity and had limited active range of motion (AROM). The patient was initially treated conservatively with a series of four subacromial corticosteroid injections with mild and diminishing improvement over eight months. She had continued decline in active forward flexion to 70° with decreased strength to 2/5 in flexion and external rotation.

Imaging

Initial x-rays on presentation demonstrated cuff tear arthropathy with superior humeral migration and narrowing of the acromiohumeral interval consistent with Hamada stage II (Fig. 1 A–B). An MRI was performed which further demonstrated moderate arthritic changes in the glenohumeral joint, and full width, full thickness tearing of the supraspinatus, infraspinatus, and subscapularis tendons with medial retraction and advanced fatty atrophy (Fig. 2 A–I). The long head of the biceps tendon exhibited partial tearing and medial dislocation from the bicipital groove. A preoperative CT was performed which also demonstrated degenerative changes, mild anterior subluxation of the humeral head, 4.3 cm of bone stock at the center of the glenoid, and normal glenoid retroversion (Fig. 3 A–C). Loose bodies were noted in the glenohumeral joint and bicipital groove.

After a year of conservative management from the onset of symptoms with functional decline and decreasing relief with corticosteroid injections and pain medications, the patient elected to proceed with RSA.

Surgical Technique

A RSA was performed using a Zimmer 36 mm baseplate/glenosphere set for implantation. After receiving two grams of preoperational cefazolin and a regional block, the procedure was performed under general anesthesia in a modified beach chair position. A deltopectoral approach was utilized and superficial and deep dissection were carried out, taking care to identify and protect the cephalic vein. The long head of the biceps tendon was identified, freed, and tagged for later reattachment to the pectoralis major tendon. The axillary nerve was identified and protected. The subscapularis was torn at the upper border and not amenable to repair. Humeral osteophytes were resected. The shoulder was dislocated and the proximal humerus was nearly devoid of rotator cuff tissue. The teres minor insertion was intact. Sequential humeral reamers were used from the Zimmer RSA set until the appropriate size was identified with a good canal fit in order to apply the intramedullary humeral cutting guide. The humerus was cut in approximately 10° of retroversion. The secondary and conical reamers were applied in sequence, and a trial stem was placed.

The degenerative labrum was then removed circumferentially from the glenoid. The 36 mm glenoid baseplate guide

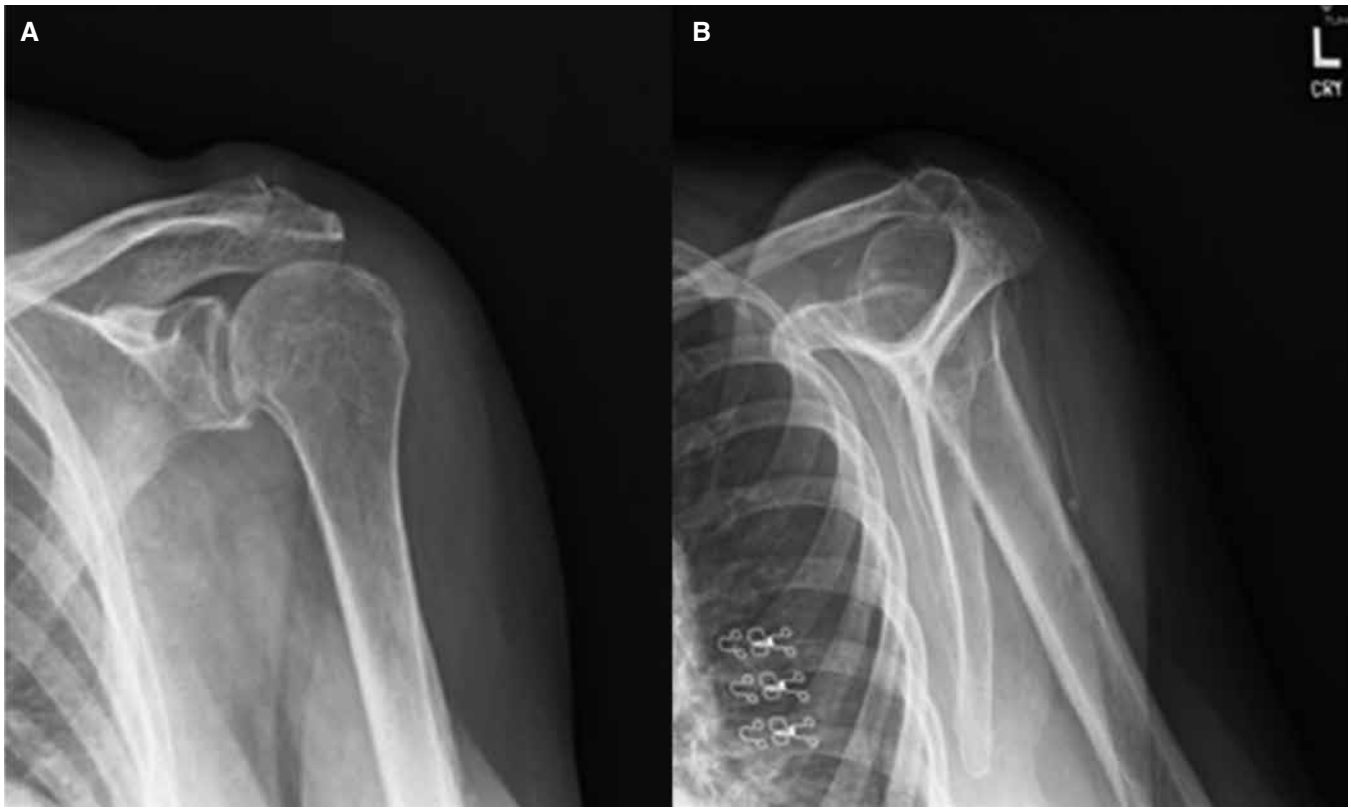

Figure 1. (A) An anteroposterior radiograph in external rotation and **(B)** A trans-scapular Y-view of the left shoulder demonstrating arthropathy of the acromioclavicular and glenohumeral joints with bony hypertrophy at the greater tuberosity.

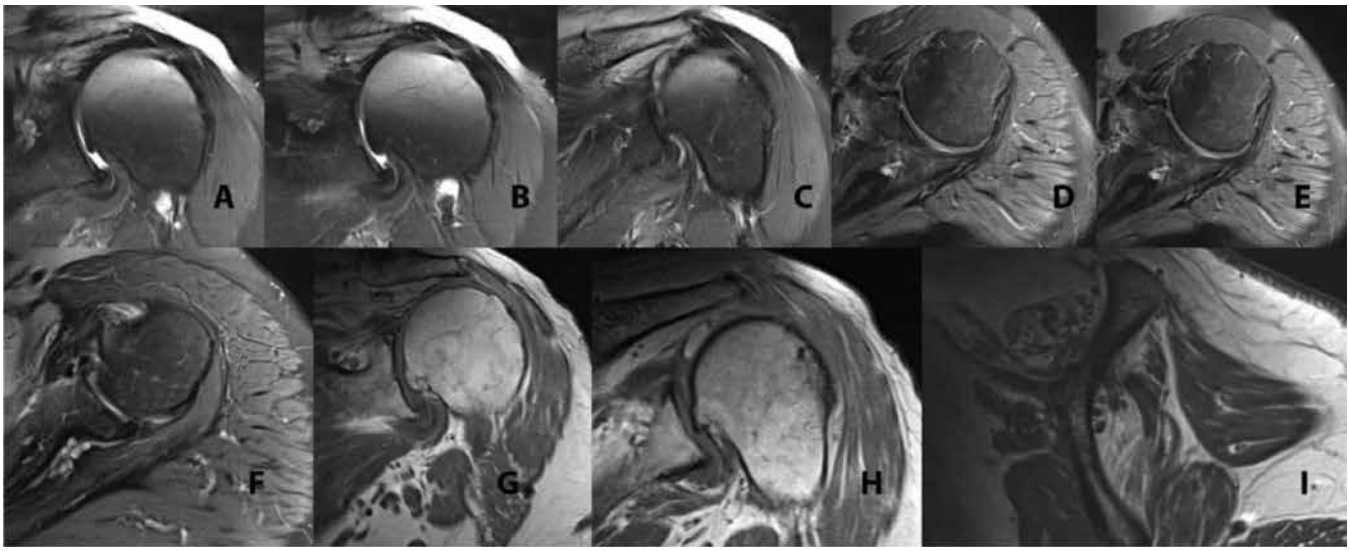

Figure 2. An MRI of the left shoulder. **(A–C)** A T2 coronal series demonstrating complete tearing of the supraspinatus tendon with medial retraction to the glenoid. **(D–F)** A T2 axial series demonstrating partial tearing and medial dislocation of the biceps tendon. **(G–H)** A T1 coronal series demonstrating good deltoid bulk without atrophy. **(I)** A T1 sagittal image demonstrating marked fatty atrophy of the supraspinatus and infraspinatus muscles.

