Temple University Journal of Orthopaedic Surgery & Sports Medicine

J. Milo Sewards, MD

Volume 14 Spring 2019

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/exhibits at accredited scientific research 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 seven-week 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 a current Temple Orthopaedic Resident to go to AIC CURE Hospital in Kenya with Temple faculty member

To support these numerous activities, the John Lachman Society is actively soliciting tax-exempt contributions which should be made as follows:

Payable to the: John Lachman Orthopaedic Research Fund

Mail to our Treasurer: Saqib Rehman, MD
Temple University 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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Letter from the Chairman

It is with great pride that I introduce this year's journal which highlights the accomplishments of our residents, students, and faculty. I hope that you enjoy this year's edition and are academically stimulated by the work being performed within our department.

The rapid growth of our department discussed in previous years has slowed to a steady state. The Department of Orthopaedic Surgery and Sports Medicine is currently comprised of 21 providers (15 surgeons, five non-surgical providers, and one physician assistant) representing all specialties. We continue to provide academic specialist care at Temple University Hospital, Northeast Philadelphia, Fort Washington, the Navy Yard, and Chestnut Hill Hospital. Our recently recruited physicians are expanding rapidly, making each of these locations busier than ever. We now have multiple and diverse physicians in every specialty area. The added value to our patients but also to resident education is apparent every day.

In the fall of 2018, we welcome Dr. J. Milo Sewards back from military deployment. His service to the US Navy and our department is highlighted and recognized in this year's journal. We again thank him for his service.

As always, this journal could not be made possible without the efforts of many. Justin Kistler (PGY5) has admirably filled the role as editor of the journal. Drs. Joe Torg and Saqib Rehman continue to be the driving force behind much of this work. We must also acknowledge the tireless efforts of Joanne Donnelly, Bridget Slattery, and the Office of Clinical Research.

It is with great pride that we present the academic accomplishments of our department faculty, residents, and students. I hope that you enjoy reading through this journal with the same sense of pride and accomplishment for Temple Orthopaedics and Sports Medicine.

Eric J. Kropf, MD
Associate Professor and Chair
Temple Orthopaedics and Sports Medicine

Letter from the Editor-in-Chief

I am proud to present the *Temple University Journal of Orthopaedic Surgery & Sports Medicine,* Volume 14! This year's edition of the journal showcases the continuing outstanding academic efforts and achievements of our faculty, residents, and medical students. Temple Orthopaedics has a proud tradition of excellence, which is highlighted throughout each section this year for our readers.

The Department of Orthopaedic Surgery and Sports Medicine experienced continued growth and development over the past year with new faculty additions and increased research productivity. In addition, we highlight the research efforts of former resident and editor-in-chief of our journal, Rick Tosti, in our Distinguished Alumni Section. This year, the editorial board has dedicated the journal to Dr. J. Milo Sewards in recognition of his outstanding service to not only the residency but to our country in his recent deployment as a Commander in the United States Navy. We are happy to have him home.

I would like to thank my associate editors, Dayna Phillips, Dana Cruz, and Colin Ackerman. I would also like to thank the faculty advisors, Joe Torg and Saqib Rehman, as well as our research coordinators, Joanne Donnelly and Bridget Slattery. Without all of your collective efforts, the publication of this journal would not be possible. As a graduating chief resident and editor-in-chief for the past two years, I am very proud of this year's publication and I look forward to the continued success of the department!

Justin Kistler, MD
Class of 2019

Letter from the Residency Director

Each year as this journal is assembled and I am asked to provide a few thoughts, I am given the opportunity to reflect upon our residency program; to consider our history, our reputation, our research endeavors, the ways in which we have improved and the ways in which we have remained true to our traditions. In this practice, I sometimes can identify opportunities for further improvement, but I am always able to identify substantial reason to be grateful. We have 20 enthusiastic, capable, and eager residents who tackle the challenges of learning their craft while navigating the modern healthcare system and the obstacles it can provide. We have a growing faculty of dedicated teachers who guide our residents not only in the operating room and office, but also in life as a physician and surgeon. I am afforded the opportunity in these pages to express my very public gratitude to my colleagues in our department and our affiliate sites, to the residents who entrust us with their continued education, and to the program's alumni and supporters whose generosity to the Lachman Fund provide for this journal and the presentation of the ever-increasing research studies generated by our residents and faculty. With this year's issue, it is my understanding that my military service is to be recognized. While my affiliation with the United States Navy is a particular source of pride for me, I must point out that I would never be able to continue in the service of our nation if it were not for the assistance and flexibility of my partners in our department.

This year, we graduate a class that has been through some changes at Temple and are much more resilient for it. Peter Eyvazzadeh will be heading south to Baltimore to Union Memorial Hospital for his Sports Medicine fellowship. Justin Kistler decided that he hasn't had enough of Philadelphia and will be staying for his fellowship in Hand Surgery at the Rothman Institute. Courtney Quinn couldn't tolerate the idea of heading back to Los Angeles, so she decided on the more rural surroundings of the University of Virginia for her Sports Medicine fellowship. Finally, Megan Reilly has postponed her return to the warmth of central Florida so she can complete a fellowship in Foot and Ankle Surgery at the Hospital for Special Surgery in New York City. I am confident that they will all thrive in their respective settings and confirm the wisdom of their fellowship directors in matching Temple residents.

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: David Junkin, 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 13. 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, 2018 through December 21, 2018 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 Solidifies Future of Temple Orthopaedic Surgery and Sports Medicine-AIC CURE Kenya Residency Trip

Erin Coleman, MA, ATC, OTC

The John Lachman Orthopaedic Research Fund, founded on the principles of ethics, resident training, patient care and research, has generously agreed to provide financial support and funding annually to provide a unique international experience to a qualified Temple Orthopaedic Surgery resident in partnership with the African Inland Church (AIC)-CURE International Hospital in Kijabe, Kenya. Through the John Lachman Orthopaedic Research Fund 501(c)(3), $3,000 annually will allow a resident a year to participate in this experience and enhance his or her professional training, while growing the relationship with AIC-CURE, expanding research opportunities, and attracting future residents committed to understanding and translating global medicine locally and abroad as it relates to orthopaedic surgery.

Temple University's Department of Orthopaedic Surgery has committed to allowing one junior resident per year a two-week period to participate in an international health experience in rural Kenya, a developing country striving to achieve middle-income country status by 2010.[4] With the John Lachman Orthopaedic Research Fund's commitment, this opportunity will continue to award residents with the opportunity to live and practice international medicine.

International health electives in developing countries are opportunities for orthopaedic surgeons in training to increase their professionalism and cultural awareness, develop improved physical examination skills and other basic skills in a setting of limited resources, as well as encounter diagnoses and conditions not typically encountered in North America.[1–2] Additionally, surgeons who participate in international health experiences during training are more likely to volunteer locally and internationally in the future, and appreciate and provide care to underserved populations in the United States,[3] a hallmark of the Temple University Orthopaedic Surgery residency.

Under the faculty guidance of Eric Gokcen, MD, AIC-CURE International Hospital has become an enthusiastic partner to accepting a resident and integrating him or her into the program at AIC, under the supervision of a Temple faculty member and staff surgeons of AIC CURE and Kijabe Hospitals. The two weeks spent with AIC-CURE Kenya includes interaction and participation with a College of Surgeons of East, Central and Southern Africa (COSECSA) certified Orthopedic Surgery Residency. AIC-CURE Kenya currently has five staff orthopaedic surgeons: Jeff Mailu, Paul Mang'oli, Francis Mbugua, James Kinyua Ndegwa, and Joseph Theuri (Medical Director). Additionally, AIC Kijabe Hospital, a 363-bed level 5 tertiary referral center,[4] sits next door to the pediatric orthopaedic hospital offering orthopaedic care to adults and trauma services for the Kijabe area as well as the people who travel for services from all over Kenya and neighboring countries for specialty care. Shared as part of the CURE rotation for the orthopaedic surgery residents, Kijabe Hospital is staffed with both local and volunteer consultant physicians and surgeons.

CURE is a non-profit organization (501(c)(3) Federal EIN: 58-2248383) operating charitable hospitals and programs in 26 countries. Founded in 1996, AIC-CURE International Hospital in Kijabe, Kenya was the organization's first hospital opened in 1998 by Dr. C. Scott Harrison, and the site of Africa's first orthopaedic pediatric teaching hospital for children with disabilities. A 30-bed hospital serving children with orthopaedic conditions, annual outpatient visits at this location for FY18 reached 15,659 with 1,949 procedures. In 2018, celebrating its 20th anniversary, CURE Kenya opened a new outpatient building and achieved ISO 9001 quality management certification. CURE progressed to develop specialty programs in clubfoot and hydrocephalus treatment, and continues to focus on expanding the reach and capacity of the CURE net-

work. To date, over 196,000 procedures have been performed at CURE hospitals.[5]

Upon completion of the experience, the residents will describe the educational objectives of the trip and direct benefits received as it applies to their medical training.

References

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2. Fan B, Zhao C, Sabharwal S. International elective during orthopaedic residency in North America: perceived barriers and opportunities. *J Bone Joint Surg Am.* 2015;97e(1–8).
3. Shultz PA, Kamal RN, Daniels AH, DiGiovanni CW, Akelman E. International health electives in orthopaedic surgery residency training. *J Bone Joint Surg Am.* 2015;97:e15(1–8).
4. Chao T, Patel P, Rosenberg J, Riviello R. Surgery at AIC Kijabe Hospital in Rural Kenya. Harvard Business Publishing. Sep 2015.
5. https://cure.org/about/

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 and Joseph S. Torg, MD and supported by the School of Medicine's Office of Clinical Research Administration, with Joanne Donnelly as the full-time research and program coordinator, along with Bridget Slattery as a full-time research coordinator.

The program is now in its 15th year and continues to fulfill the vision of providing the Department of Orthopaedic Surgery and Sports Medicine with industry-sponsored clinical trials, resident-initiated research, and the eight-week summer research program geared toward those 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 15 Temple medical students in 2019. 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." Lauri Fennell, Temple Reference and Emerging Technologies Librarian, provides the students with basic and advanced research searching options through PubMed, Ovid, and other search engines as well as RefWorks for managing citations. Gabrielle Ribblard, from the Temple Institutional Review Board, will speak to the students regarding the guidelines pertaining to clinical research. I am looking forward to another exciting and fruitful year with the students.

Current Industry-Sponsored Clinical Trials Drug or Device

Department of Defense

Assessment of Severe Extremity Wound Bioburden at the Time of Definitive Wound Closure or Coverage: Correlation with Subsequent Post-Closure Wound Infection (Bioburden Study)

Principal Investigator: Saqib Rehman, MD, MBA; Sub-Investigator: Christopher Haydel, MD, ABOS

Prospective cohort observational study. Closed to enrollment, in data collection phase — 4 subjects enrolled.

AESCULAP

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: Eric J. Kropf, MD; Sub-Investigator: Vishal Saxena, MD

Open to enrollment — 16 subjects enrolled

Department of Defense

Local Antibiotic Therapy to Reduce Infection After Operative Treatment of Fractures at High Risk of Infection: A Multi-Center, Randomized, Controlled Trial — VANCO Study

Principal Investigator: Saqib Rehman, MD, MBA; Sub-Investigator: Christopher Haydel, MD, ABOS

Closed to enrollment — 4 subjects enrolled

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

Principal Investigator: Alla Spivak, DO, Anesthesia;
Sub-Investigator: Ellen Hauck, DO, Anesthesia; Sub-Investigator: Jon Livelsberger, DO, Anesthesia;
Sub-Investigator: Christopher Haydel, MD, Orthopaedics

Open to enrollment — 28 subjects enrolled

Novartis
A 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

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; Sub-Investigator: J. Milo Sewards, MD;
Sub-Investigator: Vishal Saxena, MD

2 subjects enrolled

Potential Clinical Trials

Carmell Therapeutics
Phase 3 Bone Healing Accelerant Study for Treating Open Tibia Fractures

A phase 3 study that will evaluate the safety and efficacy of a bone healing accelerant in the treatment of open Gustilo-Anderson Grade IIIa/IIIb tibia-shaft fractures in subjects having their tibia fractures stabilized with intramedullary (IM) rodding.

Principal Investigator: Saqib Rehman, MD, MBA

PolyPID Optimized Therapeutics
Prospective, Multi-Center, Randomized SOC Controlled to Assess the Efficacy and Safety of D-PLEX 100 in Severe Open Long Bone Fractures, Phase II

This study will evaluate the use of D-PLEX, a new formulation of extended release of Doxycycline vs standard of care for the prevention of infection associated with severe open long bone fractures.

Principal Investigator: Saqib Rehman, MD
Sub-Investigator: Christopher Haydel, MD

Episurf Medical Inc.
A Prospective, Randomized, Controlled, Multi-Center Study to Evaluate the Safety and Effectiveness of the Episealer® Knee System Compared to Microfracture for the Treatment of Focal Femoral Knee Chondral or Osteochondral Lesions

Device study.

Principal Investigator: Pekka A. Mooar, MD

Joanne M. Donnelly, RC
Bridget Slattery, RC

In Remembrance

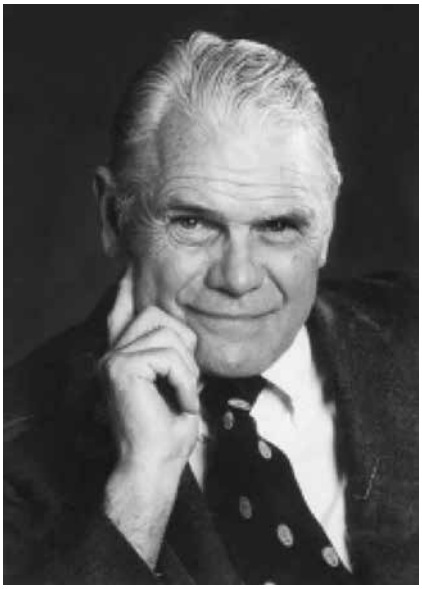
Howard Steel, MD

PHILIP ALBURGER, MD

"Who is Dr. Steel?"

I first met Howard Steel as a medical student, got to know him as a resident, and was privileged to practice with him for many years. It was never dull and very educational. His mind always seemed to be just a little quicker that everybody else's.

I would like to mainly just thank him: first for rehiring me after he fired me as a resident at Shriners Hospitals for Children, and afterwards as a colleague, for sharing a telephone booth as he described it, with me for 15 years.



Chief of Staff 1966–1986
Shriners Hospitals for Children

Dr. Steel was a uniquely talented orthopaedic surgeon who, for our purposes, I will describe as exceptional in two aspects:

1. His personal characteristics — he was a multi-talented, multi-faceted, witty, super smart, visionary and innovator, who had a thirst for knowledge, and an intellectual curiosity that knew no bounds. He had multiple avocations and has been described in the past as a polymath or a renaissance man. Our younger generation, if they knew him, might consider him a candidate for the Dos Equis award, as the *most interesting man in the world.*

2. As an orthopaedic surgeon, he was also exceptional, and we may never see another like him. The current day orthopaedic surgeon is a specialist or subspecialist or super subspecialist, who has a greater and greater depth of knowledge in a smaller and smaller area of expertise.

Dr. Steel, however, practiced orthopaedics in an era when practice was much more diverse, and expansive, and he was more diverse than most. He did hand, foot, spine, and hip, etc., in both adults and children, and was also interested in all of medicine, the pathophysiology of medicine, the history of medicine, and history itself. It was in college that his academic excellence and the incredible scope of his interest began to manifest themselves.

He attended Colgate University, majoring in chemistry. He excelled in both sports and academics and lettered in hockey, football and track. Dr. Steel was president of his class and president of his fraternity, an active member in the drama club, leader of the glee club, and founder of the outing club. He graduated *summa cum laude* and was elected to *Phi Beta Kappa.* He was always involved with his fraternity and subsequently as a member of the Board of Trustees.

After college, Dr. Steel enlisted in the U.S. Navy just before Pearl Harbor. He was injured by friendly fire and received a presidential citation from President Franklin D. Roosevelt. Following his service experiences, he could have joined the family business, since his family owns Steel's Fudge and become a fudge magnate, but decided to go to medical school. He enrolled at Temple University School of Medicine and graduated in 2½ years from their accelerated program. He also earned a PhD in anatomy. His doctoral thesis was on trauma to the atlantoaxial joint Cl, C2, concentrating on the space available for the cord, which yielded for us the rule of thirds. He took an orthopaedic residency with Dr. John Royal Moore at Temple Orthopaedics and remained on the staff. His academic record is well chronicled, having written over 100 peer reviewed articles, more than 40 of which were published in the *Journal of Bone and Joint Surgery,* along with innumerable presentations, and visiting professorships that have taken him to all parts of the globe. His portrait and an endowed chair reside in the Temple Department of Orthopaedics.

Dr. Steel's surgical innovations include the triple innominate osteotomy, celebrated in the pediatric community as the Steel Osteotomy. In the adult community, Dr. Steel may have developed an even more impactful pelvic operation, namely, hemipelvectomy for the treatment of sarcomatous tumors of the pelvis, when the standard of practice at the time was hind quarter amputation. In doing so, he may have been the father of limb salvage procedures. His heated debates with Dr. Robert Salter regarding pelvic osteotomy, and subsequently with Dr. John Hall regarding slipped capital femoral epiphysis were highlights of their respective academy meetings.

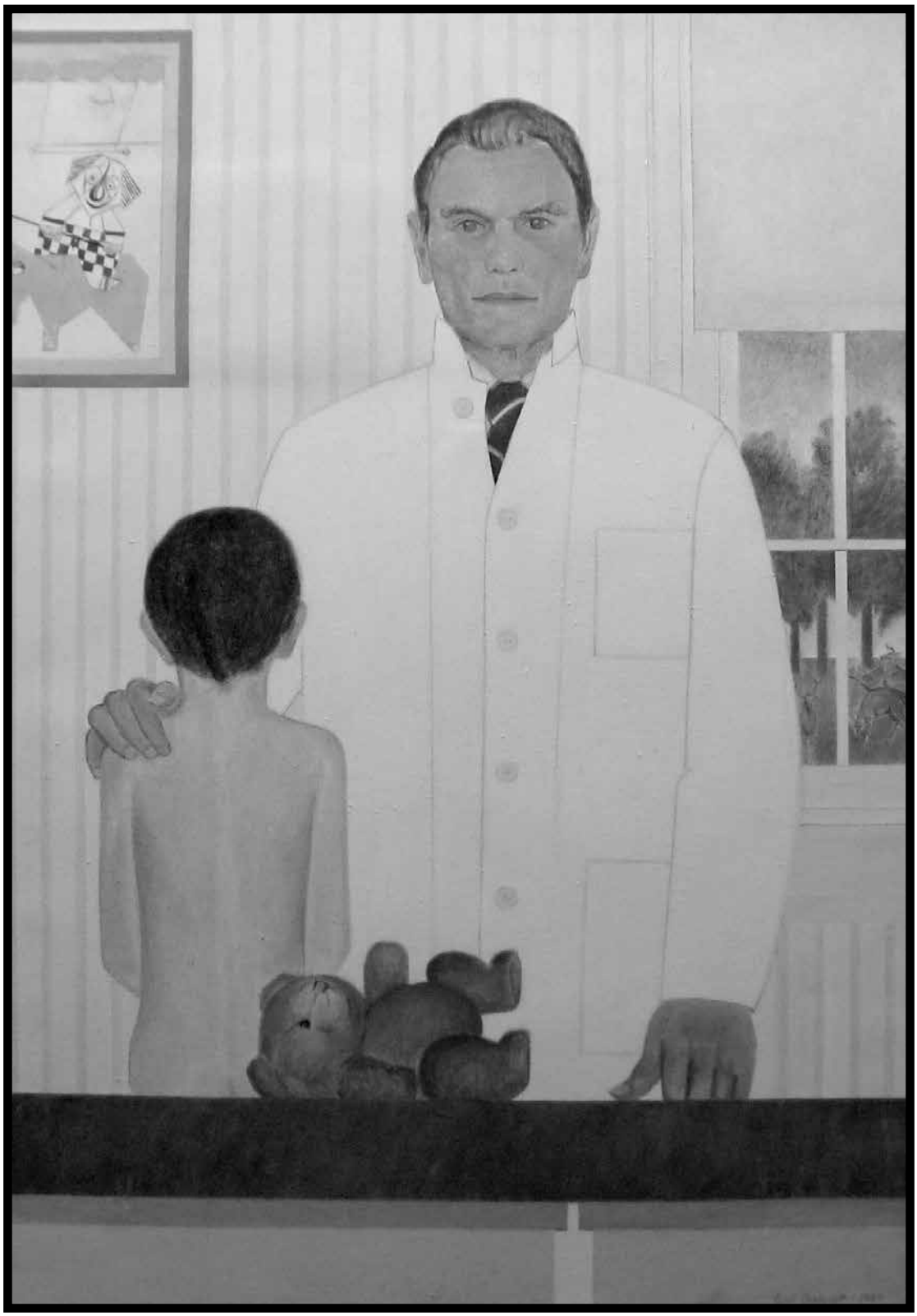
A group of patients grateful for having been spared mutilation, convened to form a Howard Steel Orthopaedic Foundation in his honor. Howard has directed funds

from the foundation toward lectures at multiple orthopaedic associations' annual meetings, including the Eastern Orthopaedic Association, the Western Orthopaedic Association, POSNA, AOA, and the Scoliosis Research Society, among others. The only qualification being that the topics are non-medical.

Howard's eclectic orientation is typically reflected in his lectures. Being more a surgeon scholar than technician expert, his talks are scientific works, but in another sense, works of art. You are unlikely to see computer-generated graphs, chart reviews, or meta-analyses, and are more likely to see an innovative medical or surgical solution to solve some problem at hand, punctuated by peripheral references. He has included in his talks references to topics such as "The Beatles," sailing from Newport to Bermuda, wine, specifically Madeira, and historic figures, such as Ben Franklin, etc. These may seem to the uninitiated to be digressions, but they always have relevance.

But most of all, Dr. Steel was the beloved teacher, mentor, and true friend to three generations of orthopaedic residents. They learned from his presentations, but mostly by observation of the elevated standards of excellence that he demanded of himself. The compassion he showed for his patients, and the *joie de vivre* that he brought to work every single day. He engendered tremendous camaraderie and loyalty. Dr. Steel made orthopaedics fun! He showed us that if we are doing good work and helping people with no complications, there is no reason that it can't be fun.

I will never forget him, but I sure will miss him.



The Howard Steel Portrait: The Howard Steel Portrait was commissioned to renowned artist Will Barnet and completed in 1987 while Dr. Steel was chief surgeon at the Shriners Hospital for Children and professor of orthopedic surgery at the Temple University School of Medicine. An oil on canvas work, it appeared on the cover of the August 27, 1987 edition of the *Journal of the American Medical Association* and was included in the collection of the Pennsylvania Academy of Fine Arts in Philadelphia. Unmistakably a Barnet work, it is simultaneously figurative, realistic, hard-edged yet abstract, and is able to transform a specific patient-physician encounter that can be appreciated as universal. Dr. Steel has generously donated the painting to Temple. The portrait now hangs on the second floor mezzanine of the new building of the School of Medicine.

In Remembrance

Howard Haldeman Steel, MD, PhD

JOSEPH TORG, MD

Howard Haldeman Steel: surgeon extraordinaire, innovator, educator, role model, entrepreneur (he owns a fudge shop on the boardwalk in Ocean City), world traveler, and without question, a legend in his time. A graduate of Colgate University which, for reasons unbeknownst to me, he always referred to as Cold Gas, he subsequently graduated from the Temple University School of Medicine in 1945, served on active duty as a Lieutenant Commander in the United States Navy where his major contribution to the war effort was the publication of a paper on "Calcified Islands in Medullary Bone" in the *Journal of Bone and Joint Surgery.* Thus, to his credit, HHS discovered "bone islands." A disciple of the then-renowned Temple chief orthopedic surgeon John Royal Moore, HHS completed his residency and a Master of Science degree in 1951 and remained on the orthopedic faculty.

Those of us at Temple University have interfaced with the good doctor over the years in his role as Professor of Orthopedic Surgery (1966–2010) and Chief of Staff, Shriners Hospital for Children (1966–1986) and Emeritus Chief (1986–2010). Over the past 60 years, to his credit and our benefit, he has directly participated in the education of hundreds of residents and thousands of medical students. I can testify, on the basis of my own experience, that to have interfaced with Howard Haldeman Steel is an experience one never forgets!

A review of Howard Steel's career can be described in one word — awesome! In addition to membership in the Phi Beta Kappa and Alpha Omega Alpha honor societies, he is also an honorary member of the Irish Orthopedic Association — no mean accomplishment for a WASP. He has received 24 major local, national, and international honors, beginning in 1942 with a Presidential Citation for Research in Beryllium while at Cold Gas, to the Sir John Charnley Award for Excellence in Orthopaedics from the Arthritis Foundation of North America in 2001.

Not adverse to travel, Dr. Steel has had 71 visiting professorships around the globe including such exotic places as Mexico City, London, Bologna, Moscow, Leningrad, Glasgow, Paris, Klamart, Teheran, Delhi, Oxford, Brussels, Jerusalem, Esbo, Seoul, Brazilia, Buenos Aires, Cairo, Cape Town, Johannesburg, Gotenborg, Adelaide, Venice, Nuremberg, Venice, Basel, Shanghai, Hong Kong, Beijing, and Truth or Consequences, New Mexico. His self-proclaimed claim to fame was his ability to make a two-week foreign junket with one piece of carry-on luggage, two projection carousels, and a deodorant.

His "out of the box" thinking and modus operandi is clearly evident with the establishment, in 1971, of the Howard H. Steel Foundation, funded by his friends and patients, to be a resource for pediatric orthopaedic care and education of orthopaedic surgeons. Seven national and international orthopaedic societies and organizations have received grants for Howard H. Steel Lectureships to "broaden the educational scope of orthopaedic surgeons" — with the sole proviso being the lecture is to be on "any subject except medicine." The Foundation is currently funding research in the search for a "cure" of spinal cord paralytic injury.

A memorable anecdote worth mentioning occurred one evening circa June 1965 when the Steels invited the residents and their wives to a "lobster bake" at their suburban Philadelphia home. There he was, sweating profusely, in shorts, tee shirt and boots with shovel in hand, having just finished digging a 4'x6'x6" trench into which he had placed and ignited a layer of cord wood. Then, in go three dozen, green, live lobsters which were then covered with a blanket of wet seaweed and off we went to play some ball and have a few beers. Upon returning an hour or so later, HHS rakes off the seaweed and there were the three dozen green, live lobsters wiggling and squirming, trying to get out of the smoldering mess. Thanks to Betty Jo Steel, the "lobster bake" was converted to a "lobster boil." And to this day, my most memorable memory of my Shriners' experience is the episode of the green, live, wiggling, and squirming lobsters.

A review of the Steel bibliography reveals 77 peer publications which he either authored or co-authored. Of these, 19 appeared in the *Journal of Bone and Joint Surgery* and to be noted, two of these in *J.B.J.S.* were primary authored by Joseph S. Torg but noted in HHS's C.V. as "with Torg, J.S."

It appears that he is best known for his descriptions of the "Triple Innominate Osteotomy" procedure for congential dislocation of the hip; "Partial or Complete Resection of the Hemipelvis . . . for Periacetabular Chondrosarcoma of the Pelvis;" "Syme Amputation for Congential Pseudarthrosis of the Tibia;" and "Cast Immobilization as the Primary Treatment for Congential Dislocation of the Hip." "Steel's Rule of Thirds," describing the special relationship of the dens, spinal cord, and the available space, is a well accepted concept. It is the view of this observer that his major and most unappreciated contribution was his role as the modern day Semmelweis; Semmelweis being the guy who solved the puerperal sepsis problem in Vienna by having the obstetricians wash their hands before delivery. In the United

States, the 1950s marked the advent of the penicillin-resistant staphylococcal infections that occurred in one out of every three elective orthopaedic procedures due to the organism and poor aseptic surgical technique. This was clearly a situation that impacted every orthopaedic surgeon. It was Howard Steel's proactive efforts — two scientific exhibits, 11 publications, and multiple lectures — that brought attention to the orthopedic community the importance of impeccable aseptic surgical technique and helped to eradicate the "staph problem." Clearly a major contribution!

Another anecdotal experience of mine as a resident, with the John Lachman-good cop and Howard Steel-bad cop phenomenon, warrants description. HHS insisted that two residents take in-house call at "the Shrine" every night and weekends on the presumption that with nothing to do, we would spend every waking hour reading orthopaedics. So one Sunday night, I left Ron Magargle, my fellow resident who was lying on the couch in the resident's quarter smoking a cigarette, drinking a beer, and watching TV, and went home to have dinner with my family. When I returned later that evening, Magargle, still lying on the couch, smoking a cigarette, drinking beer and watching TV, informs me that "Howard was by and asked for you."

"So what did you tell him?"

"Told him you went home for dinner."

"And, what did he say?"

"Nothing."

The next morning there's HHS, big smile, hand extended for a shake and I'm thinking "no problem." He then looks me in the eyes, is still smiling, shakes my hand and proclaims: "Torg — you're fired!" I go home, tell my wife Barbara that Howard fired me and she "asks what will happen now?" I reply that Dr. Lachman will call and tell me to go back to the Shrine and make amends with Howard. Purposely, we didn't answer the phone for several days and Latch doesn't reach me until Wednesday. As predicted, he tells me to go back to the Shrine and make amends with Howard. I replied that I didn't know about orthopaedics and was thinking about switching to a psychiatry residency to which he replied, "Perhaps a psychiatrist would be more fitting." So back to Shrine I go, make amends with HHS who gives me a big smile, looks me in the eyes, shakes my hand, and says "Welcome back, and by the way, you are on call tonight."

To know him is to revere him and realize that after the Lord created Howard Haldeman Steel, he clearly threw the mold away.

Dedication

J. Milo Sewards, MD

JOSEPH TORG, MD

What can we say about J. Milo Sewards: gentleman, scholar, academician, leader of men, humanitarian, etc.? Actually, all of the above based on my critical and, of course, learned observations. Currently, he is an Associate Professor of Orthopaedic Surgery, Program Director of the Orthopaedic Residency Program at Temple University Hospital, and Team physician for Temple's department of intercollegiate athletics.

However, it's his position and service to our country as Commander, Medical Corps, and United States Navy with currently active status and a veteran of two recent combat deployments that I believe is important to recognize.

From 2005 to 2008, Milo served as an active staff orthopaedic surgeon at the Beaufort Naval Hospital in Beaufort, South Carolina.

In November of 2007, he was deployed as Orthopaedic surgeon to the Naval Expeditionary Medical Facility of the Combined Joint Task Force in the horn of Africa at Djibouti until June of 2008.

His first combat assignment occurred in 2011 when he was deployed as director of surgical services/orthopaedics, Naval Expeditionary Medical Unit Operation Inherent Resolve, Al Quayyarah, Iraq from November 2017 to July 2018.

In 2008, Milo was awarded the Navy Achievement Medal for his service Djibouti, and the Navy Commendation Medal for his service at the Naval Hospital Beaufort. And in June of 2018, he was awarded the Navy Commendation Medal for service in Iraq.

Prior military awards include the Edie Award as Honor Graduate from the Naval Officer Indoctrination School in 2005, and selection for both international physician exchange programs by the Department of State in Sana'a, Yemen and Addis-Ababa, Ethiopia in 2008.

Current lecture presentations based on his military experience include: "Combat Orthopaedic Surgery: Lessons Learned" and "Leadership Lessons from North Iraq to North Broad." Clearly, Milo's unique military experience will add greatly to the residency program.

Milo's contributions to the nation are exceptional if not extraordinary. Importantly, however, is how his experiences will benefit the residency program. It is my view, having served myself, they will be considerable.

Commentary

The Distinguished Alumni Paper

RICHARD J. TOSTI, MD

Temple Ortho, Class of 2015

Volar plating is currently the most popular surgical method for treating distal radius fractures. As is the case with all techniques, advantages and disadvantages exist. One particular complication of concern of volar plating was that of hardware irritation. Some surgeons criticized the volar position of the plate noting its proximity to the flexor tendons and the inherent risk of rupture. Although most outcomes are good with this technique, trouble shooting such complications became a hot point for debate. One suggestion of "covering the plate with soft tissue" such as the pronator quadratus was postulated to reduce flexor tendon rupture, but our study challenged that assertion. We found no difference in hardware irritation with respect to repairing the pronator quadratus, which lends support to the fact that proper reduction of the fracture and position of the plate are probably more contributory in reducing soft tissue complications related to volar plating. This study was recognized at the 2013 ASSH Annual Meeting with the Julian M. Bruner Award.

Distinguished Alumni Paper

Prospective Evaluation of Pronator Quadratus Repair Following Volar Plate Fixation of Distal Radius Fractures

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Purpose: To evaluate the efficacy of pronator quadratus (PQ) repair after volar plating of distal radius fractures.

Methods: All consecutive distal radius fractures treated operatively with a volar plate during a one-year period were assigned to receive a repair of the PQ versus no repair. Surgical exposure, reduction, and postoperative rehabilitation were equivalent in both groups. Clinical outcomes with a minimum follow-up of 12 months were assessed via range of motion; grip strength; Disabilities of the Arm, Shoulder, and Hand (DASH) scores; and visual analog scale (VAS) scores.

Results: A total of 60 consecutive distal radius fractures were treated operatively with a locking volar plate. Full follow-up data were available for 33 patients in the PQ repair group and 24 patients in the control group. At 12 months, the mean DASH score was eight for the repair group and five for the control group. Range of motion at the wrist, grip strength, and VAS scores were also not significantly different between groups. In addition, we found no significant differences in any of the parameters at the two-, six-, or 12-week intervals, although we observed greater grip strength and wrist flexion in the repair group at six weeks. Reoperation was required for four patients in the repair group and 1 in the control group.

Conclusions: Pronator quadratus repair after volar plating of a distal radius fractures did not significantly improve postoperative range of motion, grip strength, or DASH and VAS scores at one year. The rates of reoperation between groups were not significantly different.

Type of Study/Level of Evidence: Therapeutic II.

Key Words: Distal radius, fracture, outcome, pronator quadratus, volar plate.

Distal radius fractures are among the most common fractures of the skeleton and are estimated to account for 2.5% of all visits presenting to the emergency room.[1] As the treatment of this common injury has evolved, internal fixation with the volar locking plate has gained popularity as a method of contemporary surgical management.[2] Volar plate fixation has the advantages of obtaining articular fragment stability, a relatively low risk of tendon rupture, and early return to motion and functional strength.[3–16] However, to gain access to the fracture site through the volar approach, the pronator quadratus (PQ) muscle must be released and elevated. Controversy surrounds the merits of its subsequent repair, which theoretically augments postoperative clinical function, stability of the distal radioulnar joint, and soft tissue coverage over the hardware. Opponents of the PQ repair claim that the quality of the tissue often precludes a durable repair, and outcomes studies are universally good regardless. Although PQ repair was included in the initial technical descriptions of volar plating, at least one retrospective study has formally challenged this assertion.[9]

The purpose of this prospective trial was to evaluate the outcomes after volar plate fixation for distal radius fractures as a function of PQ repair. We assessed outcomes primarily through range of motion; grip strength; Disabilities of the Arm, Shoulder, and Hand (DASH) scores; and visual analog scale (VAS) scores. We secondarily compared the incidence of reoperation and postoperative complications such as tendon rupture, tendonitis, neuritis, malunion, and nonunion.

Materials and Methods

We conducted a double-blinded, prospective, clinical trial from January 2011 to December 2011. Institutional review board permission was obtained, and all patients signed an informed consent. We assigned 60 consecutive distal radius fractures treated operatively with a volar plate into one of two groups. Repair of the PQ was performed in the study group, and no repair of the PQ was performed in the control group. The patients were blinded to their respective study group. For ease of facilitation, patients born in an odd birth year were assigned to the repair group, whereas those born in an even birth year were assigned to the control group. Patient demographics such as age, hand dominance, comorbidities, fracture severity, and presence of concurrent ulnar styloid fracture were recorded. The senior author (A.I.) classified all fractures in a blinded manner using the AO/ASIF classification system. Surgical exposure, reduction, and

postoperative rehabilitation were similar in both groups. Two patients were lost to follow-up before one year and were excluded from the final analysis. One patient with an ipsilateral elbow fracture-dislocation was also excluded.

Surgical Technique

A single orthopedic hand surgeon performed all surgical procedures. Either regional or general anesthesia was used in all cases with tourniquet control. The volar distal radius was exposed through a flexor carpi radialis approach. The PQ was released along its distal and radial borders and elevated in a subperiosteal fashion ulnarly, with care being taken not to violate the muscle or compromise its neurovascular pedicle inserting on the ulnar side from the interosseous membrane. All fractures were repaired with one of two variable-angle volar locking plates: a Medartis APTUS plate (Kennett Square, PA) or a Synthes 2.4 Variable-Angle LCP 2-column plate (Paoli, PA). In the repair group, repair of the PQ was performed over the plate with four to five interrupted figure-of-8 2-0 absorbable, synthetic, braided sutures to return the released edges of the PQ to the radial and distal borders of the radius. Repair of the muscle was achieved in all attempted cases, although we observed varying degrees of muscle injury. In the control group, the PQ was placed back to its anatomic position but was not repaired with sutures.