Figure 3. (A–B) Axial CT images and **(C)** a coronal CT image calibrated to a bone window demonstrating superior and anterior migration of the humeral head with arthritic changes of the glenohumeral and acromioclavicular joints including a large osteophyte in the glenohumeral joint and subchondral cystic changes with intraarticular loose body **(B).**

fit well on glenoid face and was centered on the glenoid in the medial to lateral dimension, and as inferiorly as possible while obtaining sufficient backside support. Glenoid cartilage was removed by manual scraping. A targeting guide wire was placed and the starting hole for the glenoid baseplate was drilled without perforation. Sequential reamers were then used to remove the cortical bone, as well as to correct the inclination to neutral or slight inferior tilt and version to neutral. After irrigation, a 36 mm glenoid baseplate with a 15 mm central trabecular metal post was impacted. The inferior and superior screw holes were then drilled, the screw lengths were measured, and the screws were inserted with a good bite for fixation. The locking caps were applied. The 36 mm Glenosphere with Morse taper fixation alone was impacted onto the baseplate. The fixation was tested for stability with manual traction and rotation and was found to be securely seated intraoperatively. After irrigating the humeral canal, Palacos G cement was inserted with finger packing and the Zimmer reverse stem was inserted and impacted securely in approximately 10° of retroversion. A 36 mm +0 polyethylene liner was impacted securely. The shoulder was reduced, and passive range of motion (PROM) was tested and had sufficient stable range. An axillary nerve tug test confirmed that the nerve was in continuity and not under increased tension. The arm was irrigated, a medium Hemovac drain was placed, and one gram of Vancomycin powder was placed in the wound. The deltopectoral interval was closed in the standard fashion. The patient was placed in a standard sling, extubated, and taken to the recovery room in stable condition.

Postoperative x-rays revealed incomplete seating of the glenosphere on the baseplate with cephalad tilt of the glenosphere without associated fracture or dislocation (Fig. 4 A–C; Fig. 5). The imaging findings were explained to the patient along with possible courses of action. The patient desired to avoid reoperation and elected to be closely fol-

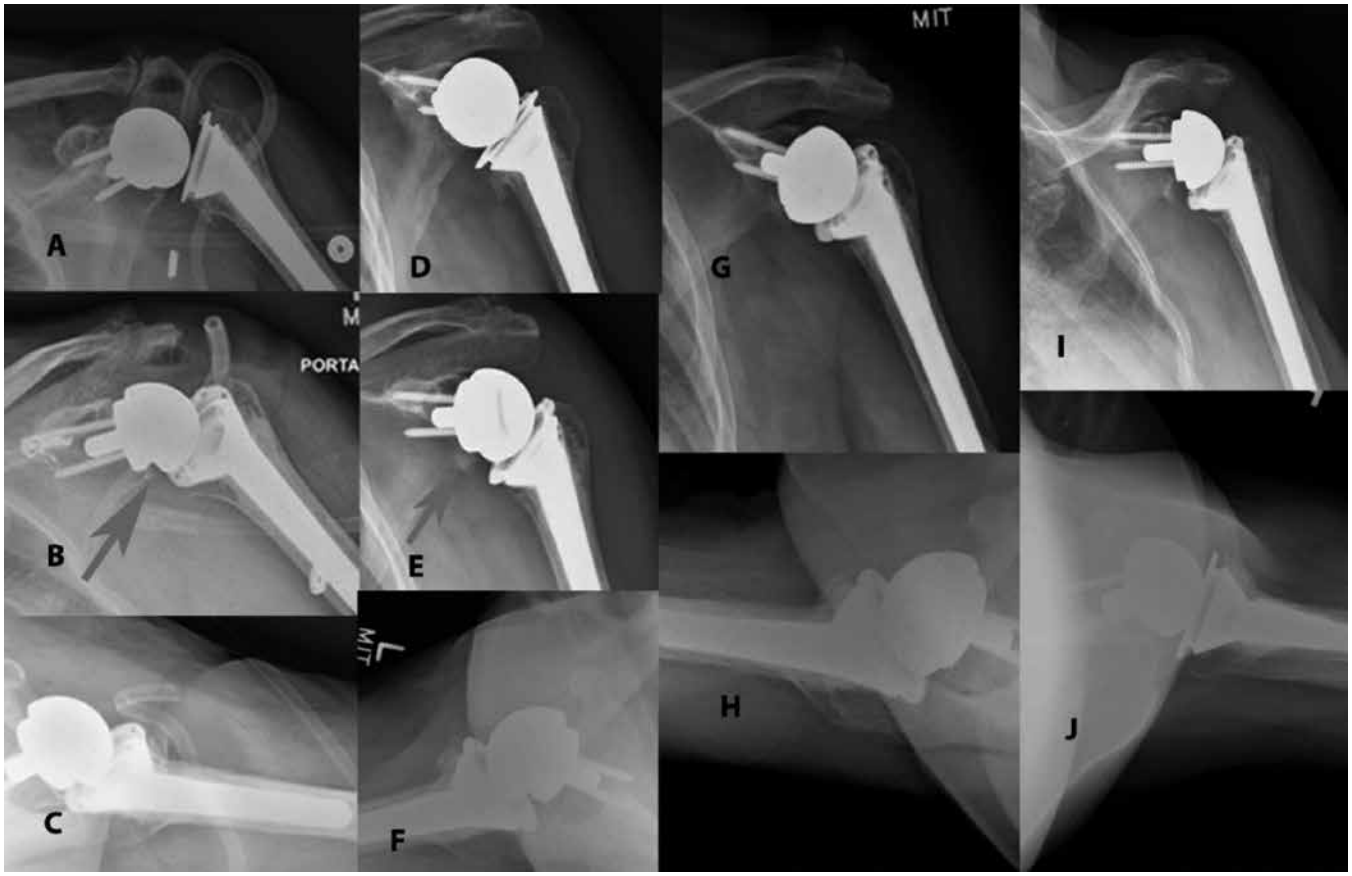

Figure 4. This figure shows the case of a patient with cuff tear arthropathy who underwent RSA for rotator cuff arthropathy. **(A–C)** X-rays from same-day post-op, **(D–F)** six-month follow-up films, and **(G–H)** one-year follow-up films. This progression demonstrates incomplete seating of the glenosphere on immediate post-operative films, followed by spontaneous seating of the glenosphere between six and 12 months. **(I–J)** 18-month follow-up demonstrating continued seating of the glenosphere. In **(A–F),** incomplete seating is observed with cephalad tilting of the glenosphere.

lowed with serial x-rays. The patient's postoperative course was otherwise uncomplicated. At the two-week visit, x-rays demonstrated unchanged incomplete seating of the glenosphere, but the patient was doing well with a clean, dry incision and intact neurovascular exam. At six weeks post-operation, the patient denied pain on gentle PROM to 90° of flexion and abduction with no change in her x-rays. She began formal physical therapy (PT) with PROM exercises and her sling was discontinued. At the three-month visit, the patient reported great improvement over preoperative status, and now had AROM to 140° of flexion and 40° of external rotation with unchanged x-rays. At the six-month visit, the patient had completed her course of PT and was doing well with home exercises despite unchanged x-rays (Fig. 4 D–F).

Significantly, at the one-year follow-up visit, the glenosphere had fully radiographically seated on the baseplate without surgical intervention or mechanical events (Fig. 4 G–H). The patient exhibited AROM to 140° of flexion and 50° of external rotation at the left shoulder and was proficient in ADLs that were impossible with her left arm preoperatively. The positioning of the implant remained stable at 18-month follow-up (Fig. 4 I–J).

Discussion

When performing RSA, baseplate positioning, offset, and tilt must be optimized in order to decrease risk of scapular notching, aseptic loosening, dislocation, glenosphere dissociation, and other complications.[5, 8, 11] Incomplete glenosphere seating with spontaneous resolution is a rarely reported outcome of RSA that may be a viable alternative to surgical revision in certain RSA designs. Newer RSA designs utilize a Morse-taper for fixation, a central screw, or both, with improved prosthesis lifespan over early Grammont RSA threaded designs.[9, 10, 14] Care must be taken to avoid entrapping surrounding structures between implant components, as *in vitro* study of the glenosphere-baseplate union showed that improper component engagement reduced torsional capacity by 60%.[5] In cases of failed Zimmer RSA prostheses, 25% of failures were attributable to glenosphere-baseplate dissociation — its most common mode of failure.[17]

Incomplete glenosphere seating is multifactorial, and testing for appropriate seating of the glenosphere on the Morse taper intraoperatively is difficult. A properly seated gleno-