Postoperative Management

Immediately after surgery, the patient was encouraged to elevate the hand and begin early and unrestricted finger motion. The postoperative soft dressing was maintained for 10 to 14 days until the first follow-up visit. At that visit, the dressings and sutures were removed, radiographs were taken, and therapy was started under the supervision of a certified hand therapist. A prefabricated orthosis was also applied for comfort and protection, but its use was optional. During weeks two through six, an aggressive anti-edema protocol was initiated along with tendon gliding and range of motion exercises. At six weeks postoperatively, patients were reevaluated and advanced to progressive strengthening and resistance exercises upon evidence of sufficient interval healing by radiographs and clinical exam. In addition, use of the orthosis was discontinued. During reevaluation at 12 weeks postoperatively, patients were advanced to a work hardening program or discharged from therapy depending on occupational needs, and orthosis use was terminated. A final visit was performed 12 months postoperatively. An equivalent postoperative protocol was used for all patients irrespective of the study arm.

Assessment of Outcomes

The primary outcome measure was the DASH score. Secondary outcome assessments included measurements of the VAS score, range of motion, and grip strength. An orthopedic nurse who was blinded to the study protocol obtained all of the outcome measurements during the follow-up visits. Wrist flexion, extension, radial-ulnar deviation, and forearm rotation measurements were recorded with a goniometer. Grip strength was measured with a dynamometer (Jamar; Therapeutic Equipment, Clifton, NJ) with the elbow at 90° and the wrist in neutral rotation. These measurements were compared with the uninjured side and expressed as a percentage. All patients were assessed at two, six, 12, and 52 weeks after surgery. The senior surgeon also analyzed radiographs at the same intervals for evidence of fracture healing and maintenance of reduction.

Statistical Analysis

We performed hypothesis testing using Fisher's exact test for categorical values and Student's t-test for continuous variables. Probability values for the outcomes measures were generated with an analysis of variance. Statistical significance was defined as $P < .05$.

Results

A total of 57 patients were reviewed; PQ repair was performed in 33 subjects, and no repair was performed in 24 subjects. Table 1 lists basic demographics. Concurrent procedures were performed in four patients in the control group and in three patients in the repair group. Ulnar fracture was identified in 17 patients of the control group and in 20 patients of the repair group. Concurrent pinning of the ulna was indicated in two cases in the control group and one case in the repair group. Concurrent carpal tunnel release at the time of plating was indicated in two cases for each group. We also compared the groups with respect to fracture severity by the AO/ASIF classification system. The differences in fracture severity between the groups were not significant. Table 2 shows range of motion measurements at each time interval. Outcomes assessed at two weeks demonstrated no significant differences in mean DASH score, VAS score,

Table 1. Basic Demographic Information

Demographics	No Repair	PQ Repair	*P*
Patients, n	24	33	
Median age, y (mean [range])	62 (30–89)	55 (16–83)	
Mean age, y (mean [standard deviation])	60 (13.7)	51 (18.9)	.04
Male, %	25	27	1.00
Concurrent ulnar pin, n	2	1	.57
Concurrent CTR, n	2	2	1.00
Dominant hand injury, n	10	23	.06
Reoperations, n	1	4	.39
Associated ulna fracture			
No ulnar fracture, n	7	13	.26
Ulnar styloid fracture, n	13	18	
Ulnar neck fracture, n	4	1	
Ulnar base fracture, n	0	1	
AO classification			
A	2	8	.26
B	1	1	
C	21	24	

AO, Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation; CTR, carpal tunnel release.

Table 2. Range of Motion Measurements at Follow-Up Intervals

	2 Weeks		6 Weeks		3 Months		12 Months	
	PQ Repair	No Repair	PQ Repair	No Repair	PQ Repair	No Repair	PQ Repair	No Repair
Extension	29°	29°	59°	52°	74°	71°	83°	80°
Flexion	33°	39°	58°*	47°*	74°	69°	84°	81°
Pronation	77°	75°	83°	81°	86°	84°	84°	84°
Supination	67°	56°	78°	71°	85°	84°	88°	86°
Ulnar deviation	31°	14°	31°	26°	34°	38°	36°	35°
Radial deviation	7°	8°	16°	11°	18°	18°	19°	20°

*Statistically significant difference.

grip strength, or range of motion. At six weeks, grip strength and flexion in the repair group were significantly greater than those of the control group, but all other variables were not significantly different. Similarly, we did not observe differences in any of the variables at three months or one year. At final follow-up, the mean DASH score was eight for the repair group and five for the control group. In both groups, grip strength was 95% of the uninjured side, and VAS scores averaged below 0.5. The mean values of all variables demonstrated a stepwise improvement over the year as range of motion and grip strength consistently increased and DASH and VAS scores consistently decreased (Figs. 1–3).

In the repair group, one patient developed extensor pollicis longus tenosynovitis and three patients presented with late symptoms of carpal tunnel syndrome; all four of these patients required reoperation for hardware removal or carpal tunnel release. In the control group, one case of extensor carpi radialis longus and brevis tenosynovitis required reoperation and plate removal. No cases of flexor tendonopathy, nonunion, hardware failure, infection, or acute carpal tunnel syndrome were observed.

Discussion

The frequency of volar plating as a treatment for unstable distal radius fractures has increased in recent years.[2] Numerous studies have reported outcomes in the good to excellent range on patient-rated scoring systems and with a relatively low rate of complications.[4–9] For example, Gruber et al.[5] described their prospective case series on 54 distal radius fractures treated with volar plating and noted an average DASH score of five at two years and 13 at six years, with no patients experiencing flexor tendonopathy. Similarly, Arora et al.[6] prospectively compared operative and nonoperative management of unstable distal radius fractures in the elderly; in the 36 cases treated with open reduction internal fixation, the average DASH score at 12 months was six, and four patients experienced flexor tendonopathy from prominent hardware. Our overall results were consistent with previous reports. We experienced no cases of nonunion, and all subjects healed in a radiographically acceptable position.

Whether repair of the PQ is necessary after volar plating has been a topic of debate. Our study detected no significant differences between the PQ repair group versus control in

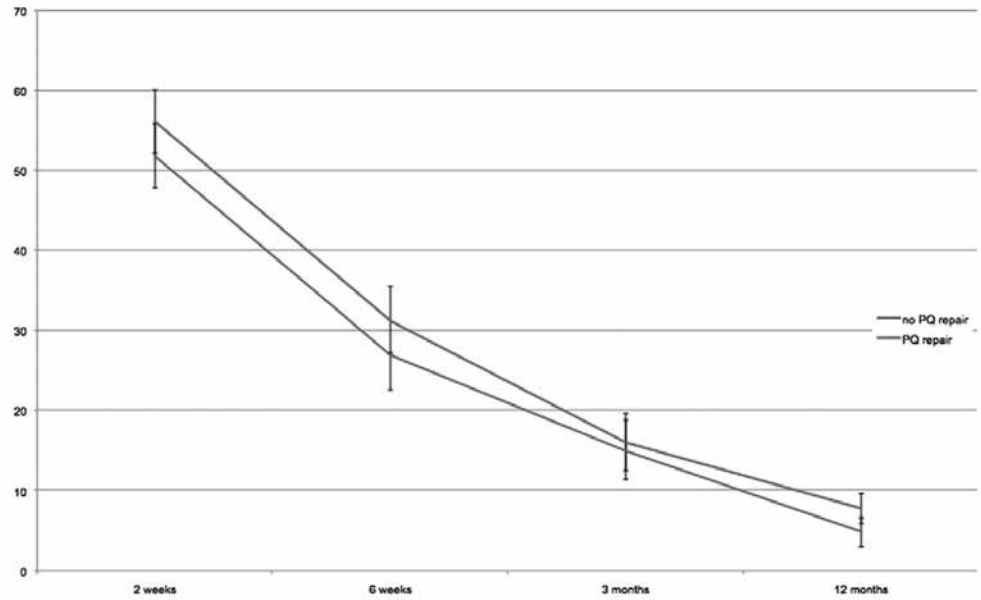

Figure 1. One-year trend of mean DASH scores after volar plate application for distal radius fractures in patients with and without repair of the PQ.

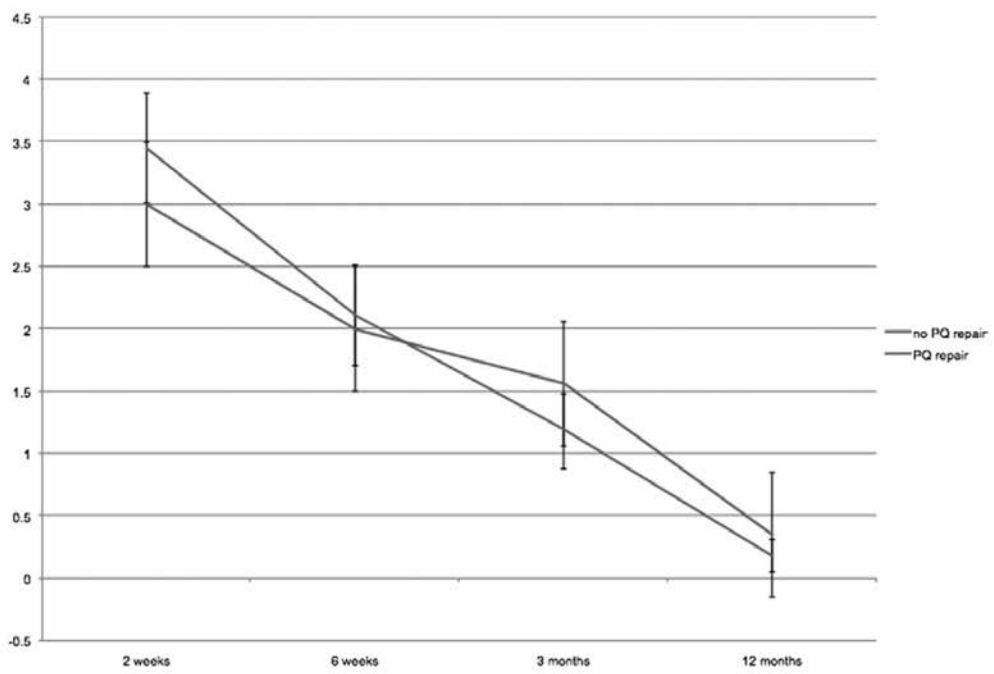

Figure 2. One-year trend of mean VAS scores after volar plate application for distal radius fractures in patients with and without repair of the PQ.

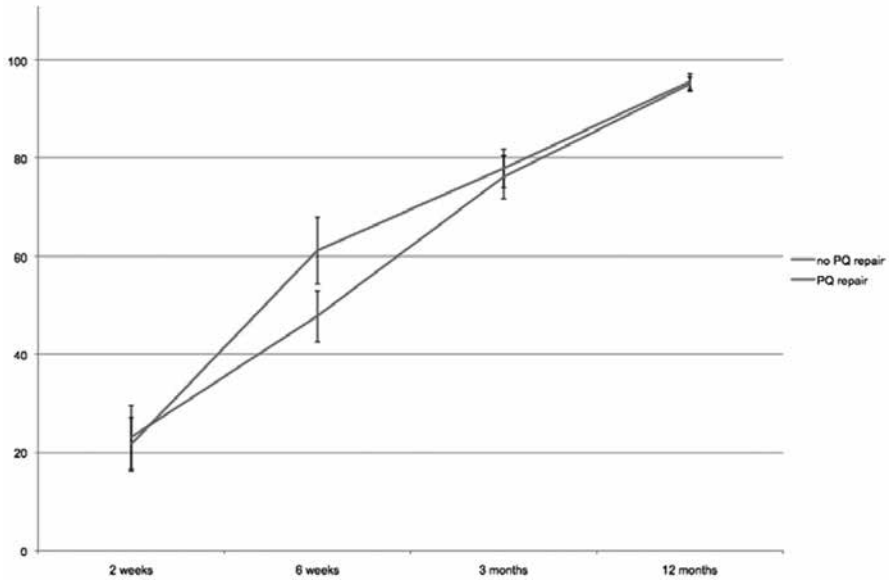

Figure3. One-year trend of mean grip strength after volar plate application for distal radius fractures in patients with and without repair of the PQ.

mean grip strength, range of motion, DASH, or VAS scores for any of the study intervals within the first year. A study by Hershman et al.[9] also examined outcomes of volar plating as a function of the PQ repair. In their retrospective review of 112 patients, 62 underwent repair of the PQ, and no significant differences were found in mean grip strength, range of motion, DASH, or VAS scores compared with the control group at one year. Four cases required reoperation: two for extensor pollicis longus rupture, one for intra-articular screw penetration, and one for flexor tendon irritation, which occurred in the repair group.

A recent survey of 608 hand surgeons reported that 83% routinely attempted a repair of the PQ after fixation.[17] This trend likely stems from the first technical descriptions of volar plating in which PQ repair was thought to augment wrist strength, distal radioulnar joint stability, and soft tissue coverage over the plate.[3] Subsequently, several authors suggested that interposing the PQ between plate and flexor ten-

dons may provide additional protection to the flexor tendons by reducing friction and attritional injury during tendon gliding.[3, 18, 19]

Conversely, opponents of PQ repair raise several questions with respect to its proposed advantages. First, no evidence exists to support any of the proposed benefits of PQ repair; and theoretical disadvantages such as over-tight repair, PQ space compartment syndrome, or iatrogenic radial artery injury have alternatively been proposed.[18, 19] Second, some of the purported advantages of PQ repair can be explained, at least in part, by other factors. Placement of the locking plate proximal to the watershed line has been suggested as the key technical feature that reduces flexor tendon complications after plating.[10–16] White et al.[16] reviewed their experience with 999 distal radius fractures treated via volar locking plates and found that six cases were complicated by nine flexor tendon ruptures, and a prominent volar plate was observed in all cases. In addition, Soong et al.[12] reported that flexor tendon rupture occurred in three of 73 cases, whereas Arora et al.[14] described nine cases of flexor tenosynovitis in 141 cases; in both of these studies, volar prominence of the plate was suggested as the causative factor although the PQ was routinely repaired. Brown and Lifchez[20] found that even though the PQ was repaired, the flexor pollicis longus tendon had eroded through muscle and was partially lacerated on a prominent plate at the time of revision surgery. A cadaveric study by Tanaka et al.[21] similarly provided evidence to suggest that an improperly placed plate distal to the watershed line increases contact pressures at the plate–tendon interface and thus negates the anatomic advantages of the concave volar distal radius regardless of the interposed soft tissue.

Other purported benefits such as increased distal radioulnar joint stability and greater wrist strength are also less convincing arguments, in that the PQ is a relatively minor contributor to both of these functions.[22–25] Chirpaz-Cerbat et al.[26] and Armangil et al.[27] showed that 12% to 19% of pronation strength may be lost compared with the unaffected side after volar plating of the distal radius. However, a similar study by Huh et al.[28] showed no differences at one year. In all of these studies, the PQ was released for exposure and subsequently repaired when possible. Alternatively, submuscular elevation of the PQ has been proposed to spare the dissection from the radial edge, but currently no biomechanical studies of postsurgical strength testing have been documented for this technique.[29]

The present study has limitations. One-year follow-up may not identify all of the potential complications such as tendon rupture, the need for hardware removal, or symptomatic posttraumatic arthritis. Although patients may present with late symptoms of flexor tendonopathy, many case studies have shown that tendon rupture and symptoms of impending rupture typically occur within 12 months after surgery.[6–9, 11, 13, 15, 16] Furthermore, we do not know whether the repairs were durable. However, a prospective trial by Swigart et al.[17] assessed the durability of the PQ repair after volar plating and found it to be intact in 96% of cases at three months. In addition, in the present study, patients were not formally randomized, but rather assigned to groups via their birth year. The average age of the repair group was significantly less than the control group, which may have introduced bias, because a younger patient may be more critical of the outcome. Finally, pronation and supination strength testing was not performed.

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Original Research

Patient Safety Issues from Information Overload in Electronic Medical Records

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Abstract

Objective: Electronic health records (EHR) have become ubiquitous in medicine and continue to grow in informational content. Little has been documented regarding patient safety from the resultant information overload. The objective of this literature review is to better understand how information overload in EHR affects patient safety.

Materials and Methods: A literature search was performed using PubMed and Google Scholar choosing articles that were relevant to the topic based upon keywords. Filters were used for English language papers and published within the last 10 years.

Results: Literature searching resulted in 2,868 articles, of which 22 articles met the criteria for this study.

Discussion: Information overload was shown to increase physician cognitive load and error rates in clinical simulations. Overabundance of clinically irrelevant information and poor data display were identified as the issues most likely to lead to information overload. An additional effect related to information overload is increased EHR-induced physician burnout due to clerical burden. Physicians displaying signs of burnout were found to be significantly more prone to medical error. Suggestions for improvements in EHR use are presented.

Conclusion: Information overload in EHR may result in higher error rates and negatively impact patient safety. Further studies are necessary to define the EHR role in adverse patient safety events and to determine methods to mitigate these errors.

Introduction

Digitizing medical records was an inevitable step in the modernization of health care fueled by the 2009 HITECH Act which incentivized electronic health record (EHR) implementation. Despite its advantages over paper-based documentation, EHR has resulted in physician-related challenges.[1] A major complaint of physicians is the large amount of extraneous patient information required in each medical chart.[2] Studies analyzing primary care physicians' EHR usage showed that they spend up to double the amount of time documenting in EHR than they do interacting with patients.[3] This increased clerical burden on physicians is not only a source of frustration and burnout but may also be potentially compromising patient safety.[4] An overload of information in a patient's chart, or "note bloat," can impair comprehension when reviewing medical records, leading to potential errors in clinical decision making.[5] This is compounded by poorly organized EHR software that is optimized for billing rather than patient care.[6] These issues increase physicians' cognitive load and leave them more susceptible to making mistakes.[7] A study analyzing data from 2013–2016 in various Pennsylvania hospitals identified 1,956 adverse patient safety events blamed on EHR in that time span, 557 of them being directly attributed to EHR usability.[8] The purpose of this literature review is to better understand the patient safety implications of "note bloat" and EHR usability issues, which may help lead to the development of solutions to make physicians more efficient and better equipped to safely care for patients.

Materials and Methods

A literature search was performed using PubMed and Google Scholar to find articles published in the last 10 years about EHR and its implications regarding patient safety. Articles were screened by first assessing the title and then the abstract for relevance to the project. Selected full text articles were obtained and reviewed for data or discussion focused on patient safety implications of EHR information overload. Filters were set for English only and full text availability. References of selected articles were also reviewed and used as an additional source of literature.

Keywords used included "electronic health record" in conjunction with the terms "information overload," "cognitive overload," "note bloat," "usability," and "patient safety." Additional searches with different combinations of these terms included "electronic health record information overload patient safety," "electronic health record usability patient safety," "electronic health record cognitive overload patient safety." Studies were deemed relevant if they: (a) defined the issue of information overload, (b) described how information overload fits into the current model of EHR safety analysis, or (c) provided data to demonstrate how information overload and poor EHR usability affect physi-

cian comprehension of clinical data. Further literature was sought out to understand the effect EHR has on physician burnout, as well as the link between burnout and medical error. Keywords included "EHR physician burnout" and "physician burnout medical error."

Results

As of 7/10/18, there were 2,868 results in total for the keywords specified above. 2,053 results came from searches that included *"patient safety,"* many of them not relevant to this project. Keywords involving information overload yielded far less articles, with 59 hits total between *"information overload," "cognitive overload,"* and *"note bloat."* The keyword *"usability"* generated 638 hits. Keywords involving physician burnout with EHR and medical error yielded 118 articles. Out of all the literature reviewed, 22 studies met the criteria for study.

The Cognitive Burden of Information Overload

Information overload was defined by Beasley et al.[11] in 2011 as: "when there are too many data, e.g., written, verbal and non-verbal, and physician's memory, for the clinician to organize, synthesize, draw conclusions from, or act on." It is categorized alongside information underload, information scatter, information conflict, and erroneous information as subclasses of "information chaos." The overload of information is generally blamed on copying and pasting into charts, use of templates, excessive alerts, and adding data that is necessary for billing but effectively useless for clinical care.[11, 12] Seven articles were found that explored the cognitive burden of information overload by assessing physician interaction with EHR in clinical simulations.

Ahmed et al.[13] illustrated the effect of cognitive load differences on error rates when using EHR for clinical decision making. A group of 20 ICU physicians were asked to review patient data in the form of a conventional versus novel streamlined EHR. The novel EHR was specifically designed to only display information that was deemed most salient to an ICU physician. The NASA task load index (an objective measure of task load from 0–100, higher indicates more work load) was a median of 58 for the conventional EHR versus 38.8 for the novel version. Completion of the task using the conventional EMR took approximately twice as long and was associated with a median four times as many errors per subject as the novel user interface.[13] This was consistent with the hypothesis that increased task load has significant detrimental effects on physicians' ability to analyze data.

A study using eye tracker technology in the ICU by Wright et al. was used to pinpoint what aspects of a chart that physicians actually utilize.[14] They found that dynamic data such as vitals and lab values were reviewed most consistently, and that other routine information is unnecessary and hinders usability.

Koopman et al.[6] performed a cognitive task analysis with 16 primary care physicians using simulated patient cases to better understand what information they considered most important for their medical decision making. A consistent finding among these physicians was that the assessment and plan was reviewed first because it provided all of the necessary information in a concise manner. The physicians were frustrated by the review of systems section as it mostly provided redundant information and was another source of clutter or "note bloat." Physicians in the study also provided insight on why they thought EHR isn't formatted to optimize physician usability. They identified current drivers of note construction as: billing (checklists for each section, especially review of systems), quality improvement measures (e.g., diabetic foot examination), avoiding malpractice, compliance (e.g., documenting informed consent, patient education), and the visit history and physical exam. These are all key factors in the generation of "note bloat."

Belden et al.[15] expanded on the idea of restructuring the fundamental structure of notes in the EHR to decrease cognitive overload. A traditional "SOAP" (Subjective, Objective, Assessment, Plan) note was compared to a newly-proposed "APSO" (Assessment, Plan, Subjective, Objective) format with an option to hide other extraneous information. A simulated case with 16 physicians demonstrated that simply changing the format of the note without changing any of the actual data had a positive effect. The APSO note performed better in regard to usability, and the physicians strongly endorsed this style as more practical.[15]

Information overload can also be mitigated through educating physicians to write more efficient notes. Kahn et al.[16] demonstrated that physicians who undergo a training session and use a template have notes that are 25% shorter and take 1.3 hours less time. This demonstrates a practical step that can be taken by physicians to reduce information overload and save time.

User composability has been proposed in the literature as a solution to improving usability. This allows physicians to customize what data is displayed based on what they find most important for patient care. A study done by Senathirajah et al. with 11 physicians reviewing the same patient data showed a significant increase in reading efficiency with a user composable versus a traditional EHR. 72% of patient data was reviewed more than once in conventional EHR compared to 17% in the user composable version. A conclusion offered by these authors was that the poor usability of conventional EHR's decreases physician comprehension. This causes data to be revisited multiple times to be fully understood.[17]

Alert fatigue is another major source of information overload identified in the literature. In a survey of 2,590 primary care physicians, 69.6% reported receiving more information than they could effectively manage, indicating susceptibility to information overload. 29.8% reported incidents where

they personally missed test results that delayed patient care.[12] Another study of alert fatigue showed that a clinician's likelihood of accepting best practice reminders dropped markedly with increases in the number of reminders, number of repeated reminders for the same patient, and overall patient complexity.[18]

Physician Burnout

Physician frustration can be a result of note bloat, with up to half of a work day spent working on EHR and an additional 1–2 hours at home according Sinsky et al.[2] Marked decreases in time spent with patients is reported by physicians as a large source dissatisfaction and burnout.[19] In a 2017 survey of primary care physicians, of the respondents that reported symptoms of burnout, 75% attributed it primarily to the burdens of EHR.[20] Burnout increases the risk of depression, substance abuse, strained relationships, and suicide among physicians.[21] This can pose a risk to patients due to a significantly higher incidence of medical errors committed by physicians with burnout.[22] Tawfik et al.[22] reported that the physicians with burnout had more than twice the odds of self-reported medical error, after adjusting for specialty, work hours, fatigue, and work unit safety rating.

Discussion

EHR's effect on patient safety is complex. When implemented properly, it can reduce medication errors and provide a potentially safer alternative to paper-based methods.[9, 10] However, its use has paradoxically also created an unintended adverse consequence of information and cognitive overload.[4] Unfortunately, an increase in cognitive load can cause a significant increase in error rates[13] and a resultant increased risk of medical errors by clinicians. In addition, it potentially increases physician frustration and burnout, which can also lead to an increase in medical errors.

Solutions for EHR information overload have been proposed, including a customizable EHR to ensure that important data is easier to find.[13, 17] Studies that tested this type of software showed significant reductions in error rates and improvements in efficiency. The success of these interventions further confirms the negative effects of information overload on physician comprehension. Changing the order of the clinical note was also shown to improve usability,[15, 16] demonstrating the importance of proper data presentation to minimize physician cognitive load. Alert fatigue also contributes to information overload and may further compromise patient safety. Excessive alerting influenced physicians to make decisions based on factors other than best practice.[18]

Information overload also results in an increase in tedious clerical work, reducing physician-patient time and hampering physician efficiency.[2] This has negatively impacted physician well-being and is a major cause of physician burnout.[19, 20, 21] Physicians with burnout have a significantly increased rate of clinical errors, further increasing the risk of adverse patient safety events.[22]

Conclusion

Studies have demonstrated that EHR information overload and alert fatigue can have a negative impact on patient safety, in addition to contributing to physician burnout and increased medical error rates. Solutions that improve EHR usability have shown promising results, but further research and implementation is necessary in order to obtain an EHR optimized for patient care and safety.

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Original Research

Orthopaedic Physician Attire Influences Patient Perceptions in the Urban Inpatient Setting

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Abstract

Background: Physician attire has a significant impact on patient perceptions, which ultimately influences the patient-physician relationship. The implications of how patients experience their care are substantial and tied to compliance with treatment, improved communication about their health, reported satisfaction, and may even contributes to physician reimbursement. Previous work has established the importance of specialty, location, and setting on patient preferences for attire.

Questions/Purposes: While patient preferences for surgeon attire have been previously examined in the outpatient setting, the aim of this study was to determine if these findings remained true for patients in the inpatient setting.

Methods: Ninety-three of 110 consecutive orthopaedic patients at an urban academic medical center participated in a three-part survey. The first section randomly presented 10 images of a surgeon, either male or female, dressed in five different outfits: business attire (BA), a white coat over business attire (WB), scrubs alone (SA), a white coat over scrubs (WS), and casual attire (CA). Respondents rated each image on a five-level Likert scale regarding how confident, trustworthy, safe, caring, and smart the surgeon appeared, how well the surgery would go, and their willingness to discuss personal information with the surgeon. In the second part, the respondent ranked all images, by gender, from most to least confident based on attire.

Results: Pairwise comparisons for the female surgeon demonstrated WB, WS, SA were equally preferable to BA or CA. The same results were found when rating surgeon intelligence, skill, trust, confidentiality, caring, and safety. For the male pairwise comparisons, WS was equally preferred to WB, SA, and BA. WB performed equally as well as SA (MD 0.035 ± 0.563; 95% CI −0.086–0.155; p = 1.00) and was preferred to BA or CA. SA and BA were equal (MD 0.267 ± 0.742; 95% CI 0.108–0.427; p = 0.061), but were both preferred to CA, with similar results found in all other categories. When asked to rank all attire, patients equally preferred female and male surgeons in WS or WP, followed by SA, PA, then CA.

Conclusions: Similar to findings in the outpatient orthopaedic setting, patients had an overall preference for physicians wearing a white coat, either over scrubs or professional attire, and to some extent, scrubs alone. These preferences likely stem from an archetypal image of how patients imagine a physician's appearance, and adherence to these predilections can easily improve the patient-physician relationship.

Level of Evidence: II, Therapeutic Study.

Introduction

Background

The patient-physician relationship lies at the heart of the practice of medicine. While countless factors influence how patients perceive this relationship, perhaps the most easily modifiable variable is physician attire. As a result, a plethora of studies across multiple specialties targeted an answer to how physicians' attire influences the perceptions of their specific patient population. It follows that patients who feel more confident and trusting in their treating doctor likely show improved compliance with treatment, openness to discuss intimate and important details about their health, and a more satisfactory overall experience.[8, 15, 16, 18] In fact, the importance of patient perceptions of their care and overall satisfaction prompted the creation of the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS), a publicly-reported and standardized national survey and other scoring systems such as Press Ganey.[1] With the passage of the Affordable Care Act in 2010, reimbursements have been tied to satisfaction as well, further emphasizing the importance of bolstering the patient experience in any way possible, attire included.[4]

Rationale

Previous work by our group demonstrated that patients' perceptions are indeed influenced by the attire of their treat-

ing physician. In the outpatient setting, we found an overall preference for the white coat followed closely by scrubs.[19] Importantly, other investigations have demonstrated that patients preferences are influenced by various factors including practice type and location.[6, 8, 9, 15] For this reason, we were interested to see if patient expectations and preferences were changed in the inpatient setting. Our null hypothesis, therefore, was that there would be no difference in patient perceptions in the urban, inpatient setting.

Study Questions

While patient preferences for surgeon attire have been previously examined in the outpatient setting, the aim of this study was to determine if these findings remained true for patients in the inpatient setting.

Methods

Study Design and Setting

For this prospective, cross-sectional study, hospitalized orthopaedic patients at an urban academic medical center participated in an electronic survey.

Participants/Study Subjects

The patients were included if they were at least 18 years old, agreed to be surveyed, and underwent an orthopaedic procedure that required admission as an inpatient.

Patients who were younger than 18 years, had an outpatient orthopaedic procedure, answered fewer than ½ of the questions, or selected responses outside the established reference range were excluded. One hundred ten consecutive postoperative inpatients were asked to complete the survey. Ninety-three of these patients successfully completed the survey, while 17 patients opted not to participate.

Description of Experiment, Treatment or Surgery

A three-part, 15-minute survey was created online using SurveyMonkey and electronically administered using an iPad (Apple Inc., Cupertino, CA). The first section of the survey consisted of 10 randomly-presented images of a surgeon, either male or female, dressed in five different outfits: business attire (BA), a white coat over business attire (WB), scrubs alone (SA), a white coat over scrubs (WS), and casual attire (CA) (Figure 1). The survey software presented the images of each attire type in a randomly-determined, unique order to participants. The survey depicted Caucasian surgeons of both sexes with similar facial expressions, jewelry, clothing and backgrounds to those used in previous studies on this topic in order to ensure comparability and isolation of the study variable of interest.

Variables, Outcome Measures, Data Sources, and Bias

Respondents used a five-point Likert scale, ranging from one to five, to rate the intelligence, trustworthiness, safety, surgical skills, and confidence of the surgeon depicted in each of the images. Six survey questions were created based on the aim of the study and administered to participants without any pretesting or piloting.

Participants were asked the following questions: How confident are you in this surgeon? How smart is this surgeon? How well do you think the surgery will go if this was your surgeon? How willing are you to discuss confidential information with this surgeon? How trustworthy is this surgeon? How safe is this surgeon? In the second section of the survey, respondents were shown a single page with all five images of the female surgeon and asked to use a five-point scale to rank the images from highest to lowest level of confidence in the surgeon's abilities. This was repeated for the images of the male surgeon. In the third and final section of the survey, respondents provided demographic information, including age, sex, race, education level, current employment, marital and insurance status and type, if applicable.

Statistical Analysis, Study Size

The survey responses were collected using the five-point Likert scale and aggregated to a derived three-level response in order to analyze the data as categorical, instead of continuous. The three-level responses included negative, positive, and neutral. The original responses of "not very" and "not at all" were combined and reclassified as "negative," while the original responses "very" and "somewhat" were combined and reclassified as "positive." The data from the survey was analyzed in two parts. First, all five of the attires were compared, using the Friedman test, as part of a single analysis to determine if there were any existing significant differences. Next, pairwise comparisons comparing only two attires were done, resulting in a total of 10 pairwise comparisons. All reported p-values are two-sided where applicable and a Bonferroni correction was applied for multiple comparisons. Analysis of each demographic variable was conducted using either the Chi-Square test or the Fisher's exact test. Demographic statistics are reported based on all participants that provided a complete data subset for any question. All statistical analyses were conducted using SAS® 9.4 (SAS Institute, Cary, NC). Statistical significance is defined as $p < 0.05$.

Results

While patient preferences for surgeon attire have been previously examined in the outpatient setting, the aim of this study was to determine if these findings remained true for patients in the inpatient setting.

In total, 93 consecutive inpatients meeting the inclusion criteria completed a survey. Demographic data, represented in Table 1, shows respondents mostly 45–64, slightly more than half male, and most either Caucasian or African American (53.8% male, 30.1% Caucasian, 48.4% African American). Most patients had a high school degree or greater in terms of education, were either currently employed or

Figure 1. The photographs show the **(A)** male and **(B)** female surgeons wearing a white coat over formal attire, scrubs, white coat over scrubs, business attire, and casual attire.

retired, and had either private insurance, Medicare, or Medicaid (19.4% had less than high school degree, 39.9% were unemployed, 79.6% had some type of insurance). When asked to order physician attire, patients equally preferred female surgeons in a white coat over scrubs or professional dress (Mean Difference (MD) 0.033 ± 0.875; 95% Confidence Interval (CI) –0.149–0.215; p = 1.00), followed by scrubs alone (MD 0.560 ± 1.002; 95% CI 0.352–0.769; p < 0.001), professional attire (MD 0.769 ± 1.359; 95% CI 0.486–1.052; p < 0.001), and lastly casual attire (MD 1.341 ± 0.991; 95% CI 1.134–1.547; p < 0.001) (Figure 2). When performing the same task for male surgeons, similarly, white coat over scrubs or professional attire were equally preferred (MD 0.011 ± 0.819; 95% CI –0.159–0.180; p = 1.00), followed by scrubs alone (MD 0.674 ± 1.080; 95% CI 0.450–0.898; P < 0.001), professional attire (MD 0.728 ± 1.343;

Table 1

Demographic Variable	Number of Patients	Percentage of Total
Age range (years)		
18–34	17	18.3
35–54	34	36.6
55 or older	42	45.2
Missing	0	0.0
Gender		
Female	42	45.2
Male	50	53.8
Missing	1	1.1
Ethnicity		
Asian or Pacific Islander	1	1.1
Black or African American	45	48.4
Hispanic/Latino	14	15.1
White/Caucasian	28	30.1
White/Caucasian and Hispanic/Latino	1	1.1
Missing	4	4.3
Education level		
Less than high school degree	18	19.4
High school degree or equivalent	43	46.2
Some college but not degree	12	12.9
Associate degree	5	5.4
Bachelor degree	7	7.5
Graduate degree	4	4.3
Missing	4	4.3
Employment status		
Employed, working full-time	24	25.8
Employed, working part-time	6	6.5
Not employed, NOT looking for work	5	5.4
Not employed, looking for work	6	6.5
Retired	20	21.5
Disabled, not able to work	26	28.0
Missing	6	6.5
Relationship status		
Married	22	23.7
Widowed	9	9.7
Divorced	6	6.5
Separated	7	7.5
In a domestic partnership or civil union	5	5.4
Single, but cohabiting with a significant other	10	10.8
Single, never married	29	31.2
Missing	27	29.0
Insurance status		
Private insurance	16	17.2
Medicare	18	19.4
Medicaid	23	24.7
Private insurance and Medicaid	4	4.3
Private insurance and Medicare	9	9.7
Medicare and Medicaid	4	4.3
No insurance	7	7.5
Missing	28	30.1

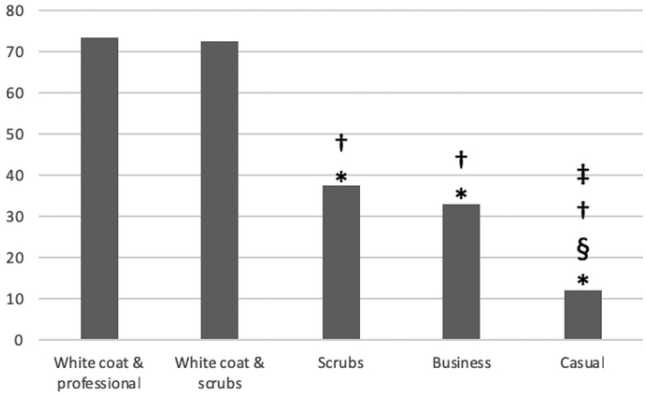

Figure 2. Overall order of preference for female surgeons' attire. Respondents preferred white coat & professional attire and white coat & scrubs compared to scrubs alone, business attire, and casual attire.