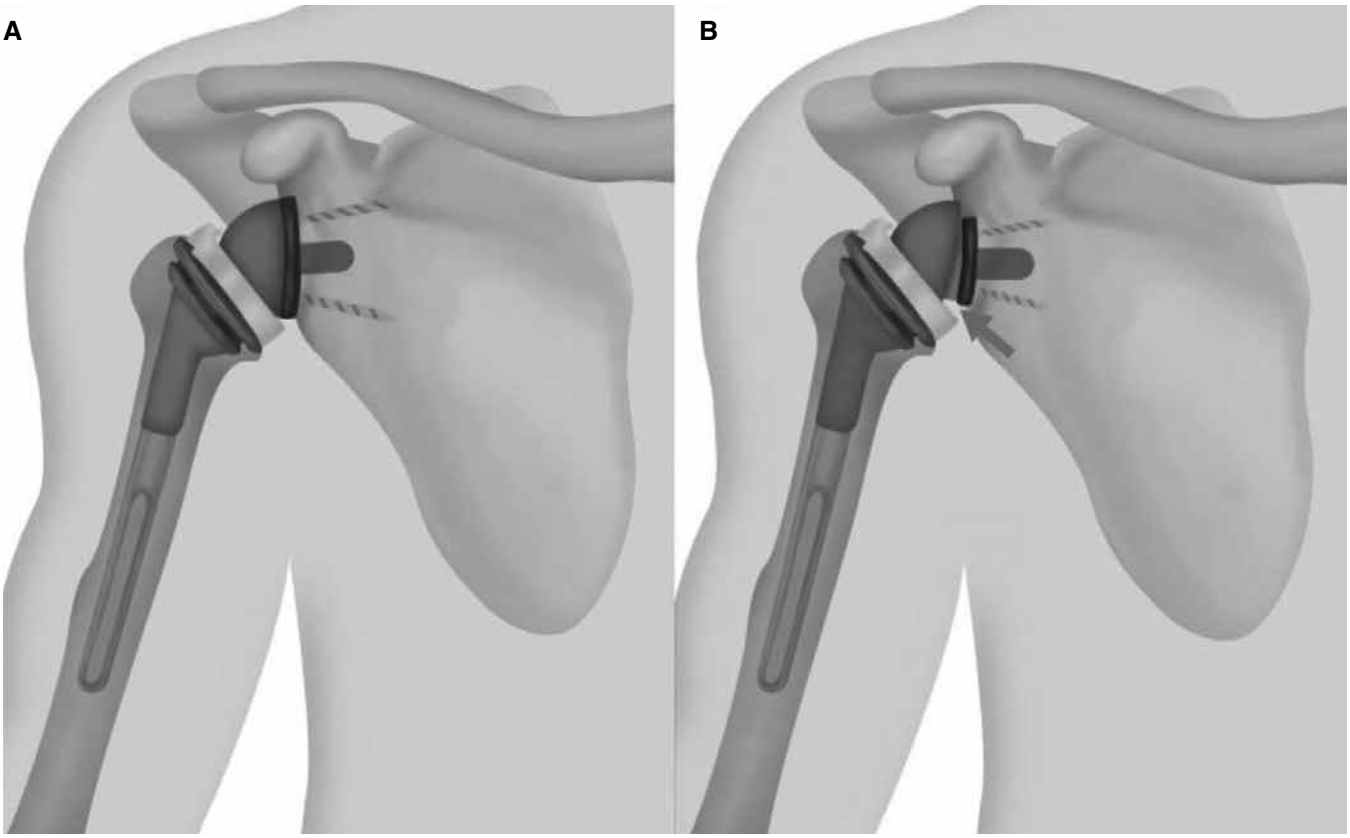

Figure 5. (A) A graphical rendering of the reverse shoulder arthroplasty prosthesis and **(B)** the incompletely seated glenosphere component with cephalad tilt as seen on post-operative x-rays.

sphere may require in excess of 4500 Newtons to dissociate intraoperatively, and even improperly-seated glenospheres may seem cold-welded in place.[5] Overly aggressive manual testing runs the risk of damaging the glenosphere surface or intraoperative fracture.[13] Some prostheses have a threaded hole for T-handle attachment on the glenosphere to allow for manual distraction testing intraoperatively, but this method fails to assess rotational stability.[5] The author now uses both manual testing and a thin curved clamp to examine the glenosphere and ensure gap symmetry before impaction and again after impaction to ensure complete seating. In glenoid components that include a central fixation screw through the glenosphere, counting the number of screwdriver turns or using an electric torque screwdriver have been proposed evaluation methods.[13]

Intraoperative radiographs can be used to evaluate the glenosphere-baseplate construct but appreciating subtle angulation of the glenosphere requires evaluation tangential to the baseplate which can be complicated by patient positioning, room size, available equipment, and technician skill and adds radiation exposure to the procedure.[13, 14] Introducing more personnel and equipment to the surgical field can increase infection risk.

Larger glenospheres, while providing more postoperative ROM, are more technically difficult to position intraoperatively.[14] Increased incidence of glenosphere dissociation has been associated with large 40 mm and 44 mm glenosphere sizes when compared to smaller glenospheres, though this case used a 36 mm diameter glenosphere.[5] Baseplate thickness may also influence proper glenosphere seating, as thinner baseplates may result in the glenosphere directly contacting the glenoid bone, whereas thicker baseplates allow more bony clearance and less risk for incomplete seating.

RSA designs also exist with both medialized and lateralized glenoid components. Medialized designs may decrease shear forces at the glenoid-baseplate and baseplate-glenosphere interfaces, thereby reducing glenoid component loosening and dissociation at the expense of increased rates of scapular notching, whereas lateralized designs have increased rates of aseptic loosening.[4] This case utilized a medialized glenoid component, which should theoretically decrease the risk of an incompletely seated glenosphere completely dissociating. The patient's obesity with a BMI of 33.1 is another notable factor that could have influenced the results. Obesity can induce a cam effect through excess soft tissue in the limb and trunk to promote instability, and can also limit exposure.

Previous articles addressing glenosphere dissociation primarily utilized revision surgery to manage that complication.[9] While glenosphere dissociation is one of the possible endpoints of poor glenosphere-baseplate union, this case demonstrated spontaneous correction. In the absence of pain

or dysfunction, this patient's desire to avoid revision surgery overruled her desire for a radiographically perfect outcome. The surgeon considered the patient's age, the type of prosthesis, demand on the limb, and commitment to follow-up, ultimately offering her the choice to monitor the prosthesis conservatively. In light of the spontaneous seating of the glenosphere on the baseplate one year post-operation, this population of RSA patients with incomplete glenosphere seating may benefit more from conservative management than revision.

Conclusion

While there is no gold standard for management of incompletely seated glenosphere components in RSA, this case demonstrates spontaneous seating of the glenosphere component with non-operative management within one-year follow-up in an elderly patient with low demand for the affected joint. A judicious approach must be taken when analyzing management of glenosphere complications on a case-by-case basis. Further studies may be useful to define what factors have positive prognostic value for spontaneous component seating.

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Case Report

Giant Cell Tumor of Bone Involving the Base of the First Metacarpal: A Case Report and Review of the Literature

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Abstract

Giant cell tumors of bone (GCT) are uncommon overall and reports in the hand are rare. We relate the presentation and management of a 61-year-old patient a remote history of invasive breast cancer in remission with a giant cell tumor involving the base of the first metacarpal.

Introduction

Giant cell tumor of bone (GCT) is a benign mesenchymal tumor with a rare tendency to metastasize characterized by multinuclear giant cells.[1] These rare, benign but locally aggressive lesions are most often located in the epiphyseal and metaphyseal regions of long bones and occur infrequently in the hand.[1, 2] Patients with hand lesions are typically between the age of 20–40 years and present with complaints of pain, swelling and stiffness.[2, 3] Radiographic identification of GCTs often occurs after seemingly trivial injury and may be associated with pathologic fracture.[1, 3] The classic radiographic features of GCTs are often sufficient for diagnosis; however, MRI and biopsy may be necessary.[1, 4] Surgical excision, either marginal or wide resection, remains the mainstay of GCT management; however, the benefits of joint preservation must be carefully measured against the risk of local recurrence.[4, 5] Relatively recent advances in adjuvant treatments include local agents such as phenol, alcohol or liquid nitrogen and neoadjuvant therapies including the bisphosphonate zolendronic acid and the RANKL inhibitor denosumab.[6, 7] Despite acceptable risk of local recurrence with curettage and local adjunctive treatment elsewhere in the body,[5] that risk appears higher in the hand[3, 8] and challenges the treatment goals of cure and maintenance of function.

Case Report

A 61-year-old right-handed female with a history of invasive breast cancer treated with mastectomy, lymph node biopsy and chemotherapy (now in remission) presented to the orthopaedic hand clinic with roughly two months of atraumatic pain in the base of the left thumb. The patient was evaluated initially at an urgent care facility two weeks prior, noting pain and swelling associated with decreased grip strength without antecedent injury. Radiographs obtained at that time demonstrated a small cystic lesion at the base of the first metacarpal and associated minimally displaced pathologic intra-articular fracture (Fig. 1 A–C).

Given the benign appearance of the pathological lesion, consistent with enchondroma, the patient was initially treated with cast immobilization for symptomatic pain relief. Serial radiographs were obtained over the course of two months demonstrating lack of fracture consolidation and progressive expansion of the cystic lesion (Fig. 2 A–C). Subsequent MRI (Fig. 3 A–C) demonstrated an expansile destructive lesion within the base of the metacarpal with disruption of three cortices and extension into the carpometacarpal joint. Ultrasound-guided biopsy was obtained demonstrating a giant cell rich neoplasm, consistent with GCT. CT evaluation of the chest did not reveal any evidence of metastatic disease.