*p < 0.05 for comparisons with white coat over scrubs
†p < 0.05 for comparisons with white coat over professional attire
‡p < 0.05 for comparisons with scrubs
§p < 0.05 for comparisons with business attire

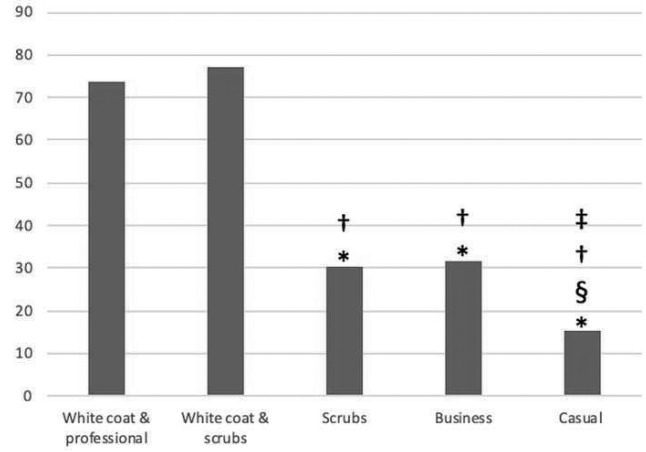

Figure 3. Overall order of preference for male surgeons' attire. Respondents preferences were largely in favor of white coat over scrubs and white coat over professional attire.

*p < 0.05 for comparisons with white coat over scrubs
†p < 0.05 for comparisons with white coat over professional attire
‡p < 0.05 for comparisons with scrubs
§p < 0.05 for comparisons with business attire

95% CI 0.450–1.006; p < 0.001), then casual dress (MD 1.293 ± 1.095; 95% CI 1.067–1.520; p < 0.001) (Figure 3). Similar results were found when individual pairwise comparisons made by category for each gender surgeon. For confidence regarding the female physician, respondents rated white coat over professional attire, white coat over scrubs, and scrubs alone as equally preferable (WS vs WB: MD 0.090 ± 0.615; 95% CI –0.040–0.219; p = 1.00, WS vs SA: MD 0.157 ± 0.689; 95% CI 0.012–0.302; p = 0.689, WB vs SA: 0.067 ± 0.850; 95% CI –0.112–0.246; p = 1.00) to professional or casual attire (Table 2). The same results were found when rating surgeon intelligence, how successful the surgery would go, the surgeon's confidentiality, trustworthiness, and safety (Figure 4). For the male surgeon, with regards to patient confidence, white coat over scrubs was equally preferred to white coat over professional attire, scrubs alone, and professional attire alone (WS vs WB: MD –0.093 ± 0.644; 95% CI –0.0231–0.045; p = 1.00, WS vs SA: MD –0.058 ± 0.443; 95% CI –0.153–00.037; p = 1.00, WS vs BA: MD 0.209 ± 0.828; 95% CI 0.032–0.387; p = 0.569). White coat over professional attire performed equally as well as scrubs alone (MD 0.035 ± 0.563; 95% CI –0.086–0.155; p = 1.00) and was preferred to professional attire alone or casual attire (WB vs BA: MD 0.302 ± 0.783; 95% CI 0.134–0.470; P = 0.024, WB vs CA 0.977 ± 0.982;

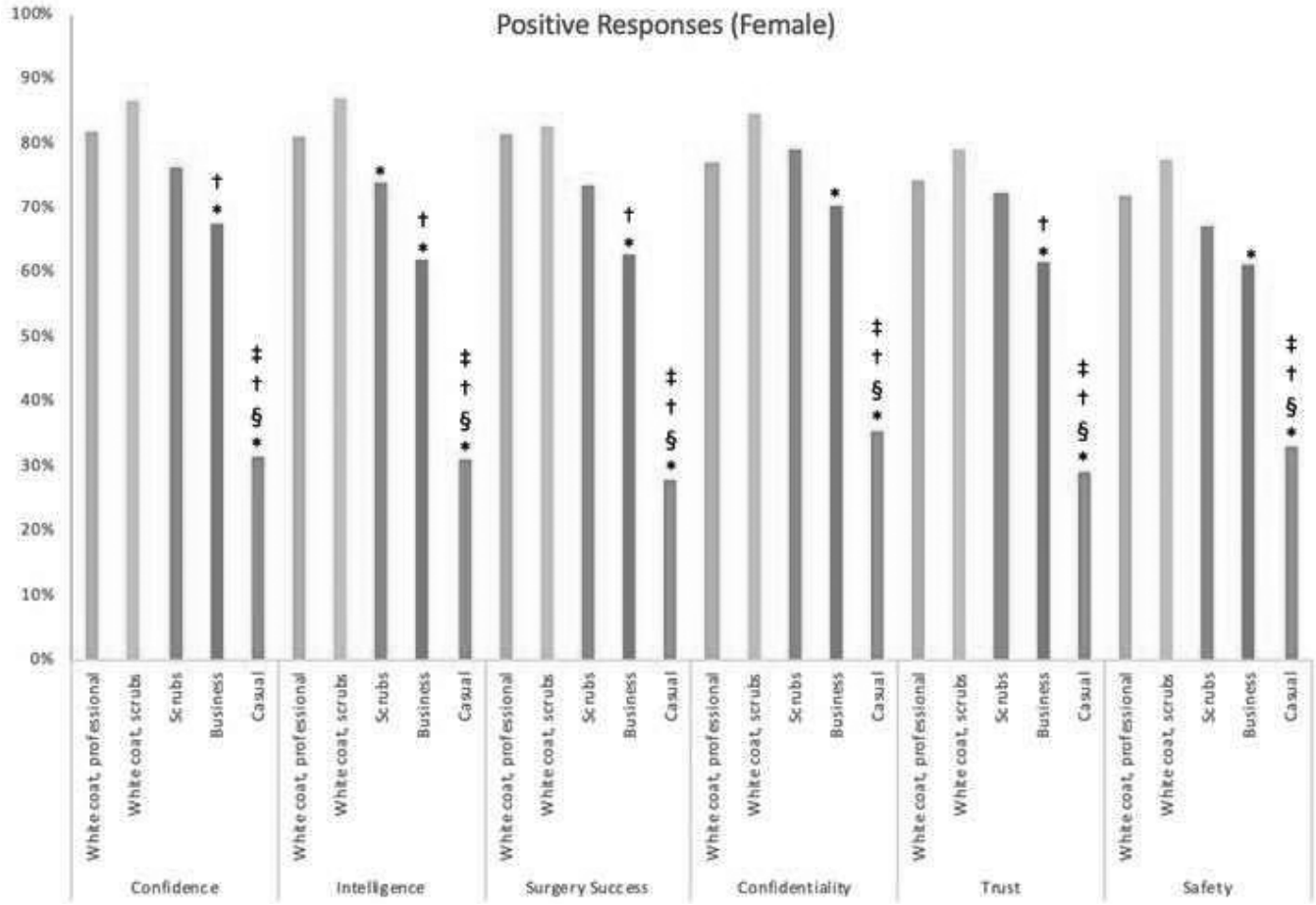

Figure 4. Patients' positive responses for female attire, stratified by six questions. Respondents were asked how confident are you in this surgeon (confidence), how smart do you think this surgeon is (intelligence), how well do you think the surgery would go (surgery success), how willing would you be to discuss confidential information with this surgeon (confidentiality), how trustworthy do you feel this surgeon is (trust), and how safe do you feel with this surgeon (safety).

*$p < 0.05$ for comparisons with white coat over scrubs
†$p < 0.05$ for comparisons with white coat over professional attire
‡$p < 0.05$ for comparisons with scrubs
§$p < 0.05$ for comparisons with business attire

95% CI 0.766–1.187, $p < 0.001$). Scrubs alone and professional attire were not statistically different when compared with each other (MD 0.267 ± 0.742; 95% CI 0.108–0.427; $p = 0.061$), but were both preferred to both casual attire (SA vs CA: 0.942 ± 1.010; 95% CI 0.725–1.158; $P < 0.001$, BA vs CA: 0.674 ± 1.011; 95% CI 0.458–0.891; $p < 0.001$). The same results were found for perception of surgeon intelligence, how the surgery would go, the surgeon's confidentiality, trustworthiness, and safety (Table 2 and Figure 5).

Discussion

Background and Rationale

The recent explosion in publications on the topic of physician attire across nearly every medical specialty is predicated on several factors. First, previous work confirmed the belief that physician attire can significantly influence patient perceptions.[7, 8, 15, 16] Circumstantially, time for the patient-physician encounter is steadily diminishing in lockstep with the growing emphasis on patient satisfaction scores, therefore emphasizing the importance of the first impression. In fact, Rascoe et al. recently conducted a large prospective cohort study which convincingly showed higher physician scores resulted from patient perception biases rather than the overall care they received.[2] While numerous qualities and circumstances may influence this first impression, certainly one of the most mutable and easily studied components is physician dress.[16, 17] Importantly, subsequent studies discovered these perceptions are contingent upon geography, specialty, culture, and various other factors.[8] In the largest study to date, Petrilli et al. surveyed over 4,062 patients finding that patients have different preferences for surgeons than other specialties, with scrubs being preferable. Furthermore, they reiterated the influence of location of care, such as inpatient versus outpatient office, on patient perceptions and preferences as well.[14] These findings reinforce those found

Table 2

Sex	Attire	Confidence p (mean ± SD) [95% CI]	Intelligence p (mean ± SD) [95% CI]	Surgery Success p (mean ± SD) [95% CI]	Confidentiality p (mean ± SD) [95% CI]	Trust p (mean ± SD) [95% CI]	Safety p (mean ± SD) [95% CI]
Male	White coat & scrubs versus white coat & professional	p = 1.000 (–0.093 ± 0.644) [–0.231–0.045]	p = 1.000 (–0.086 ± 0.574) [–0.213–0.041]	p = 1.000 (0.000 ± 0.609) [–0.134–0.134]	p = 1.000 (–0.011 ± 0.494) [–0.117–0.094]	p = 1.000 (0.036 ± 0.502) [–0.073–0.145]	p = 1.000 (–0.013 ± 0.464) [–0.116–0.091]
Male	White coat & scrubs versus scrubs	p = 1.000 (–0.058 ± 0.443) [–0.153–0.037]	p = 1.000 (–0.062 ± 0.429) [–0.156–0.033]	p = 1.000 (–0.012 ± 0.430) [–0.107–0.082]	p = 1.000 (0.000 ± 0.457) [–0.098–0.098]	p = 1.000 (0.036 ± 0.451) [–0.062–0.134]	p = 1.000 (0.025 ± 0.389) [–0.062–0.112]
Male	White coat & scrubs versus casual	p < 0.001 (0.884 ± 0.987) [0.672–1.095]	p < 0.001 (0.753 ± 0.859) [0.563–0.943]	p < 0.001 (0.878 ± 0.935) [0.673–1.083]	p < 0.001 (0.805 ± 0.926) [0.607–1.002]	p < 0.001 (0.774 ± 0.883) [0.582–0.965]	p < 0.001 (0.825 ± 0.991) [0.605–1.045]
Male	White coat & scrubs versus business	p = 0.569 (0.209 ± 0.828) [0.032–0.387]	p = 1.000 (0.160 ± 0.766) [–0.009–0.330]	p = 1.161 (0.280 ± 0.879) [0.087–0.474]	p = 0.435 (0.218 ± 0.738) [0.061–0.376]	p = 0.121 (0.274 ± 0.766) [0.108–0.440]	p = 0.275 (0.250 ± 0.819) [0.068–0.432]
Male	White coat & professional versus scrubs	p = 1.000 (0.035 ± 0.563) [–0.086–0.155]	p = 1.000 (0.025 ± 0.474) [–0.080–0.129]	p = 1.000 (–0.012 ± 0.533) [–0.129–0.105]	p = 1.000 (0.011 ± 0.560) [–0.108–0.131]	p = 1.000 (0.000 ± 0.538) [–0.117–0.117]	p = 1.000 (0.038 ± 0.489) [–0.071–0.146]
Male	White coat & professional versus casual	p < 0.001 (0.977 ± 0.982) [0.766–1.187]	p < 0.001 (0.840 ± 0.968) [0.626–1.053]	p < 0.001 (0.878 ± 1.047) [0.648–1.108]	p < 0.001 (0.816 ± 0.947) [0.614–1.018]	p < 0.001 (0.738 ± 1.007) [0.519–0.957]	p < 0.001 (0.838 ± 1.049) [0.604–1.071]
Male	White coat & professional versus business	p = 0.024 (0.302 ± 0.783) [0.134–0.470]	p = 0.076 (0.247 ± 0.643) [0.105–0.389]	p = 0.120 (0.280 ± 0.821) [0.100–0.461]	p = 0.282 (0.230 ± 0.677) [0.086–0.374]	p = 0.337 (0.238 ± 0.705) [0.085–0.391]	p = 0.176 (0.263 ± 0.759) [0.094–0.431]
Male	Scrubs versus casual	p < 0.001 (0.942 ± 1.010) [0.725–1.158]	p < 0.001 (0.815 ± 0.950) [0.605–1.025]	p < 0.001 (0.890 ± 1.018) [0.666–1.114]	p < 0.001 (0.805 ± 0.950) [0.602–1.007]	p < 0.001 (0.738 ± 0.983) [0.525–0.951]	p < 0.001 (0.800 ± 1.011) [0.575–1.025]
Male	Scrubs versus business	p = 0.061 (0.267 ± 0.742) [0.108–0.427]	p = 0.154 (0.222 ± 0.689) [0.070–0.375]	p = 0.073 (0.293 ± 0.824) [0.112–0.474]	p = 0.321 (0.218 ± 0.813) [0.045–0.392]	p = 0.261 (0.238 ± 0.786) [0.068–0.409]	p = 0.372 (0.225 ± 0.826) [0.041–0.409]
Male	Casual versus business	p < 0.001 (–0.674 ± 1.011) [–0.891–−0.458]	p < 0.001 (–0.593 ± 0.932) [–0.799–−0.386]	p < 0.001 (–0.598 ± 0.992) [–0.816–−0.380]	p < 0.001 (–0.586 ± 1.006) [–0.801–−0.372]	p < 0.001 (–0.500 ± 1.024) [–0.722–−0.278]	p < 0.001 (–0.575 ± 1.003) [–0.798–−0.352]
Female	White coat & scrubs versus white coat & professional	p = 1.000 (0.090 ± 0.615) [–0.040–0.219]	p = 1.000 (0.107 ± 0.515) [–0.005–0.219]	p = 1.000 (0.070 ± 0.549) [–0.048–0.187]	p = 1.000 (0.121 ± 0.534) [0.010–0.232]	p = 1.000 (0.070 ± 0.455) [–0.028–0.167]	p = 1.000 (0.094 ± 0.503) [–0.014–0.203]
Female	White coat & scrubs versus scrubs	p = 0.697 (0.157 ± 0.689) [0.012–0.302]	p = 0.230 (0.202 ± 0.576) [0.077–0.327]	p = 1.000 (0.151 ± 0.584) [0.026–0.276]	p = 1.000 (0.077 ± 0.582) [–0.044–0.198]	p = 1.000 (0.116 ± 0.562) [–0.004–0.237]	p = 0.961 (0.153 ± 0.588) [0.026–0.280]
Female	White coat & scrubs versus casual	p < 0.001 (1.090 ± 1.030) [0.873–1.307]	p < 0.001 (0.976 ± 0.944) [0.771–1.181]	p < 0.001 (0.093 ± 0.916) [0.897–1.289]	p < 0.001 (0.934 ± 0.964) [0.733–1.135]	p < 0.001 (0.872 ± 0.905) [0.678–1.066]	p < 0.001 (0.847 ± 0.958) [0.641–1.054]
Female	White coat & scrubs versus business	p = 0.017 (0.292 ± 0.757) [0.133–0.452]	p < 0.001 (0.369 ± 0.741) [0.208–0.530]	p = 0.015 (0.314 ± 0.724) [0.159–0.469]	p = 0.114 (0.264 ± 0.712) [0.115–0.412]	p = 0.053 (0.291 ± 0.701) [0.140–0.441]	p = 0.084 (0.282 ± 0.701) [0.131–0.433]
Female	White coat & professional versus scrubs	p = 1.000 (0.067 ± 0.850) [–0.112–0.246]	p = 1.000 (0.095 ± 0.705) [–0.058–0.248]	p = 1.000 (0.081 ± 0.707) [–0.070–0.233]	p = 1.000 (–0.044 ± 0.698) [–0.189–0.101]	p = 1.000 (0.047 ± 0.572) [–0.076–0.169]	p = 1.000 (0.059 ± 0.713) [–0.095–0.213]
Female	White coat & professional versus casual	p < 0.001 (1.000 ± 1.000) [0.789–1.211]	p < 0.001 (0.869 ± 0.954) [0.662–1.076]	p < 0.001 (1.023 ± 0.982) [0.813–1.234]	p < 0.001 (0.813 ± 1.043) [0.596–1.030]	p < 0.001 (0.802 ± 0.905) [0.608–0.996]	p < 0.001 (0.753 ± 1.011) [0.535–0.971]
Female	White coat & professional versus business	p = 0.266 (0.202 ± 0.868) [0.019–0.385]	p = 0.058 (0.262 ± 0.823) [0.083–0.441]	p = 0.073 (0.244 ± 0.796) [0.073–0.415]	p = 1.000 (0.143 ± 0.783) [–0.020–0.306]	p = 0.418 (0.221 ± 0.788) [0.052–0.390]	p = 0.926 (0.188 ± 0.838) [0.007–0.369]
Female	Scrubs versus casual	p < 0.001 (0.933 ± 1.042) [0.713–1.152]	p < 0.001 (0.774 ± 0.998) [0.557–0.990]	p < 0.001 (0.942 ± 1.033) [0.720–1.163]	p < 0.001 (0.857 ± 0.926) [0.664–1.050]	p < 0.001 (0.756 ± 0.880) [0.567–0.945]	p < 0.001 (0.694 ± 0.951) [0.489–0.899]
Female	Scrubs versus business	p = 1.000 (0.135 ± 0.842) [–0.043–0.312]	p = 0.938 (0.167 ± 0.819) [–0.011–0.344]	p = 1.000 (0.163 ± 0.824) [–0.014–0.339]	p = 1.000 (0.187 ± 0.802) [–0.020–0.354]	p = 1.000 (0.174 ± 0.829) [–0.003–0.352]	p = 1.000 (0.129 ± 0.768) [–0.036–0.295]

Table 2 ***(Continued)***

Sex	Attire	Confidence p (mean ± SD) [95% CI]	Intelligence p (mean ± SD) [95% CI]	Surgery Success p (mean ± SD) [95% CI]	Confidentiality p (mean ± SD) [95% CI]	Trust p (mean ± SD) [95% CI]	Safety p (mean ± SD) [95% CI]
Female	Casual versus business	p < 0.001 (–0.798 ± 1.013) [–1.011––0.584]	p < 0.001 (–0.607 ± 0.919) [–0.806––0.408]	p < 0.001 (–0.779 ± 0.999) [–0.993––0.565]	p < 0.001 (–0.670 ± 1.044) [–0.888––0.453]	p < 0.001 (–0.581 ± 0.913) [–0.777––0.386]	p < 0.001 (–0.565 ± 0.919) [–0.763––0.367]

p value, mean ± SD, and 95% CI are reported for each sex, pairwise comparison of attire, and question; for the three-level Likert style rating for a given attire, positive responses were assigned a value of 1, neutral responses were assigned a value of 0, and negative responses were assigned a value of –1. Difference calculations are based on the rating of first listed attire (a three-level Likert style rating of positive, neutral, or negative) minus the rating of the second listed attire; in the context of the three-level Likert style rating, a mean difference of 1.0 reflects a higher (i.e., better).

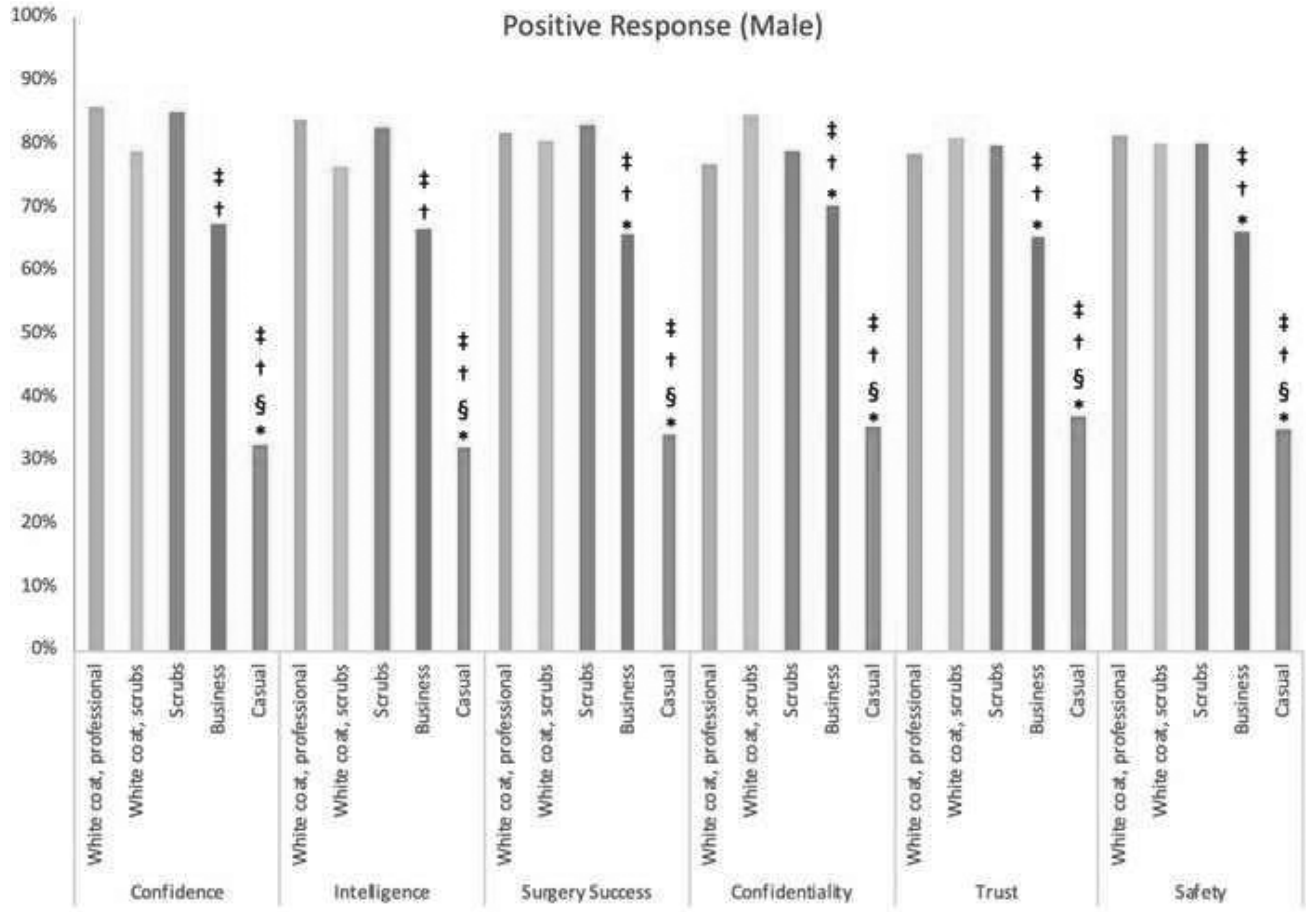

Figure 5. Patients' preferences for male attire, stratified by each of the six questions.

*p < 0.05 for comparisons with white coat over scrubs
†p < 0.05 for comparisons with white coat over professional attire
‡p < 0.05 for comparisons with scrubs
§p < 0.05 for comparisons with business attire

in several smaller previous studies, and further emphasize their importance.[6, 8, 9, 15] Given these data, this study elaborated on previous work in the orthopaedic setting by framing the survey for attire preferences in the yet unexamined inpatient environment. When querying a cohort of outpatient orthopedic patients, Jennings et al. found an overall preference for both white coat over formal attire and scrubs alone.[19] Lands and colleagues looked even more specifically at 97 patients in the outpatient orthopaedic hand surgery office reiterating higher scores for surgeons in a white coat, although unlike the aforementioned study, this was significantly preferred to scrubs.[12] Future studies should be performed in alternative geographic locations to examine the differences in patient preferences.

Limitations

There were several limitations, many of which were consistent with other studies on the topic of attire. While conducting a survey utilizing pictures of physicians in various attire permits distribution to a large number of potential

respondents, it cannot take into account factors such as physician bedside manner and various other factors known to influence patient perceptions.[2, 8, 14] Likewise, the pictured provider was a relatively young Caucasian male and female, which permits comparability to other similar studies; however, this of course may influence patient perceptions as well. By keeping the physician constant, however, we hoped to largely isolate attire as the only changing variable being studied. Similarly, the chosen attire was consistent with previous studies for comparison and cannot capture the nearly infinite combination of dress that a treating surgeon may wear.[8, 9, 11–13, 15, 19] Lastly, Likert scales have inherent flaws including discrete, predefined categories as well as floor and ceiling effects, and conversion of ordinal to numeric data for comparison.

Here, we demonstrated that in an urban, inpatient orthopaedic surgery setting, patients overall preferred physicians with a white coat, either over scrubs or professional attire, and for male surgeons, scrubs alone was equally preferred. When examining categorical pairwise comparisons, respondents preferences echo those previously demonstrated in the outpatient setting, with a preference for both white coat over scrubs or over professional attire, as well as scrubs alone.[19]

Conclusions

In conclusion, patients prefer both male and female surgeons with a white coat or scrubs, which confirms our original hypothesis. We believe this is in line with the archetypal image of a surgeon and is thus what patients expect in their treating physician.[2, 5, 10] Compared with a previous study in the outpatient setting, there was a higher acceptance for scrubs alone, which follows logically given the higher number of physicians and staff encountered in the hospital wearing scrubs. Perhaps television and media influence this as well, although this is well beyond the scope of the current study. Attire is an important part of the patient-physician relationship which influences first-impressions, and as such, scrubs alone or a white coat over either professional attire or over scrubs should be strongly considered by orthopaedic surgeons.

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Original Research

Physician Burnout and Associated Factors: Orthopaedics Versus Anesthesia

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Abstract

Background: Physician burnout has garnered increased attention in recent studies. It is attributed to the intrinsic stresses of medical practice and affects the quality of patient care. Previous studies have reported roughly half of orthopedic surgery and anesthesiology faculty and residents suffer symptoms of burnout.

Objective: The purpose of this study is to determine if there is a significant difference in burnout rates among orthopedic surgeons and anesthesiologists, between faculty and residents in both specialties, and possible associated factors that may predispose participants to experience burnout.

Methods: Data was gathered using the Maslach Burnout inventory survey (42 questions), which was distributed during the spring/summer of 2017 to orthopaedic surgery and anesthesiology residents and attending physicians, anesthesiology residents, orthopedic surgery faculty, and orthopedic surgery residents from various programs in the northeastern United States.

Results: Survey Response rate was 238/666 = 38% response. As compared to attendings, residents scored worse on Emotional Exhaustion, worse on Depersonalization and worse on Personal Accomplishment. When comparing specialties for Emotional Exhaustion, Orthopaedic surgery scored better as compared with Anesthesiology. On Personal Accomplishment, Orthopaedic surgery scored better as compared with Anesthesiology. Residents had higher levels of burnout compared to attendings. Regarding specialty, Orthopaedic surgery scored significantly lower with regard to Emotional Exhaustion and Personal Accomplishment. It was also discovered that Orthopaedic surgeons overall have more social events, and more residents have mentors.

Conclusion: Residents consistently demonstrated higher levels of burnout than attendings in both anesthesiology and orthopaedic surgery. Having a mentor and more interdepartmental social events may protect against burnout.

Introduction

Physician burnout has become a significant concern in recent years. In 2012, a national study found that 46% of United States physicians reported at least one symptom of burnout.[1] A meta-analysis found that the aggregate rates of suicide were 1.41–2.27 higher in physicians than that of the general population and found that workplace dissatisfaction and burnout were almost three times higher in practicing physicians compared to non-physicians.[2] The same meta-analysis demonstrated mental illness, likely linked to physician burnout, demonstrated a strong correlation to physician suicide.[2] The most commonly accepted definition of occupational burnout syndrome consists of three equally important domains: 1) emotional exhaustion 2) depersonalization, and 3) a perceived lack of personal accomplishment, which are components of the Maslach Burnout Inventory: Human Services Survey (MBI-HSS).[3] Absenteeism, personnel turnover, cynicism, emotional depletion, and decreased job satisfaction have all resulted from physician burnout and may have a negative impact on co-workers and patients.[4]

In 2004, Sargent et al. found that orthopaedic surgery residents reported higher rates of burnout compared to faculty, demonstrating higher rates of emotional exhaustion and depersonalization. In 2009, Sargent et al. surveyed 384 residents and 264 faculty at orthopaedic surgery residency programs using the MBI-HSS.[5] It was found that roughly 30% of residents and faculty showed high levels of emotional exhaustion and more than half of residents and a quarter of faculty showed high levels of depersonalization.

Burnout affects anesthesiologists as well. In the same 2012 national study, nearly half of the 309 anesthesiologists who responded to the survey also experienced burnout, only slightly lower than the fraction of orthopaedic surgeons.[1] In a 2013 national study of 1,508 United States anesthesiology residents, high burnout risk was found in 41%. Residents who were at high risk of burnout and depression also reported more medical errors, more mistakes resulting in negative consequences for patients, and less vigilance in patient monitoring.[6]

Lifestyle differences are evident between orthopaedic surgeons and anesthesiologists. Based on the 2017 Medscape Physician Compensation Report, the average annual salary for orthopaedic surgeons and anesthesiologists are $489,000 and $364,000.[7] Anesthesiologists work on average 43–55 hours per week and take call 1.5 nights per week.[7] In 2011, Balch et al. studied 155 private practice and academic orthopaedic surgeons and found that they averaged 51.1 work hours per week and 1.8 nights on call per week, with a career satisfaction rate of 80%.[8]

The purpose of this study is to determine if there is a significant difference in burnout rates among orthopaedic surgery and anesthesiology residents and faculty overall, and between residents and faculty in each specialty. Based on previous studies, we expect burnout rates between specialties to be similar and expect residents to have higher rates of burnout. While burnout at one point in time among these groups has been studied and published in the past using the MBI-HSS survey, no study to our knowledge has directly compared these groups.

Methods and Statistical Analysis

Rights to use the validated Maslach Burnout Inventory: Human Services Survey (MBI-HSS) were purchased and permission to perform this study was obtained from our Institutional Review Board. A cross-sectional online survey was distributed during the spring and summer of 2017 to orthopaedic surgery and anesthesiology residents and attending physicians from various urban academic programs in the northeastern United States. The survey, consisting of 42 questions, included the MBI-HSS survey plus additional questions examining potential indicators of burnout such as sociodemographic and work stressors. A total of 228 surveys were collected from orthopaedic surgery attendings (29), orthopaedic surgery residents (61), anesthesia residents (63), and anesthesia attendings (75). Responses were collected via an online survey tool and responses were completely anonymous.

Statistical analysis was performed by the Temple Clinical Research Institute Department of Clinical Sciences. The dependent variable was professional burnout, measured by three subscales of the Maslach Burnout Inventory survey. Degrees of burnout (low, average, and high) have been used frequently in the literature to compare and contrast burnout among different groups. The cut off values in Table 1 [from the Third Edition of the *Maslach Burnout Inventory Manual,* Maslach et al. (1996)] are typically cited in the literature as representative of low, average, and high degrees of burnout.

High levels of depersonalization and emotional exhaustion or low scores on personal accomplishment indicated professional burnout. Statistical analyses as categorical variables of the individual question data was performed as well as a statistical analysis of continuous variables of the three core scales relating to the burnout syndrome — Emotional Exhaustion, Depersonalization, and Personal Accomplishment. A statistical analysis of categorical variables regarding the degree of burnout associated with the three core aspects of burnout syndrome was also performed. Lastly, a univariable analyses of Emotional Exhaustion, Depersonalization, and Personal Accomplishment scores based on the partitions created by the responses to Question 25 through Question 41 was performed.

Scores for each of the three core scales were partitioned into low, average, or high categories based on the criteria for each scale (Table 1). The resulting categorical data was assessed using the Chi-Square test (or the Fisher's exact test as appropriate) for each score for each of the three respondent partitionings. Question 39 identified respondents as either orthopaedic surgery attendings (29), orthopaedic surgery residents (61), anesthesiology residents (63), or anesthesiology attendings (75).

Derived scores for the three core scales of burnout syndrome (Emotional Exhaustion, Depersonalization, and Personal Accomplishment) were assessed using non-parametric methods. For this study, the Wilcoxon test was used if two groups were compared and the Kruskal-Wallis test was used if three or more groups were compared. Based on statistical analysis, the results of the study were found to have a non-normal distribution based on three tests of normality.

A univariable analysis of the three core scales of burnout was created using responses to Questions 25 through 41 using the Kruskal-Wallis and Wilcoxon tests as described above. The data was cleaned as respondent 135 responded six (i.e., 'Every day') to all 23 burnout questions and identified him or herself as both an anesthesia resident and attending in separate responses. In addition, two respondents seemed to have made "fat finger errors" on Q41 of the survey, in which they identified themselves as residents but responded that they had been practicing for 1–5 years as attendings. These respondents answered all other questions in the survey as residents consistently.

For selected questions, alternative data sets creating a derived response were created excluding responses of "prefer not to answer" and for those who "did not take any call" in Questions 31–33. These alternative data sets were created such that only informative answers were analyzed.

Table 1. Maslach Burnout Inventory: Human Services Survey (MBI-HSS)

Core Scale	Low	Average	High	Directional Interpretation
Emotional Exhaustion	≤18	19–26	≥27	Higher score suggests higher burnout
Depersonalization	≤5	6–9	≥10	Higher score suggests higher burnout
Personal Accomplishment	≥40	39–34	≤33	Lower score suggests higher burnout

Results

The Survey Response rate was 238/666 = 38% response rate. As compared to attendings, residents scored worse on Emotional Exhaustion (M 21.50 vs 24.00, SE 1.25 vs 1.06, p = 0.1075); worse on Depersonalization (M 6.0 vs 10.5, SE .64 vs .63, p < .0001); and worse on Personal Accomplishment (M 41.0 vs 38.0, SE .59 vs .63, p = 0.0051) (Table 2). For Emotional Exhaustion, orthopaedic surgery scored better compared to anesthesiology (M 20.0 vs 24.5, SE 1.19 vs 1.07, p = 0.0181). On Depersonalization, anesthesiology scored better than orthopaedic surgery (M 9.5 vs 7.5, SE .73 vs .60, p = 0.0867). On Personal Accomplishment, orthopaedic surgery scored better as compared with anesthesiology (M 42.0 vs 38.5, SE .67 vs .58, p = 0.0117) (Table 3). It was also discovered that orthopaedic surgeons overall have more social events, residents take more overnight call (higher rates of burnout), more anesthesiologists are married (81.5 vs 69.5, p = 0.0365, higher rates of burnout), more anesthesiologists take in-house call (higher rates of burnout), and more residents have mentors (higher rates of burnout).

Inspecting levels of burnout partitioned by role, we found a similar trend, particularly with regard to Depersonalization and Personal Accomplishment, with residents showing increased rates of "high" burnout (Depersonalization 54.8% vs 34.6%, p = 0.0012, Personal Accomplishment 24.2% vs 13.5%, p = .0317). Regarding specialty, orthopaedic surgery scored significantly better in Emotional Exhaustion and better in Personal Accomplishment (Emotional Exhaustion 30.0% vs 44.2%, p = 0.0371, Personal Accomplishment 14.4% vs 22.5%, p = .0068) (Table 4).

Univariable analysis results demonstrated many statistically significant findings with results reported for those that the authors felt were most revealing. Regarding gender, (Q25 alt, excluding those who "prefer not to respond") male respondents had higher median Personal Accomplishment scores (suggesting lower burnout) as compared with female respondents (p = 0.0446). Regarding partnerships, respondents in a partnership had lower median Depersonalization scores (suggesting lower burnout) as compared with respondents in that are not in a partnership (p = 0.0400). For the revised response data (Q29 alt), having fewer social events was associated with higher Emotional Exhaustion scores (p = 0.0364, suggesting higher burnout) and was associated with lower Personal Accomplishment (p = 0.0066), suggesting higher burnout).

When only considering respondents that take call (Q31 alt), respondents for whom a majority (greater than 50%) of their call was home call (defined as not required to physically remain in the hospital at all times) had a higher median Personal Accomplishment scores (suggesting lower burnout) as compared with respondents for whom a majority of their call was in-house call (p = 0.0163). A derived response data set was imputed from Q31, Q32, and Q33 identifying whether the respondent takes or does not take any call. Based on this derived data set, respondents that did not take call had lower median Emotional Exhaustion and Depersonalization scores (suggesting lower burnout) as compared with respondents that do take call (p = 0.0188 and 0.0148, respectively).