The initial treatment plan was devised in coordination with the hand surgeon, orthopaedic oncologist and medical oncologist consisting of 6–12 weeks of neoadjuvant denosumab, marginal resection and staged reconstruction. After three weeks of denosumab therapy, however, the patient returned to the office with persistent complaints of unrelenting pain and disability and the desire to proceed with prompt surgical excision. Five months after her initial presentation, the patient underwent an uncomplicated intralesional resection followed by placement of a polymethyl methacrylate cement spacer (Figures 4 A–C). Final histological evaluation was consistent with GCT (Fig. 5). Following an uncomplicated post-operative recovery and three months of denosumab therapy, the patient underwent staged reconstruction with iliac crest autograft (Fig. 6). At the time of reconstruction, a well-defined biomembrane was noted without evidence of local tumor recurrence. Her early post-operative recovery remains uncomplicated (Fig. 7).

Discussion

Representing roughly 5% of all primary bone tumors, giant cell tumor of bone has an estimated incidence of 1.49–1.7 per million inhabitants per year in recent population studies.[9, 10] The occurrence of these bony tumors in the hand is even more infrequent, estimated at 1–5% of all GCTs.[8] Despite the benign nature of these bony lesions, approximately 1–6% of benign GCTs develop pulmonary metastases which can be fatal.[1]

Figure 1. (A–C) Initial radiographs of the left thumb.

Figure 2. (A–B) Repeat radiographs of the left thumb two months after initial presentation.

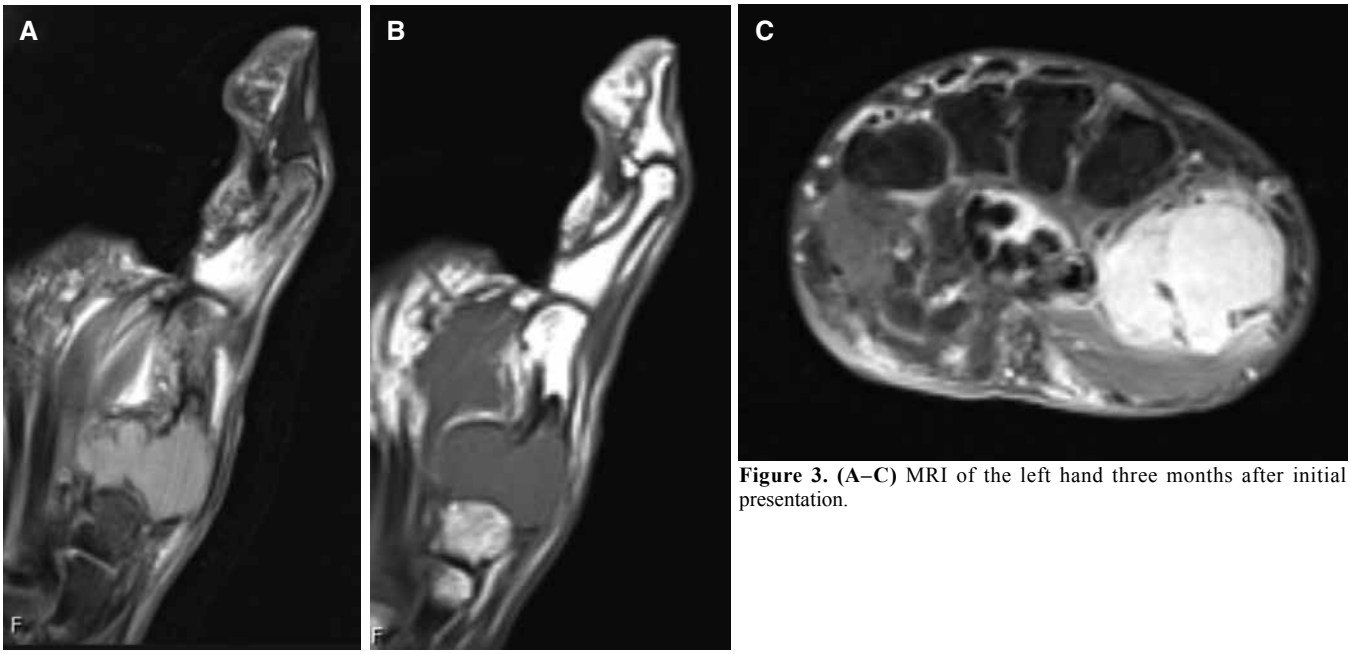

Figure 3. (A–C) MRI of the left hand three months after initial presentation.

Figure 4. (A–C) Intraoperative photos and fluoroscopic image demonstrating intra-lesional excision and placement of PMMA cement spacer.

The clinical presentation illustrated in this case highlights the rapidly growing and aggressive nature of GCTs in the hand as well as the diagnostic and treatment challenges. The patients history of basilar thumb pain combined with pathologic fracture through an otherwise benign appearing lesion, was initially attributed to an enchondroma, the most common bone tumor occurring in the hand. Conventional GCT may initially appear similar to an enchondroma as a lytic, eccentric lesion in the epiphysis extending into the metaphysis without evidence of periosteal reaction, stippling or calcifications. Evidence of rapid expansion over less than eight weeks, however, prompted a more comprehensive examination and ultimately, tissue diagnosis. These authors would caution other practitioners to closely follow even benign-appearing lesions radiographically to determine the rate of progression and assess the need for early advanced imaging.

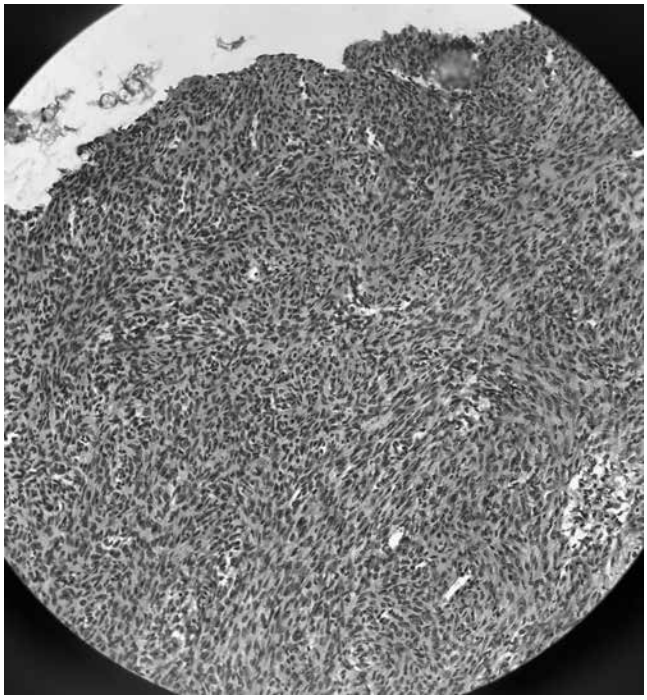

Figure 5. Histologic specimen.

Given the benign nature and metaphyseal location of these tumors, the most common course of modern treatment includes a combination of systemic therapy and intralesional resection with attempts to preserve a functional joint.[4] Previous attempts at intralesional curettage alone resulted in local recurrence rates as high as 45%; however, the use of adjuvant therapy has significantly reduced recurrence to less than 20%.[1] Current treatment recommendations combine Denosumab systemic therapy with intralesional excision and adjuvant therapy; however, recent studies are concerning for persistently high rates of local recurrence and metastasis.[11, 12] Of additional concern, GCT in the hand demonstrates a higher rate of local recurrence and propensity to metastasize

Figure 6. (A–B) Intraoperative fluoroscopic image demonstrating reconstruction of the first metacarpal.

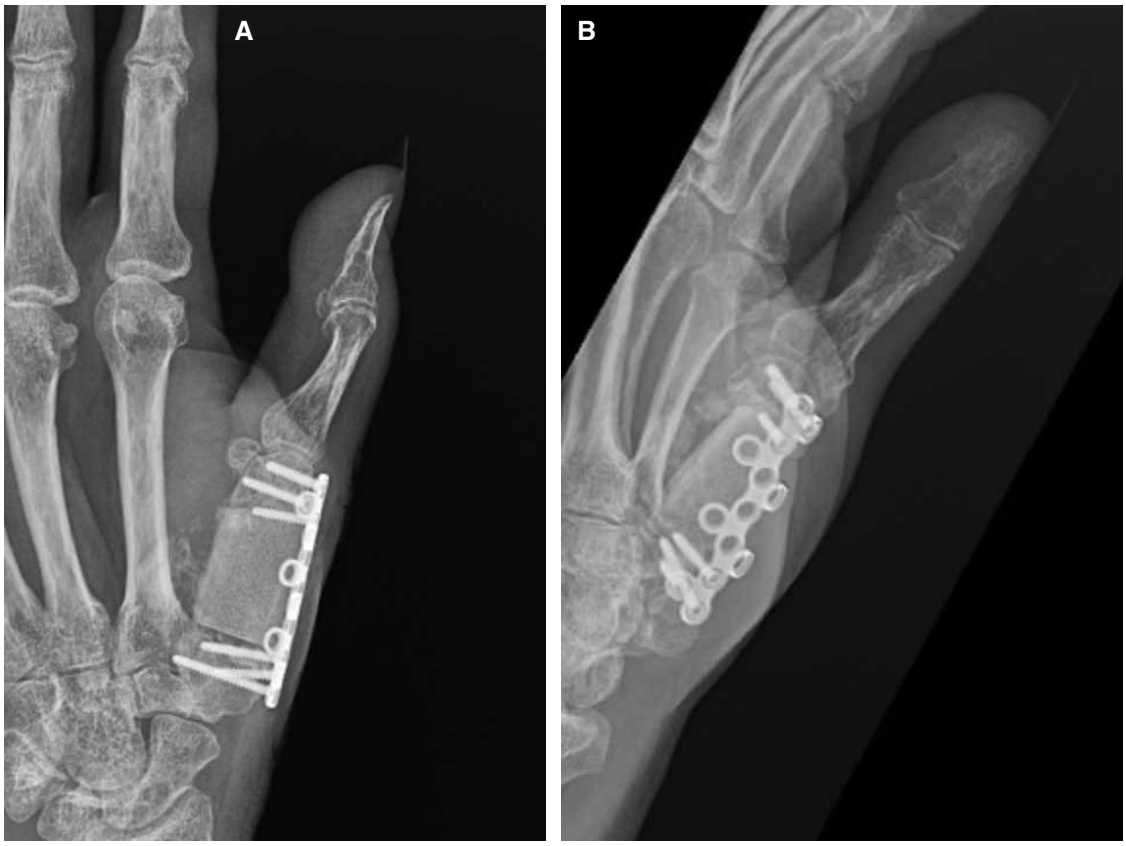

Figure 7. (A–B) Follow-up radiographs, two months s/p reconstruction.

compared to those elsewhere in the skeleton. The initial treatment plan for the patient presented in this case study included systemic denosumab therapy with the hope to reduce tumor burden and stage marginal excision, optimizing her functional outcome while reducing the risk of local recurrence. Unfortunately, the patient was unable to tolerate denosumab therapy and elected for early intralesional excision. Early results including intraoperative findings at the time of reconstruction and follow-up are encouraging; however, continued follow-up for the next five years will be essential including routine radiographic examination of the hand and chest. In the absence of initial cure, early identification of local recurrence and treatment will provide the best chance for preserving life and limb.

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Senior Profiles — Class of 2020

ROBERT JOSEPH AMES

Hometown: Dallas, TX

Undergraduate University: Rutgers University

Undergraduate Degree: Sociology

Medical School: Temple University School of Medicine

Fellowship: San Diego Spine Foundation

Significant Other: Sara Jennings

Children: Elijah, Harper and Levon

Fun Fact/Memorable Moment During Residency: During my chief year, a woman came in with a broken femur who was 39 weeks pregnant. She needed an urgent c-section prior to treatment of the fracture. The OB team graciously allowed me to assist in the delivery of the child . . . and then we nailed the femur. It was a very special day in OR 10.

DAYNA MARIE PHILLIPS

Hometown: Rosenhayn, NJ

Undergraduate University: University of the Sciences

Undergraduate Degree: Biology (BS)

Medical School: Rutgers New Jersey Medical School

Fellowship: Cincinnati Children's Hospital Medical Center, Pediatrics

Significant Other: Donovan Smalls

Children: Baby Smalls (due July 2021)

Hobbies/Interests: Travel, beating my husband's March Madness Bracket, and spending time with family

Interesting Fact: I have a twin brother

COLIN MACELROY VROOME, JR.

Hometown: Havertown, PA

Undergraduate University: Villanova

Undergraduate Degree: Chemical Engineering (BS)

Medical School: Sidney Kimmel Medial College at Thomas Jefferson University

Fellowship: University of Pittsburgh Medical Center, Hand/Upper Extremity Surgery

Significant Other: Erika Mayfield Vroome

Children: Rowdy (7), Nala (5), Conor (1), Baby Vroome (due September 2021)

Hobbies: Running, piano

Interesting Fact: In medical school, I delivered a baby with the OB that delivered me (Llankenau)

JEFFREY WERA

Hometown: Villa Hills, KY

Undergraduate University: The College of William & Mary

Medical School: University of Louisville School of Medicine

Fellowship: University of Pittsburgh Medical Center, Hand/Upper Extremity Surgery

Significant Other: Meghan Walker Wera

Hobbies: Drinking bourbon and quoting sports trivia

Senior Profiles — Class of 2021

DANA LESLIE CRUZ

Hometown: Bronx, NY

Undergraduate University: University of Southern California

Undergraduate Degree: Biochemistry (BS)

Medical School: Albert Einstein College of Medicine

Fellowship: University of Arizona, Hand/Upper Extremity and Microsurgery Fellowship

Significant Other: Ryan Brown

Hobbies: Cooking, accumulating stamps in my passport, running

Interesting Fact: I ran 27 races during residency, including two marathons

ALEXANDER JOSEPH JOHNSON

Hometown: East Norriton, PA

Undergraduate University: Randolph-Macon College

Undergraduate Degree: Biology (BS)

Medical School: Drexel University College of Medicine

Fellowship: University of Colorado, Sports Medicine

Significant Other: Erin Shea

Hobbies: Cooking, biking, traveling, snowboarding, hiking, camping, playing with my dog, watching Philadelphia sports, trying new restaurants

Interesting Fact: I have a dog named Turkey

NIMIT LAD

Hometown: Winona, MN

Undergraduate University: Duke University

Undergraduate Degree: Chemistry (BS)

Medical School: Duke University School of Medicine

Fellowship: Duke University, Sports Medicine

Significant Other: Sharmistha Rudra

Children: Nayan Lad

Hobbies: Traveling, trying new restaurants, watching sports, politics, and health policy

Interesting Fact: I am a Canindian (Indian person born in Canada)

JOHN M. REYNOLDS

Hometown: Malvern PA

Undergraduate University: Villanova University

Undergraduate Degree: Business Administration (BS), Economics, Spanish (Minor)

Medical School: Jefferson Medical College

Fellowship: Cleveland Clinic, Hand/Upper Extremity

Significant Other: Anna Reynolds

Hobbies: Villanova basketball, Phillies baseball, fitness, traveling, cooking, tailgating any and all sporting events

Interesting Fact: Relative to General John F. Reynolds, who was the first general to die in the Civil War and was replaced by Abner Doubleday, the founder of the game of baseball

Special Event

Socially Distanced Camaraderie

2020 presented many unique challenges for the residency program from the aspect of healthcare, coverage of clinical duties and maintaining safe practices to prevent the spread of COVID-19 amongst each other, our families and friends, and most importantly our patients.

The Temple Orthopaedics Department thrives on the friendships and mentorship built during social activities outside of the hospital to strengthen the teamwork and synergy amongst residents and faculty alike. Needless to say, COVID-19 led to social distancing as the norm, which naturally led to less social events.

However, in true Temple fashion, we decided to not let that stop us from sharing time together as a program. Throughout the year, we had Zoom group chats where we were able to share departmental news and updates as well as grab an adult beverage in the comfort of our home to simply catch up and relax. This helped to continue the tradition of Temple Orthopaedics strong camaraderie both inside and outside the hospital.

Hopefully, 2021 and the vaccine will allow for social gatherings sooner rather than later!

Max McQuade, DO

To support its activities, the John Lachman Society is actively soliciting your tax-exempt contributions, which can be made two ways:

Via our new secure website, which is https://lachmanfund.org. Once there, you can make a donation and also view current and past issues of the journal as well as other resident activity.

Or, if you wish to write a check, please make it payable to John Lachman Orthopaedic Research Fund and mail it to our Treasurer: Saqib Rehman, MD, Department of Orthopaedic Surgery, Temple Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

Clearly, these programs greatly enhance the medical student and resident orthopaedic experience! And clearly, your contribution to the program will be greatly appreciated!