In regards to having a mentor, respondents who had a mentor (Q35) had higher Depersonalization scores (suggesting higher burnout) and lower Personal Accomplishment scores (suggesting higher burnout) as compared with those who had no mentor (p < 0.0001 and 0.0185, respectively). However, regarding the reported agreement relative to the benefits of having a mentor (Q35 alt), statistically significant

Table 2. Summary Statistics and Testing of Three Core Scales Partitioning by Role

Core Scale	N	Mean	StdDev	StdErr	Min	Q1	Median	Q3	Max	p-Value	Method
Emotional Exhaustion										0.1074	Wilcoxon
Attending	104	22.69	12.72	1.25	0.00	12.50	21.50	31.00	54.00		
Resident	124	25.06	11.79	1.06	0.00	17.00	24.00	33.00	52.00		
Depersonalization										<.0001	Wilcoxon
Attending	104	8.08	6.57	0.64	0.00	3.00	6.00	12.00	30.00		
Resident	124	11.68	7.00	0.63	0.00	6.00	10.50	16.50	29.00		
Personal Accomplishment										0.0051	Wilcoxon
Attending	104	40.22	6.04	0.59	18.00	36.50	41.00	45.00	48.00		
Resident	124	37.73	6.98	0.63	11.00	34.00	38.00	43.00	48.00		

Table 3. Summary Statistics and Testing of Three Core Scales Partitioning by Specialty

Core Scale	N	Mean	StdDev	StdErr	Min	Q1	Median	Q3	Max	p-Value	Method
Emotional Exhaustion										0.0181	Wilcoxon
Orthopaedic surgery	90	21.52	11.34	1.19	0.00	14.00	20.00	30.00	50.00		
Anesthesiology	138	25.58	12.60	1.07	0.00	16.00	24.50	34.00	54.00		
Depersonalization										0.0867	Wilcoxon
Orthopaedic surgery	90	10.92	6.93	0.73	0.00	6.00	9.50	16.00	25.00		
Anesthesiology	138	9.46	7.05	0.60	0.00	4.00	7.50	14.00	30.00		
Personal Accomplishment										0.0117	Wilcoxon
Orthopaedic surgery	90	40.08	6.40	0.67	17.00	36.00	42.00	45.00	48.00		
Anesthesiology	138	38.08	6.76	0.58	11.00	34.00	38.50	43.00	48.00		

Table 4. Degree of Burnout, Four-Way Partitioning, Summary Statistics

Scale	Low	Average	High	Total	p-Value	Test Method
Degree of Burnout — Emotional Exhaustion					0.0325	Chi Square
Orthopaedic surgery attending	15 (51.7%)	8 (27.6%)	6 (20.7%)	29 (100.0%)		
Orthopaedic surgery resident	25 (41.0%)	15 (24.6%)	21 (34.4%)	61 (100.0%)		
Anesthesiology attending	28 (37.3%)	16 (21.3%)	31 (41.3%)	75 (100.0%)		
Anesthesiology resident	12 (19.0%)	21 (33.3%)	30 (47.6%)	63 (100.0%)		
Total	80 (35.1%)	60 (26.3%)	88 (38.6%)	228 (100.0%)		
Degree of Burnout — Depersonalization					0.0252	Chi Square
Orthopaedic surgery attending	11 (37.9%)	7 (24.1%)	11 (37.9%)	29 (100.0%)		
Orthopaedic surgery resident	11 (18.0%)	16 (26.2%)	34 (55.7%)	61 (100.0%)		
Anesthesiology attending	33 (44.0%)	17 (22.7%)	25 (33.3%)	75 (100.0%)		
Anesthesiology resident	15 (23.8%)	14 (22.2%)	34 (54.0%)	63 (100.0%)		
Total	70 (30.7%)	54 (23.7%)	104 (45.6%)	228 (100.0%)		
Degree of Burnout — Personal Accomplishment					0.0008	Chi Square
Orthopaedic surgery attending	21 (72.4%)	5 (17.2%)	3 (10.3%)	29 (100.0%)		
Orthopaedic surgery resident	38 (62.3%)	13 (21.3%)	10 (16.4%)	61 (100.0%)		
Anesthesiology attending	43 (57.3%)	21 (28.0%)	11 (14.7%)	75 (100.0%)		
Anesthesiology resident	18 (28.6%)	25 (39.7%)	20 (31.7%)	63 (100.0%)		
Total	120 (52.6%)	64 (28.1%)	44 (19.3%)	228 (100.0%)		

associations between agreement and scores were observed. Those respondents who strongly agreed or agreed that having a mentor benefitted them had lower median Emotional Exhaustion scores, lower median Depersonalization scores, and higher median Personal Accomplishment scores ($p = 0.0487$, $p = 0.0195$, and $p = 0.0002$, respectively for each score, based on an overall comparison of all five levels).

There was a statistically significant association between Emotional Exhaustion and exercise (Q37) ($p = 0.0389$), in which those exercising the least had the highest burnout and those exercising the most had the lowest burnout. Regarding sleep (Q38), there was a statistically significant association between Emotional Exhaustion and sleep ($p = 0.0040$) where those sleeping the least had the highest burnout and those sleeping the most had the lowest burnout. For Depersonalization and sleep, the association approached statistical significance ($p = 0.0600$), in which those sleeping the least had the highest burnout and those sleeping the most had the lowest burnout. Those sleeping less than five hours had the highest burnout.

Looking at years of practice for attendings only (Q41 alt), there is a statistically significant association between years of practice and Depersonalization scores ($p = 0.0414$). Based on these data, attendings with more than 30 years of practice have lower Depersonalization scores, suggesting lower burnout rates.

Discussion

Results of our study demonstrated that overall, residents experience higher rates of burnout than attendings in both orthopaedic surgery and anesthesiology, which is consistent with previous findings. However, our results suggest that anesthesiology residents and attendings experience higher levels of burnout when directly compared to their orthopaedic surgery counterparts, which is inconsistent with previous studies and surprising.[1] This challenges the common belief that surgical specialties carry a higher prevalence of burnout due to increased hours and a more stringent call schedule. A 2011 study of 384 orthopaedic surgery residents and 264 full-time orthopaedic surgery faculty reported residents work an average of 74.2 ± 20.2 hours per week and faculty 62.8 ± 18.2 hours per week.[9] This is compared to a 2013 study which found that 76% of anesthesiology residents work less than 70 hours a week and 24% work more than 70 hours per week. The same study found that 56% of anesthesiology residents have less than five days between calls while 44% have more than five days between calls.[10] An important difference between specialties that was found to directly correlate with physician burnout is number of social events per year. Orthopaedic surgery was found to have significantly more social events and overall lower rates of physician burnout.

Socialization outside of work settings helps promote teamwork and comradery. This strategy of teambuilding and morale-boosting events outside of the work setting has been utilized and found to be effective in the financial and corporate world. Results of the study indicated an inverse correlation between number of social events and burnout based on the three core values. One possibility for the observed difference in number of social events between orthopaedic surgeons is that more anesthesiologists were found to be married, which limits time outside of work to be spend with fellow colleagues due to the responsibilities inherent to partnership and family. Married orthopaedic surgery residents who had higher Revised Dyadic Adjustment Scale scores had a greater sense of personal achievement, while married faculty with higher scores was strongly associated with lower emotional exhaustion, lower depersonalization, and higher personal achievement.[7] A 2012 study comparing burnout and satisfaction with work-life balance of 7,288 US physicians and 3,442 working United States adults found that being married was associated with a lower overall risk of burnout.[1]

Another possibility is that orthopaedic surgeons tend to come from background of competitive sport where teamwork and the understanding of the importance of supporting one's associate is imperative to success. Social events focused around team-building activities should be a regular occurrence among residency departments and must involve both residents and attendings, so that the whole department feels engaged in efforts to build relationships and bonds that can be carried over into the workplace. These building blocks, forged away from the familiar hospital setting, can develop relationships that can act as pillars of support and strength should a physician experience the symptoms of burnout. Closer relationships with colleagues may help an attending or resident physician seek help before symptoms severely impact patient care and one's mental health.

Findings of our study highlight that mere involvement in a mentor-mentee relationship does not protect against symptoms of burnout. More residents have a mentor, but experience higher levels of burnout than attendings in both orthopaedic surgery and anesthesiology. However, regarding the reported agreement relative to the benefits of having a mentor, statistically significant associations between agreement and scores were observed. Those respondents who strongly agreed or agreed that having a mentor benefitted them had lower overall rates of burnout than those who disagreed and strongly disagreed. In a study of 384 orthopaedic surgery residents, Sargent et al. found that 60% reported having at least one mentor. Levels of emotional exhaustion decreased and personal achievement increased as the frequency of contact between mentor and mentee increased.[9] Higher personal achievement, lower emotional exhaustion, and lower depersonalization scores were also found in those who reported it helpful to speak with their mentors.[7]

Often times, mentors are assigned to a resident when they begin residency randomly with no prior relationship between the two. In order to create more valuable mentor-mentee relationships, care must be taken to provide mentees with mentors that are an optimal "fit." If attendings and residents can socialize and familiarize themselves with one another to establish relationships ahead of time, this can be achieved. Random pairing of mentors to mentees can lead to this relationship being suboptimal due to differences in personalities, professional and personal interests, and the parities' overall interest in a mentor-mentee relationship.

One suggestion to help foster this important relationship is to have residents seek out attendings who they would like to have as a mentor based on an already established relationship. This way residents can choose whether or not they would like a mentor at all. If so, they can select a relationship which they feel will help them grow personally and professionally. Those who may feel this relationship has no benefit can save themselves the time and strain associated with a mentor that they did not choose, or has little interest in truly being a mentor. One study of a radiology residency program found that residents having self-selected their mentors were significantly more likely to consider their faculty mentor as their primary mentor than those with assigned mentors. They also reported significantly higher satisfaction with the mentoring program than those with an assigned mentor.[10] Another study of an emergency medicine residency program concluded that an individual's active participation in mentor selection can yield better outcomes, as 44% of residents thought shared academic interest and 44% thought a comfortable personal dynamic were most important to a successful mentor-mentee match. In this program, at the end of intern year, residents provided a list of three possible mentors for the remainder of training and were assigned one of those mentors.[11]

There are several weaknesses inherent in our study. One weakness is that the surveys were collected during a single time point during the spring and summer months in the northeastern United States. Temporal and seasonal difference may impact survey results, as rates of seasonal depression peak in the winter. We only polled physicians in large urban medical centers. Opportunity for future studies include redistributing surveys over the course of a year (winter vs summer) to find if seasonal changes may affect the outcomes. Studies could compare burnout rates with nonperioperative specialties with mostly daytime hours and thus no overnight calls and patients without critical illnesses. Comparing rural and urban centers and different areas of the country can give insight to the potential effects of demographic factors. Given our findings about the impact of social events, studies could explore the details about the types of social events, frequency, quality, etc., that could potentially impact burnout rates.

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Original Research

Opioid Prescription Trends in Orthopaedic Shoulder Surgery Before and After Initiation of a Statewide Registry

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Abstract

The purpose of this paper was to examine the effect of a statewide prescription drug monitoring program (PDMP) on opioid prescribing patterns within the context of elective orthopaedic shoulder surgery at a Pennsylvania academic hospital in an urban setting. A total of 425 patients (18 years or older) who had undergone shoulder arthroscopy, arthroscopic rotator cuff repair, and arthroscopic labral repair between January 1, 2015 and July 31, 2017 were included in this study with data collected on patient age, medical comorbidities, post-operative complications, insurance type, opioid naivety, the amount and type of pain medication prescribed post-operatively for a period of six months, and the prescriber. Statistical tests including Student t-tests, Wilcoxon-Mann-Whitney, Chi-Square, Fisher's Exact, Kruskal-Wallis, as well as two-way and multivariable ANOVA were performed by our statistician to compare variables between patients before (N = 215) and after (N = 181) statewide implementation of the PDMP, as well as six months later. We also sought to determine what specific factors were associated with greater amounts of opioid prescriptions. There was no difference in opioid prescription rates before and after implementation of the statewide drug monitoring program in this study. Through use of multivariate analysis, this study did demonstrate a number of factors that correlated with greater amounts of opioid prescriptions as measured in morphine equivalents. Specifically, the presence of a greater number of medical comorbidities, post-operative complications, Medicaid status, and the prescriber type was associated with higher numbers of total morphine equivalents prescribed for similar procedures.

Introduction

Opioid use and abuse with its resultant mortality has become an increasingly challenging problem in the United States. Between 1999–2016, the number of deaths related to opioids has increased fivefold, contributing to the deaths of over 350,000 Americans over that span.[1, 2] As these deaths have continued to rise, the rate of opioid prescriptions has risen in tandem, suggesting that opioid prescribing practices play a role in this epidemic.[1, 3, 4] The opioid epidemic is also a serious economic burden, as it has been shown that chronic opioid users constitute a much greater proportion of healthcare usage and related costs than their non-using counterparts.[5] As a result, there have been major efforts in the United States towards both understanding this problem, as well as how to combat it.

Prescription narcotics have been elucidated in recent years as contributing to the opioid epidemic. This may happen through diversion of unused pills to opioid abusers or through dependence on opioid medication when non-opioid medication may be as effective.[6, 7] These unused medications may be stolen or shared by relatives and friends for non-medically indicated purposes.[6, 8, 9]

To this end, one recent measure taken has been the establishment of state-wide prescription drug monitoring programs (PDMPs). These databases collect information on prescription opioids for individual patients received by any prescriber which is then posted online in a secure database.[10] This went into effect on August 25th, 2016 in the state of Pennsylvania, and has been implemented in the majority of states in the US.[11] The effect of these PDMPs has been a topic of research, with studies showing that their implementation is associated with both a reduction in opioid prescriptions as well as drug abuse in their respective states.[12–15] Being relatively recent, the understanding of how these PDMPs have affected prescribing patterns within specific specialties is still evolving. This is of importance to orthopaedic surgeons specifically as they are the third highest prescribers of opioids across all specialties.[16] The goal of this paper is to examine these effects within the context of elective orthopaedic shoulder surgery at an academic tertiary care urban Pennsylvania hospital.

Materials and Methods

A retrospective chart review was conducted on patients at Temple University Hospital under IRB approval #24691. Eligible patients were 18 years or older who had undergone treatment for the following procedures between January 1, 2015 and July 31, 2017: shoulder arthroscopy, arthroscopic rotator cuff repair, and arthroscopic labral repair. The following CPT codes were used to determine which patients

had undergone these procedures: 29827, 23472, 29807, 29805. Variables collected included patient age, medical comorbidities, post-operative complications, insurance type, opioid naivety, the amount and type of pain medication prescribed post-operatively for a period of 6 months, as well as the prescriber. Opioid prescriptions were converted into morphine milligram equivalents (MME) for ease of comparison. All data was collected in a de-identified secure database, taken from the hospitals online medical records program, Epic, as well as Pennsylvania's online prescription drug monitoring program (PDMP), accessible at pennsylvania.pmpaware.net/login.

A total of 425 patients were initially identified for study inclusion. A box-and-whisker plot analysis demonstrated three extreme outliers who were subsequently dropped from the data set to avoid bias. The resultant 422 patients were then divided into those whose prescriptions were given before the PDMP implementation on August 25th, 2016, and those after. Twenty-six patients whose 6-month post-operative prescriptions crossed over this date were excluded, leaving a total of 396 patients. There were 215 patients in the group who were prescribed opioids prior to the initiation of the statewide physician database, and 181 who were prescribed opioids after the initiation of the statewide physician database. Student T-tests, Wilcoxon-Mann-Whitney, Chi-Square, and Fisher's Exact tests were then performed to compare initial continuous and categorical variables, using a critical value of 0.05.

Median cumulative MME was then assessed based on partitioning by groups within selected comorbidities and clinical activities to identify possible associations using Wilcoxon-Mann-Whitney or Kruskal-Wallis tests. For binary variables, only those with at least 10 observations in each category were included.

Two-way and multivariate analyses were then performed to assess combined association of two or more variables relative to observed cumulative MME using logarithmic transformation of the data. The first two-way analysis examined the interaction between Group (Before/After PDMP), provider, and their interaction, while the second involved Group (Before/After PDMP), insurance, and their interaction using ANOVA.

Multivariable ANOVA was then performed to assess the cumulative and interactive effects of select variables regarding cumulative MME. Binary comorbidities and clinical parameters with less than 10 events were eliminated from analysis. One-way Anova was performed on the remaining categorical variables to determine inclusion. Categorical variables with significance of 0.15 or less were included. Model building included the interaction term "Group" (Before/After PDMP) for each variable. It was conducted using stepwise regression based on a significance level for entry of 0.35 and on a significance level to stay in the model of 0.05. The variable "Group" was forced into the model as this was the overall focus of the paper.

Patients were then divided into groups whose prescriptions fell before 6-months post-PDMP implementation (February 25th, 2017), and another whose prescriptions fell after this date. Twenty-eight patients whose 6-month post-operative prescriptions crossed over this date were excluded, leaving 307 patients before, and 87 patients after for a total of 394. The same set of analyses was subsequently performed. All statistical analyses were conducted through use of SAS® 9.4 (SAS Institute, Cary, NC).

Results

Summary Statistics of Select Continuous Variables

Mean age at surgery between before and after PDMP groups showed no difference (p = 0.5093). However, it was seen that there were significant differences between the groups in terms of median number of comorbidities (p = <.0001), total data duration by patient (p = 0.0134), as well as cumulative MME (p = 0.0018). All of these values were higher in the after PDMP group. Comparing the same variables between before 6-months post-PDMP and after showed no significant differences in age (p = 0.2722), total data duration by patient (p = 0.3867), or cumulative MME (p = 0.1423). The difference in number of comorbidities was statistically significant (p = <.0001), being higher in the after group (Tables 1–2).

Summary Statistics of Select Categorical Variables

Comparing categorical variables between the before and after PDMP groups demonstrated that they exhibited some significant baseline differences. For comorbidities, the patients in the after PDMP group had significantly higher anxiety/depression (p = 0.0089), chronic pain (p = 0.018), hypertension (p = 0.0093), diabetes (p = 0.0047), and prior

Table 1. Summary Statistics of Select Continuous Variables (Before/After PDMP)

Category	Before PDMP (Mean/Median Values)	After PDMP (Mean/Median Values)	Test	P-Value
Age at surgery	56.4	57.1	T-test	0.5093
# of comorbidities	1	2	Wilcoxon	<.0001
Total data duration by patient (days)	1	31	Wilcoxon	0.0134
Cumulative MME	675	945	Wilcoxon	0.0018

Table 2. Summary Statistics of Select Continuous Variables (Before/After 6-Months Post-PDMP)

Category	Before 6-Months Post-PDMP (Mean/Median Values)	After 6-Months Post-PDMP (Mean/Median Values)	Test	P-Value
Age at surgery	56.4	58	T-test	0.2722
# of comorbidities	1	2	Wilcoxon	<.0001
Total data duration by patient (days)	9	13	Wilcoxon	0.3867
Cumulative MME	675	855	Wilcoxon	0.1423

use of opioids (p = 0.0023). The groups did not differ on the usage of intra-operative nerve blocks (p = 0.4481), substance abuse (p = 0.1388), smoking (p = 0.1152), adhesive capsulitis (p = 0.3357), or fibromyalgia (p = 0.7376). Comparing the same variables between the before 6-months post-PDMP and after groups showed that they also differed on baseline characteristics. The after group had higher chronic pain (p = 0.0361), hypertension (p = 0.0019), diabetes (p = 0.021), and prior opioid use (p = 0.0076). The groups did not differ on anxiety/depression (p = 0.2163), usage of intra-operative nerve blocks (p = 0.3973), substance abuse (p = 0.3089), smoking (p = 0.775), adhesive capsulitis (p = 0.124), or fibromyalgia (p = 0.6525) (Tables 3–4).