Joe Torg, MD Joe Thoder, MD

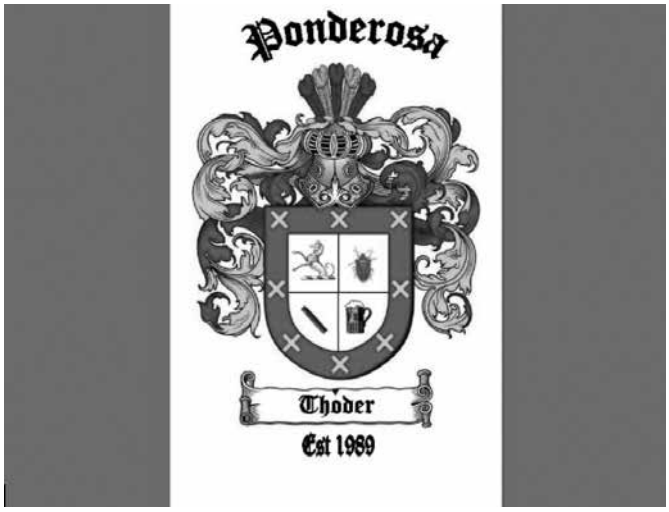
Special Event

How to Be a Gentleman and Gentle Lady Social

November 14, 2020

This year's Ladies and Gentlemen's party was held outdoors on the patio at the Ponderosa so that social distancing precautions could be taken in light of COVID-19. The patio was well heated with many space heaters, and in keeping with tradition, the residents and attendings were dressed in semi-formal attire. Educational presentations were given by many of the chief residents in attendance. Nimit Lad and his wife Sharmistha gave the group a lively talk on Indian culture and attire, while the recently-engaged Dana Cruz gave an informative overview of the many facets to consider when selecting an engagement ring. Andrew Porter presented to the group the principles of building a professional wardrobe and also reviewed appropriate professional attire for interviews, conferences, and day-to-day clinic. Dr. Thoder and Dr. Solarz then took an informal break and brought out the standing mirror to give the gentlemen in attendance a review of how to tie a bow tie (Ryan Judy, in particular, required significant remediation despite his many years in Catholic school). Alexander Johnson concluded the evening by giving a talk on how to compose a charcuterie board, the highlight of which was the two delicious charcuterie boards which he made himself and brought from home. During this time of the COVID-19 pandemic in which social events are few and far between, the Ladies and Gentlemen's party was a welcome evening in which the residents and attendings were able to gather together and continue a well-loved tradition of celebration and light-hearted education.

Heather Flynn, MD PGY3



Departmental News

Faculty

Temple University Department of Orthopaedic Surgery and Sports Medicine

Interim Chairman

Joseph Thoder, MD

Professors

Joseph Thoder, MD, *The John W. Lachman Professor*
Pekka Mooar, MD
Ray Moyer, MD
Saqib Rehman, MD, *Vice Chairman*
Joseph Torg, MD

Associate Professors

Leslie Barnes, MD
Eric Gokcen, MD
Cory Keller, DO
Michelle Noreski, DO
J. Milo Sewards, MD

Assistant Professors

Hesham Abdelfattah, MD
David Galos, MD
Matthew Lorei, MD
Theresa Pazionis, MD
Vishal Saxena, MD
Ryan Schreiter, DO
Mark Solarz, MD

Adjunct Faculty — Philadelphia Shriners Hospital for Children

Scott Kozin, MD, *Chief of Staff*
Philip Alburger, MD
Corinna Franklin, MD
Steven Hwang, MD
Sarah Nossov, MD
Amer Samdani, MD, *Chief of Surgery*
Joshua Pahys, MD
Harold van Bosse, MD
Albert Weiss, MD
Daniel Zlotolow, MD

Adjunct Faculty — Jefferson Health–Abington Memorial Hospital

Andrew Star, MD, *Chief of Orthopaedics*
Shyam Brahmabhatt, MD
David Craft, MD
Matthew Craig, MD
Daniel Fuchs, MD
John Horneff, MD
Victor Hsu, MD
Moody Kwok, MD
Guy Lee, MD
Thomas Peff, MD
T. Robert Takei, MD

Adjunct Faculty — St. Christopher's Hospital for Children

Peter Pizzutillo, MD, *Chief of Surgery*
Alison Gattuso, DO
Dustin Greenhill, MD
Megan Gresh, MD
Michael Kwon, MD
Martin Herman, MD, *Chief of Orthopaedics*
Joseph Rosenblatt, DO
Shannon Safier, MD
Arianna Trionfo, MD

Division Report

Division of Adult Reconstruction

Matthew Lorei, MD
Division Chief

Pekka Mooar, MD

General

Our division heads the musculoskeletal care of the older adult with hip and knee conditions. Our surgical focus is on hip and knee replacement: including partial knee replacement, primary total joint replacement, revision replacement and complex reconstruction. One of our primary missions is to educate residents in the art and science of hip and knee replacement surgery and advanced reconstruction. We also have a strong focus on scholarly activity as highlighted throughout this journal and listed below.

In the spring and summer of 2020, we unfortunately saw the departure of Julie Shaner and Min Lu who both moved out of state to be closer to their respective families.

Starting in March of 2020, we began to greatly increase our role at Jeanes Hospital. Our expansion was interrupted by the COVID-19 pandemic. However, growth has been brisk, and we now are performing two-thirds of our joint replacement volume at Jeanes. We have also opened a new satellite office on the Jeanes campus to better serve the needs of the local population. Due to the growth of our venture at Jeanes Hospital, we made the difficult decision to end our relationship with Chestnut Hill Hospital. We ceased operations there in the fall of 2020. We continue to maintain strong ties with the local CHH providers and patients in northwest Philadelphia with whom we had a close and productive relationship for the past seven years.

We are pleased to announce that we have adapted and implemented our electronic comprehensive care plan (Pathway) for perioperative joint replacement patients at Jeanes Hospital. There is now one consistent and almost seamless pathway for joint replacement surgery at Jeanes and Temple. The pathway is a series of orders, expectations and instructions that stewards the patient's care and experience from surgical scheduling, through PATs, preop clearances, joint class, preop preparation, intraop and PACU care as well as postop care and PT on the floor. It also covers discharge instructions and the plan for outpatient follow-up. The pathway will continue to streamline the preop and postop processes and eliminate errors and omissions for the joint replacement patient. We anticipate that the pathway will improve the patient experience and reduce length of stay at Jeanes, similar to what we accomplished at Temple. This will also help us as we move toward a unified Jeanes/TUH bundled payment arrangement for Medicare patients.

Dr. Mooar is currently involved in the Novacart trial comparing MACI cartilage transplantation vs. microfracture of femoral condylar articular cartilage defects. He is also involved in a clinical trial assessing the ability of intra-articular LNA043 injections to regenerate articular cartilage of the knee.

Dr. Lorei was honored as the distinguished alumni of the year for the 2019 Lenox Hill Hospital Department of Orthopaedic Surgery Research Day. He gave a keynote presentation on "Management of the Displaced Femoral Neck Fracture in the Elderly."

Research Activity

Publications

Mooar PA, et al. ACR Appropriateness Criteria — Acute Foot Trauma. *Journal of the American College of Radiology.*

Mooar PA, et al. ACR Appropriateness Criteria — Acute Knee Pain. J*ournal of the American College of Radiology.*

Division Report

Division of Foot and Ankle Surgery

Eric Gokcen, MD
Division Chief

The Division of Orthopaedic Foot and Ankle Surgery provides comprehensive care for the foot and ankle patient, including deformity correction, sports medicine, joint reconstruction, and trauma care. In addition, teaching of orthopaedic residents, medical students, and physician assistant students is performed with both didactic and clinical education.

Residency education is of primary importance in the division, and despite the ongoing pandemic, training has continued unhindered. Several presentations and teaching sessions over the course of the year included Hallux Valgus and Rigidus, Achilles Ruptures, Ankle Arthroscopy, and Global Orthopaedic Surgery, Lisfranc Injuries, Diabetic Foot, Adult Acquired Flatfoot Deformity, Global Health Orthopaedics, among others.

The division previously organized international orthopaedic experiences for the department residents with trips to Kenya. Unfortunately, the pandemic has resulted in restricted travel, and thus, the program has been postponed. The expectation and hope is that we will resume the program in late 2021.

Research is progressing well with foot and ankle projects, along with international orthopaedic research. Presentations included "Ankle Fracture Care in Resource-poor Countries" at the AOFAS annual virtual meeting, along with poster presentations of "Perceived Effectiveness of a Short-term Orthopaedic Foot and Ankle Mission Trip to Kenya" and "Resuming Humanitarian Medical Trips After COVID-19 — Perspectives from Volunteers." "Bugs and Bullets: Infections Following Ballistic Injuries to the Foot and Ankle" was a poster presentation at the Philadelphia Orthopaedic Trauma Symposium. Further research projects are ongoing, including studying driving after foot surgery supported by a grant from the OREF, cost analysis of ankle fracture surgery, effect of EMR on patient safety, radiation exposure with ankle fracture surgery, and others. A paper entitled "Tarsal Coalition of the Cuneiforms in a Young Athlete: A Case Report" has been accepted for publication in the JBJS Case Connector, and a paper by Dr. Gokcen with Temple medical student Alec Talsania entitled "COVID-19 and Orthopaedic International Humanitarianism" was accepted for publication in the JAAOS Global Research journal.

The division founded the Philadelphia Orthopaedic Foot Club in 2017, which provide networking opportunities for the foot and ankle orthopedists in the Philadelphia area in order to provide the best care possible to our patients. The meetings were put on hold due to the pandemic but should resume once gatherings are permissible again.

In summary, the Division of Foot and Ankle Surgery continues to grow, providing excellent care for our patients in an academic teaching environment, while researching to improve foot and ankle care for all.

Division Report

Division of Hand Surgery

Joseph Thoder, MD
Division Chief

Hesham Abdelfattah, MD

Mark Solarz, MD

The Division of Hand Surgery at Temple continues to provide compassionate care to our patients. In addition to patient care, our team of fellowship-trained hand and upper extremity surgeons are dedicated to resident as well as medical student education. As we continue to provide comprehensive care to our patients, our clinical accomplishments and contributions to the field of hand surgery continue as well. These accomplishments are represented in the list of podium presentations, scientific exhibits and publications listed in this journal as well as prior journal issues.

Over the last three decades, Temple Orthopaedics has graduated 35 residents who have pursued fellowships and continue on to have successful careers in hand surgery. Many of these graduates are now leaders in the field. This year's graduating class has Dana Cruz going to the University of Arizona and Jack Reynolds going to the Cleveland Clinic Foundation for their hand fellowship training.

Division Report

Division of Orthopaedic Trauma

Saqib Rehman, MD, MBA
Division Chief

David Galos, MD

The Division of Orthopaedic Trauma is focused on the care of patients with fractures, multiple trauma, and related injuries. We strive for excellence in patient care, education, research, and service. Working collaboratively on interdisciplinary teams has helped standardize care, minimize errors, improve efficiency, and ultimately improve patient care. Through continuous performance improvement reviews and innovation, we hope to continue improving for our patients at Temple.

The 10th Annual Philadelphia Orthopaedic Trauma Symposium was hosted by Temple again, with over 150 participants gathered for two days of CME lecture, case discussion, and learning.

Resident and student didactic educational efforts have continued to evolve with increasing use of online resources and flipped classroom teaching methods and strong emphasis on the "active learning" approach.

The ortho trauma faculty continue to teach at national courses and meetings including annual meetings of the American Academy of Orthopaedic Surgeons (AAOS), Orthopaedic Trauma Association (OTA) and Foundation for Orthopaedic Trauma (FOT), and AO Trauma. In addition, we have taught at local and regional courses, and given grand rounds lectures at other teaching programs. In addition, we have been actively serving many of these societies, chair committees and serve on Executive Boards in national organizations in our specialty, and serve as manuscript reviewers for multiple scientific journals. Back home at Temple, the ortho trauma faculty actively serve and chair numerous committees and project teams at the university, hospital, and departmental levels.

Research Activity

Clinical Trials

The Division of Orthopaedic Trauma, as Principal and Sub-Investigators, have been involved in the following clinical trials:

- Regional vs. General Anesthesia for Promoting Independence After Hip Fracture Surgery (REGAIN)
- Multimodal Prevention of Postoperative Delirium in Geriatric Fracture Patients

Scientific Publications

1. Hoehmann CL, DiVella M, Osborn NS, Taylor BD, Galos DK. Supra-Acetabular Pin Placement Without Fluoroscopy in Anterior Pelvic External Fixation Application: Description of a Surgical Technique. *Orthopedics*. November 2020 (Accepted)
2. Hoehmann CL, Thompson J, Long M, DiVella M, Munnangi S, Galos DK. Unnecessary Pre-Operative Cardiology Evaluation and Transthoracic Echocardiogram Delays Time to Surgery for Geriatric Hip Fractures. *J Orthop Trauma.* August 2020 (Accepted)
3. Galos DK, Doering T. High Energy Fractures of the Pelvis and Acetabulum in the Pediatric Patient. *JAAOS.* May 2020 (Published)
4. Passias BJ, Korpi FP, Chu AK, Myers D, Grenier G, Galos DK, Taylor BC. Safety of Early Weight Bearing Following Fixation of Bimalleolar Ankle Fractures. *Cureus*. 2020 Apr 06;12(4):e7557. doi: 10.7759/cureus.7557 (Published)
5. Thompson J, Long M, Rogers E, Pesso R, Galos DK, Dengenis RC, Ruotolo C. Fascia Iliaca Block Decreases Hip Fracture Postoperative Opioid Consumption: A Prospective Randomized Controlled Trial. *J Orthop Trauma.* Jan 2020 (Published)

6. Yngstrom K, Stapleton E, Aberman Z, Galos DK. Bilateral Acetabular Fractures Associated with Seizures: A Report of Two Cases. *JBJS Case Connector.* Vol 10, No 4, 2020 (Published)
7. Hoehmann CL, Osborn NS, DiVella M, Giordano J, Singh I, Fogel J, Galos DK. Excessively Long Interfragmentary Screws for Posterior Wall Acetabular Fractures Can Predict Intraarticular Penetration. *J Orthop Trauma.* April 2020 (Submitted)

Scientific Podium and Poster Presentations

1. Thompson J, Long M, Rogers E, Pesso R, Galos DK, Dengenis RC, Ruotolo C. Fascia Iliaca Block Decreases Hip Fracture Postoperative Opioid Consumption: A Prospective Randomized Controlled Trial. *OTA Annual Meeting,* October 2020.
2. Hoehmann CL, Thompson J, Long M, DiVella M, Munnangi S, Galos DK. Unnecessary Pre-Operative Cardiology Evaluation and Transthoracic Echocardiogram Delays Time to Surgery for Geriatric Hip Fractures. *OTA Annual Meeting,* October 2020.
3. Ackerman C, Boehm A, Sadeghipour K, McLaughlin J, Abdelfattah H, Rehman S. Modern Drilling and the Impact of Plunge Distance, Biomechanical, and Thermal Properties Using Cadaveric Models. *11th Annual Philadelphia Orthopaedic Trauma Symposium,* June 13, 2020.
4. Flynn H, Rehman S, Ramsey F, McKinney R, Jennings J. Are CT scans needed to rule out occult femoral neck fractures in femoral shaft fractures caused by firearm injury? *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 7–8, 2019.
5. Johnson A, Wiekrykas B, Ebbot D, Haydel C, Rehman S. Infection rates after gunshot-related tibia shaft fractures are comparable to rates after closed tibia shaft fractures. *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 7–8, 2019.
6. Reynolds J, Harper K, Reynolds M, Wang B, Li S, Ali S, Haydel C. Long-term radiation safety profiles of x-rays after undergoing femoral intramedullary nailing. *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 7–8, 2019.

Awards

1. OTA Annual Meeting Resident Memorial Award 2020: Thompson J, Long M, Rogers E, Pesso R, Galos DK, Dengenis RC, Ruotolo C. Fascia Iliaca Block Decreases Hip Fracture Postoperative Opioid Consumption: A Prospective Randomized Controlled Trial. *OTA Annual Meeting,* October 2020.

Educational Presentations

1. Course Chairman: *11th Annual Philadelphia Orthopaedic Trauma Symposium,* 06/20 (Rehman).
2. Moderator: Medical Management of the Trauma Patient. *11th Annual Philadelphia Orthopaedic Trauma Symposium,* 06/20 (Rehman).
3. Moderator: Resident Research Poster Virtual Tour. *11th Annual Philadelphia Orthopaedic Trauma Symposium,* 06/20 (Rehman).
4. Lecture: Basic Principles of Fracture Management. *Division of Plastic and Reconstructive Surgery, Temple University Hospital,* 09/20 (Rehman).
5. Faculty Guest Lecture: *43rd Annual Howard Rosen Memorial Tri-State Trauma Symposium,* 10/20 (Galos).

Division Report

Division of Sports Medicine and Shoulder Surgery

J. Milo Sewards, MD
Director of Sports Medicine

Leslie Barnes, MD

Cory Keller, DO
Medical Director, TU Athletics

Ray Moyer, MD

Michelle Noreski, DO

Vishal Saxena, MD

Ryan Schreiter, DO

J. Milo Sewards, MD
Residency Program Director

Joseph Torg, MD
Professor Emeritus

The division of Sports Medicine has been such an integral part of our department that it remains part of the official title of Temple's Department of Orthopaedic Surgery and Sports Medicine. As such, it also remains the largest part of the department in terms of surgeons and non-operative physicians. In addition to our clinical and educational efforts, we have continued our relationship with Temple Athletics, persevering through monumental challenges over the past year. Dr. Cory Keller, in his role as the Director of Athletic Medicine, took a leading role this year with the Medical Advisory Group for the American Athletic Conference in contending with COVID-19 protocols and recommendations to allow for continued competition for our varsity athletes over the past academic year.

On the clinical front, while we bid farewell to our former chair and director of Sports Medicine, Eric Kropf, MD, we have maintained a high volume of arthroscopic and reconstructive surgeries. We have also been able to continue our educational endeavors, not only in the office and operating rooms, but also with arthroscopy labs and with sending the residents to arthroscopy courses. As always, our focus has been on excelling in patient care, providing our residents and medical students with the best clinical experience and hands-on education, and providing the University Athletic Department unparalleled coverage and care of our athletes. As I am surrounded by a skilled and dedicated group of surgeons and physicians, it is truly my privilege to follow in the footsteps of Drs. Lachman, Torg, Moyer, and Kropf to lead our Sports Medicine division.

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2020–2021

Dana Cruz, MD

Hometown: Bronx, NY

Undergraduate: University of Southern California

Medical School: Albert Einstein College of Medicine

Fellowship: Hand/upper extremity at University of Arizona

Alex Johnson, MD

Hometown: East Norriton, PA

Undergraduate: Randolph-Macon College

Medical School: Drexel University College of Medicine

Fellowship: Sports medicine at University of Colorado

Nimit Lad, MD

Hometown: Winona, MN

Undergraduate: Duke University

Medical School: Duke University School of Medicine

Fellowship: Sports medicine at Duke University

Jack Reynolds, MD

Hometown: Malvern, PA

Undergraduate: Villanova University

Medical School: Jefferson Medical College

Fellowship: Hand/upper extremity at Cleveland Clinic

Colin Ackerman, MD

Hometown: Allentown, PA

Undergraduate: Pennsylvania State University

Medical School: Jefferson Medical College

Interest: Hand

Joshua Luginbuhl, MD

Hometown: Denver, PA

Undergraduate: Muhlenberg College

Medical School: Drexel University College of Medicine

Interests: Foot and ankle

Akul Patel, MD

Hometown: Bedford, England

Undergraduate: Duke University

Medical School: University of North Carolina School of Medicine

Interest: Spine

Andrew Porter, MD

Hometown: Chester, NH

Undergraduate: Boston University

Medical School: Lewis Katz School of Medicine at Temple University

Interest: Adult reconstruction

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2020–2020 *(cont.)*

Jared Colon, MD

Hometown: Colorado Springs, CO

Undergraduate: University of Colorado

Medical School: Lewis Katz School of Medicine at Temple University

Interests: Hand/upper extremity, sports

Heather Flynn, MD

Hometown: Sea Girt, NJ

Undergraduate: Georgetown University

Medical School: Georgetown University School of Medicine

Interests: Sports, hand

Rajkishen Narayanan, MD

Hometown: Stony Point, NY

Undergraduate: New York University

Medical School: New York University School of Medicine

Interests: Hand, spine

Bradley Wiekrykas, MD

Hometown: Reading, PA

Undergraduate: Pennsylvania State University

Medical School: Lewis Katz School of Medicine at Temple University

Interests: Hand/upper extremity

Kristofer Bires, MD

Hometown: Holland, PA

Undergraduate: Temple University

Medical School: Rutgers Robert Wood Johnson Medical School

Interests: Trauma, hand, sports

Patrick Donaghue, MD

Hometown: Chadds Ford, PA

Undergraduate: Villanova University

Medical School: Lewis Katz School of Medicine at Temple University

Interests: Foot and ankle, hand

Ryan Judy, MD

Hometown: Bryn Mawr, PA

Undergraduate: The College of the Holy Cross

Medical School: University of Pittsburgh School of Medicine

Interests: Hand/upper extremity, foot and ankle, pediatrics

Rabia Qureshi, MD

Hometown: Philadelphia, PA

Undergraduate: Drexel University

Medical School: Drexel University College of Medicine

Interest: Trauma, joints

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2020–2021 *(cont.)*

Melissa Soderquist, MD

Hometown: Edina, MN

Undergraduate: University of Florida

Medical School: Georgetown University School of Medicine

Interests: Sports, hand, tumor

Temidayo Aderibigbe, MD

Hometown: Simi Valley, CA

Undergraduate: Yale University

Medical School: New York Medical College

Interest: Undecided

Etka Kurucan, MD

Hometown: Clifton, NJ

Undergraduate: Duke University

Medical School: University of Rochester School of Medicine & Dentistry

Interest: Undecided

Max McQuade, DO

Hometown: Long Beach, NY

Undergraduate: Saint Joseph's University

Medical School: Philadelphia College of Osteopathic Medicine

Interests: Hand/upper extremity

Ronit Shah, MD

Hometown: Toledo, OH

Undergraduate: University of Toledo

Medical School: University of Toledo College of Medicine

Interest: Undecided

Joseph J. Thoder
Orthopaedic Excellence Award

"Awarded in recognition of Dr. Thoder's steadfast dedication to the Temple Orthopaedic Surgery Residency. Through his mentorship, we pursue academic and clinical excellence, while learning the importance of heritage, teamwork, and family. This award, presented by the chief residents, honors the orthopaedic resident who best exemplifies the standards of scholarly achievement and personal excellence set forth by Dr. Thoder."

Given as a graduation gift by the class of 2010, Drs. Abi Foroohar, Allan Tham, Ifran Ahmed, and John Parron fund a yearly award given to the resident that demonstrates qualities which commensurate with Dr. Thoder's vision of a Temple orthopaedic surgeon. Selected by the graduating chief resident class, the recipient is presented with a cash prize and a plaque of recognition.

This year, **Jared Colon** (Class of 2023) was selected by chief residents Robert Ames, Dayna Phillips, Colin Vroome, and Jeffrey Wera (Class of 2020).

Previous Winners:
2019 — Josh Luginbuhl, MD
2018 — Nimit Lad, MD
2017 — Colin "Mac" Vroome, MD
2016 — Courtney Quinn, MD
2015 — Katharine Harper, MD
2014 — Arianna Trionfo, MD
2013 — Rupam Das, MD
2012 — Matthew Kleiner, MD
2011 — Richard Han, MD
2010 — John Fowler, MD

Jared Colon, MD

The Dr. Eremus Teaching Award 2020

The Dr. Eremus Teaching Award was created in 2017 to commemorate Dr. Joseph Eremus. Dr. Eremus was not only an exceptional Temple faculty member but also an excellent orthopaedic educator. Since the award has been established, every year the graduating chief resident class selects one faculty member who has been influential in their development as surgeons. The recipient of the award has their name engraved on a plaque that hangs in the Clancy conference room.

The 2017 inaugural award was given to Dr. Joseph Thoder. He was selected by the graduating class, which included Dr. Jim Lachman, Dr. Arianna Trionfo, Dr. Anastasia Newbury, and Dr. Dustin Greenhill. Dr. Thoder is not new to receiving educator awards, as he has been the recipient of the "Faculty Award for Excellence in Orthopaedic Education" for several years.

The most recent graduating resident class selected Dr. Milo J. Sewards as the 2020 award recipient. Dr. Sewards is an essential component of our department and residency program. He not only plays a pivotal role in resident education and faculty development but was laudable in his management of our program during the early stages of the Covid pandemic. Dr. Sewards has worn many hats during his distinguished tenure at Temple, first as a resident, and later as faculty. He serves on the medical school's admission committee, as our program director and team physician to Temple University's intercollegiate athletics. Dr. Sewards has repeatedly distinguished himself in his service to our country and the United States Navy. He is a respected mentor, dedicated father and admirable physician. His contributions are innumerable, and his receipt of this award is fitting.

Dana Cruz, MD

Instructions to Authors

Editorial Philosophy

The purpose of the *Temple University Journal of Orthopaedic Surgery & Sports Medicine (TUJOSM)* is to publish clinical and basic science research performed by all departments of Temple University that relate to orthopaedic surgery and sports medicine. As such, *TUJOSM* will consider for publication any original clinical or basic science research, review article, case report, and technical or clinical tips. All clinical studies, including retrospective reviews, require IRB approval.

Editorial Review Process

All submissions will be sent to select members of our peer review board for formal review.

Manuscript Requirements

Manuscripts are not to exceed 15 double spaced type-written pages and/or 5,000 words (minus figures/tables/pictures). The manuscript should contain the following elements: Title page, Abstract, Body, References, and Tables/Legends. Pages should be numbered consecutively starting from the title page.

(1) Title Page — The first page, should contain the article's title, authors and degrees, institutional affiliations, conflict of interest statement, and contact information of the corresponding author (name, address, fax, and email address).

(2) Abstract — The second page, should be a one-paragraph abstract less than 200 words concisely stating the objective, methods, results, and conclusion of the article.

(3) Body — Should be divided into, if applicable, Introduction, Materials & Methods, Results, Discussion, and Acknowledgements. Tables (in Word) and figures (in JPEG format) with their headings/captions should be listed consecutively on separate pages at the end of the body, not continuous within the text.

(4) References — Should be listed following the format utilized by *JBJS.* For example: Smith, JH, Doe, JD. Fixation of unstable intertrochanteric femur fractures. *J Bone Joint Surg Am.* 2002;84:3553–58.

Submissions

All submissions are now digital. Please submit the manuscript in a Microsoft Word document to templejournal@gmail.com. When submitting, please include the following:

(1) Word document of manuscript with text and tables only (no figures)

(2) Send all figures and photos as separate, individual files

(3) Word document with captions and legends for all figures

(4) Title page with all authors and credentials listed

Disclaimer: **This journal contains manuscripts that are considered interpersonal communications and extended abstracts and not formalized papers unless otherwise noted.**

In Remembrance

Marianne Kilbride

February 1954–July 11, 2021

Fondly remembered for her humor, loyalty and dedication to the Department.

To support its activities, the John Lachman Society is actively soliciting your tax-exempt contributions, which can be made two ways:

Via our new secure website, which is https://lachmanfund.org. Once there, you can make a donation and also view current and past issues of the journal as well as other resident activity.

Or, if you wish to write a check, please make it payable to John Lachman Orthopaedic Research Fund and mail it to our Treasurer: Saqib Rehman, MD, Department of Orthopaedic Surgery, Temple Hospital, 3401 North Broad Street, Philadelphia, PA 19140.

Clearly, these programs greatly enhance the medical student and resident orthopaedic experience! And clearly, your contribution to the program will be greatly appreciated!

Joe Torg, MD Joe Thoder, MD

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