Summary Statistics of Surgical Complications

Most surgical complications showed no significant differences between before and after PDMP groups including weakness (p = 0.5523), stiffness (p = 0.8103), infection (p = 1), and failure (p = 0.236). However, there was a significant difference in terms of pain (p = 0.0402), with higher pain outcomes in the before PDMP group. Pain (p = 0.3663), weakness (p = 1), stiffness (p = 0.4387), infection (p = 1), and failure (p = 0.3831) did not differ significantly between the before 6-months post-PDMP and after groups (Tables 5–6).

Testing of Cumulative MME by Selected Clinical Categorical Variables

Comparing the median MME values by looking at the presence or absence of certain categorical variables demonstrated that MME varied with certain factors. The presence of anxiety/depression (p = <.0001, p = <.0001), smoking (p = <.0001, p = <.0001), prior opioid use (p = <.0001, p = <.0001), hypertension (p = <.0001, p = <0.0003), and diabetes (p = <.0001, p = <0.0008) was associated with a statistically significant higher median MME in both sets of analyses. The presence of chronic pain was found to be statistically significant in terms of a higher median MME in the before/after PDMP data analysis (p = 0.0309), but not in the before/after 6-months post-PDMP data set (p = 0.0571). Intra-operative nerve blocks (p = 0.3079, p = 0.499) and substance abuse (p = 0.1344, p = 0.1269) did not demonstrate a significant difference in either set of analyses (Tables 7–8).

Testing of Cumulative MME by Surgical Complications

The surgical complications pain (p = 0.2532, p = 0.0897), weakness (p = 0.7023, p = 0.9909), stiffness (p = 0.1474, p = 0.0588), and failure (p = 0.6035, p = 9357), did not demonstrate an association with MME values in either set of analyses (Tables 9–10).

Two-Way Analyses of Group and Provider on MME

Tables 11–12 depict the percentages of patients that were prescribed opioids before/after the PDMP, and before/after 6-months post-PDMP, by specific providers, as well as the total median and median MME values by group. Providers B, K, and S are orthopedic surgeons at Temple University Hospital while P is all other providers. Upon two-way analyses of the interaction between Group (Before/After PDMP) and provider, it was found that the interaction among the two was not significant (p = 0.094, R-square = 0.111983). When

Table 3. Summary Statistics of Select Categorical Variables (Before/After PDMP)

Category	Yes (Before PDMP)	No (Before PDMP)	Yes (After PDMP)	No (After PDMP)	Test	P-Value
Opiod naïve	91	124	50	131	Chi Square	0.0023
Intra-op nerve block	186	21	163	14	Chi Square	0.4481
Anxiety/depression	35	180	49	132	Chi Square	0.0089
Substance abuse	4	211	8	173	Chi Square	0.1388
Smoker	29	186	35	146	Chi Square	0.1152
Adhesive capsulitis	1	214	3	178	Fisher's Exact	0.3357
Chronic pain	7	208	16	165	Chi Square	0.018
Fibromyalgia	4	211	5	176	Fisher's Exact	0.7376
Hypertension	79	136	90	91	Chi Square	0.0093
Diabetes	23	192	38	143	Chi Square	0.0047

Table 4. Summary Statistics of Select Categorical Variables (Before/After 6-Months Post-PDMP)

Category	Yes (Before 6-Months Post-PDMP)	No (Before 6-Months Post-PDMP)	Yes (After 6-Months Post-PDMP)	No (After 6-Months Post-PDMP)	Test	P-Value
Opiod naïve	122	185	21	66	Chi Square	0.0076
Intra-op nerve block	267	30	79	6	Chi Square	0.3973
Anxiety/depression	59	248	22	65	Chi Square	0.2163
Substance abuse	8	299	4	83	Fisher's Exact	0.3089
Smoker	49	258	15	72	Chi Square	0.775
Adhesive capsulitis	1	306	2	85	Fisher's Exact	0.124
Chronic pain	13	294	9	78	Fisher's Exact	0.0361
Fibromyalgia	5	302	2	85	Fisher's Exact	0.6525
Hypertension	119	188	50	37	Chi Square	0.0019
Diabetes	37	270	19	68	Chi Square	0.021

Table 5. Surgical Complications (Before/After PDMP)

Category	Yes (Before PDMP)	No (Before PDMP)	Yes (After PDMP)	No (After PDMP)	Test	P-Value
Pain	44	171	23	158	Chi Square	0.0402
Weakness	11	204	7	174	Chi Square	0.5523
Stiffness	21	194	19	162	Chi Square	0.8103
Infection	1	214	0	181	Fisher's Exact	1
Failure	11	204	5	176	Chi Square	0.236

Table 6. Surgical Complications (Before/After 6-Months Post-PDMP)

Category	Yes (Before 6-Months Post-PDMP)	No (Before 6-Months Post-PDMP)	Yes (After 6-Months Post-PDMP)	No (After 6-Months Post-PDMP)	Test	P-Value
Pain	55	252	12	75	Chi Square	0.3663
Weakness	15	292	4	83	Fisher's Exact	1
Stiffness	30	277	11	76	Chi Square	0.4387
Infection	1	306	0	87	Fisher's Exact	1
Failure	15	292	2	85	Fisher's Exact	0.3831

Table 7. Testing of Cumulative MME by Selected Clinical Categorical Parameters (Before/After PDMP)

Category	Yes (Median MME)	No (Median MME)	Test	P-Value
Opiod naïve	488 (N = 141)	945 (N = 255)	Wilcoxon	<.0001
Intra-op nerve block	750 (N = 349)	530 (N = 35)	Wilcoxon	0.3079
Anxiety/depression	1410 (N = 84)	675 (N = 312)	Wilcoxon	<.0001
Substance abuse	1556 (N = 12)	683 (N = 384)	Wilcoxon	0.1344
Smoker	1350 (N = 64)	675 (N = 332)	Wilcoxon	<.0001
Chronic pain	1350 (N = 23)	675 (N = 373)	Wilcoxon	0.0309
Hypertension	975 (N = 169)	675 (N = 227)	Wilcoxon	<.0001
Diabetes	1395 (N = 61)	675 (N = 335)	Wilcoxon	<.0001

Table 8. Testing of Cumulative MME by Selected Clinical Categorical Parameters (Before/After 6-Months Post-PDMP)

Category	Yes (Median MME)	No (Median MME)	Test	P-Value
Opiod naïve	525 (N = 143)	945 (N = 251)	Wilcoxon	<.0001
Intra-op nerve block	750 (N = 346)	565 (N = 36)	Wilcoxon	0.499
Anxiety/depression	1388 (N = 81)	675 (N = 313)	Wilcoxon	<.0001
Substance abuse	1556 (N = 12)	675 (N = 382)	Wilcoxon	0.1269
Smoker	1350 (N = 64)	675 (N = 330)	Wilcoxon	<.0001
Chronic pain	1313 (N = 22)	675 (N = 372)	Wilcoxon	0.0571
Hypertension	938 (N = 169)	675 (N = 225)	Wilcoxon	0.0003
Diabetes	1365 (N = 56)	675 (N = 338)	Wilcoxon	0.0008

Table 9. Testing of Cumulative MME by Surgical Complications (Before/After PDMP)

Category	Yes (Median MME)	No (Median MME)	Test	P-Value
Pain	900 (N = 67)	675 (N = 329)	Wilcoxon	0.2532
Weakness	713 (N = 18)	750 (N = 378)	Wilcoxon	0.7023
Stiffness	1230 (N = 40)	675 (N = 356)	Wilcoxon	0.1474
Failure	1163 (N = 16)	720 (N = 380)	Wilcoxon	0.6035

Table 10. Testing of Cumulative MME by Surgical Complications (Before/After 6-Months Post-PDMP)

Category	Yes (Median MME)	No (Median MME)	Test	P-Value
Pain	975 (N = 67)	675 (N = 327)	Wilcoxon	0.0897
Weakness	750 (N = 19)	690 (N = 375)	Wilcoxon	0.9909
Stiffness	1350 (N = 41)	675 (N = 353)	Wilcoxon	0.0588
Failure	975 (N = 17)	690 (N = 377)	Wilcoxon	0.9357

they were considered as independent terms, it was found that the provider's effect on MME was statistically significant ($p < 0.0001$) while Group (Before/After PDMP) was not ($p = 0.869$), (R-square = 0.097243). Upon two-way analyses of the interaction between Group (Before/After 6-months post-PDMP) and provider, it was found that the interaction among the two was significant ($p = 0.025$, R-square = 0.133695) (Tables 11–12).

Two-Way Analyses of Group and Insurance on MME

Tables 13–14 depict the percentages of patients that fell into each insurance type before/after the PDMP, and before/after 6-months post-PDMP, as well as the total median and median MME values by group. Upon two-way analyses of the interaction between Group (Before/After PDMP) and insurance, it was found that the interaction among the two was not significant ($p = 0.112$, R-square = 0.076399). When considered as independent terms, it was found that both Group (Before/After PDMP) and insurance were significant ($p = 0.0259$ and 0.0013, respectively), (R-square = 0.058263). Upon two-way analyses of the interaction between Group (Before/After 6-months post-PDMP) and insurance, it was found that the interaction among the two was not significant ($p = 0.118$, R-square = 0.083927). When

Table 11. Provider Types and Cumulative MME (Before/After PDMP)

Provider	Before PDMP	After PDMP	Median MME Before	Median MME After	Median MME Total
B	26 (12.1%)	93 (51.4%)	1028	1125	1125
K	86 (40.0%)	23 (12.7%)	490	450	450
P	8 (3.7%)	10 (5.5%)	3323	2925	3323
S	95 (44.2%)	55 (30.4%)	525	623	525

Table 12. Provider Types and Cumulative MME (Before/After 6-Months Post-PDMP)

Provider	Before 6-Months Post-PDMP	After 6-Months Post-PDMP	Median MME Before	Median MME After	Median MME Total
B	68 (22.1%)	51 (58.6%)	1215	1080	1125
K	104 (33.9%)	7 (8.0%)	450	450	450
P	15 (4.9%)	3 (3.4%)	3645	425	3510
S	120 (39.1%)	26 (29.9%)	525	656	525

considered as independent terms, it was found that Group (Before/After 6-months post-PDMP) was not significant (p = 0.743), but that insurance type was significant (p = <0.0001), (R-square = 0.066129) (Tables 13–14).

Multivariable Analyses

The variables included in the multivariable model for the analysis of the before and after PDMP groups included Group (Before/After PDMP), medical provider, prior opioid use, hypertension, diabetes, anxiety/depression, smoking, and fibromyalgia. The analysis demonstrated that all of these factors, except for Group (Before/After PMDP), had a significant impact on median MME (p = 0.0004, p = 0.0005, p = 0.0178, p = 0.0480, p = 0.0106, p = 0.0008, p = 0.0053, respectively). Group (Before/After PDMP) was found not to be significant (p = 0.3703, R-square = 0.234).

The variables included in the multivariable model for the analysis of the before 6-months post-PDMP and after groups included Group (Before/After 6-months post-PDMP), medical provider, prior opioid use, post-surgical pain, diabetes, anxiety/depression, and smoking. The analysis demonstrated that all of these factors, except Group (Before/After 6-months post-PDMP), had a significant impact on median MME (p = <.0001, p = 0.0004, p = 0.0206, p = 0.0290, p = 0.0019, p = 0.0012, respectively). Group (Before/After 6-months post-PDMP) was found not to be significant (p = 0.167, R-square = 0.225891).

Discussion

Pennsylvania's prescription drug monitoring program (PDMP) was implemented on August 25th, 2016. Its implementation included the mandate that all prescribers of opioids and other Schedule II–IV medications query the PDMP upon initial prescription, as well as when there is suspicion of addiction or diversion activity.[17, 18] Such regulations exhibit great variability among states with PDMPs.[11] Studies looking into how PDMPs affect opioid prescriptions at a statewide level have shown that specific mandates are critical for having an impact.[12, 19, 20] For instance, Haffajee et al. (2018) found that in Kentucky, New Mexico, and Tennessee, the implementation of mandates requiring features like prescriber use, registration, access by delegates, consistent information updates, administrative capacity, and simple user interfaces was particularly important for reducing opioid prescriptions in adults with commercial insurance.[12]

In our study, we initially found that in the six months after implementation of Pennsylvania's PDMP, there was a statistically significant increase in the quantity of opioid prescriptions. However, the populations of patients that were com-

Table 13. Insurance Types and Cumulative MME (Before/After PDMP)

Insurance	Before PDMP	After PDMP	Median MME Before	Median MME After	Median MME Total
Private	88 (41.1%)	73 (40.6%)	506	675	675
Medicare	50 (23.4%)	33 (18.3%)	675	1013	825
Medicaid	51 (23.8%)	54 (30%)	1200	1335	1200
Workers Comp	21 (9.8%)	15 (8.3%)	600	675	656
Other	4 (1.9%)	5 (2.8%)	675	675	675

Table 14. Insurance Types and Cumulative MME (Before/After 6-Months Post-PDMP)

Insurance	Before 6-Months Post-PDMP	After 6-Months Post-PDMP	Median MME Before	Median MME After	Median MME Total
Private	124 (40.7%)	32 (36.8%)	525	675	675
Medicare	67 (22.0%)	16 (18.4%)	780	994	825
Medicaid	79 (25.9%)	28 (32.2%)	1350	945	1230
Workers Comp	29 (9.5%)	8 (9.2%)	600	675	675
Other	6 (2.0%)	3 (3.4%)	469	675	675

pared before and after demonstrated a variety of baseline differences, including factors like anxiety and depression, chronic pain, hypertension, diabetes, prior opioid exposure, and post-surgical pain. When some of these factors and others, including prior opioid use, medical provider, hypertension, diabetes, anxiety/depression, smoking, and fibromyalgia, were controlled with multivariable analyses, it was found that there was in fact, no significant difference in opioid prescriptions before and after the PDMP. Similar results were found when looking six months out. While these results appear to contradict what has been found at a statewide level, there has been minimal research into how specific specialties have responded to PDMPs, especially orthopaedic surgery. Studies examining the impact of PDMPs on opioid prescriptions in other specialties have shown mixed effects.[21, 22]

The results of our study also demonstrated that a number of factors were associated with higher values of MME such as prior opioid exposure, anxiety/depression, smoking, hypertension, diabetes, chronic pain, fibromyalgia, and post-surgical pain. These results are not unlike other studies that have examined risk factors associated with higher opioid prescription rates. Factors such as opioid naiveté, tobacco use, substance abuse, anxiety/depression, preoperative pain, and arthritis, among others, are well documented associations.[23–26] Interestingly, our results demonstrated that intra-operative nerve blocks were not associated with a difference in MME. This is a topic of interest in a number of fields, especially in orthopaedic surgery, as there is evidence that intra-operative nerve blocks are associated with reductions in post-surgical opioid usage.[27]

The effects of specific insurance and provider types on MME were also examined. In our two-way analyses, it was found that insurance type as an independent term displayed a significant association with MME. In Tables 13–14, it is evident that patients on Medicaid displayed the highest total median MME values, with the only exception being 6-months post-implementation when Medicare became higher and Medicaid decreased. In a study looking into opioid consumption patterns following upper-extremity surgery, Kim et al. (2016) similarly found that patients with self-pay or Medicaid had the highest consumption of opioids. Yet this was followed by Workers' Compensation, private insurance, and Medicare in their study, while Medicare and Medicaid were consistently highest in ours.[28] Provider types did demonstrate statistically significant associations with MME values, but with provider P encompassing a great variety of physicians, it is difficult to draw general conclusions. This is likely a topic for further research.

Some limitations of our study included that we only examined a specific subset of patients undergoing orthopaedic procedures at Temple University Hospital. Another is that there were significant baseline differences between our patient groups. While multivariable analyses were helpful for this, our models did not explain the full degree of variance in the data, and thus there were likely other unmeasured factors making contributions. Finally, in several instances, there were a small number of observations for specific variables that limited the stability of our models. This was evident in the period after six months post-PDMP, where there were only three observations in both the provider "P" category, and the "Other" insurance category.

Conclusion

Ultimately, our study was unable to show a difference in opioid prescriptions in a subset of patients undergoing orthopaedic shoulder procedures at an academic hospital in an urban setting before and after implementation of Pennsylvania's PDMP. Comorbid factors, insurance types, and prescriber types demonstrated significant associations with cumulative MME, but with multivariable analysis, it was shown that our independent variables did not explain the entirety of variance in the data. Future studies should aim to look more broadly at the field of orthopaedics and see how it has responded to PDMPs across the country, especially comparing regions based on patient population. The patient population at Temple University Hospital is reflective of its North Philadelphia location which is one of the most economically disadvantaged in the city, and interestingly, a recent study showed that PDMPs have a significantly decreased impact on areas that have below national median wages.[19, 29] Finally, it is clear that more work needs to be done examining how the associated factors we have demonstrated, as well as many other studies, should inform physicians on prescribing patterns and how they can minimize opioid over-prescription in the future.

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Original Research

Total Hip Arthroplasty Versus Hemiarthroplasty for Displaced Femoral Neck Fractures: An Analysis of Usage Rates, Demographics, and Complication Rates Using a National Database

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Abstract

The purpose of this study was to compare hemiarthroplasty and total hip arthroplasty (THA) for the treatment of displaced femoral neck fractures. Using the Nationwide Inpatient Sample for 2002–2015 (Quarter 3), the usage rates, demographics, comorbidities, and complication rates were compared between patients who underwent either of these two procedures. THA patients were younger on average (75.03 years versus 81.03 years), had higher rates of tobacco use (18.34% versus 13.66%), and had lower Charlson Comorbidity scores (1.14 versus 1.42). After controlling for differences in preoperative factors, THA was associated with clinically and statistically differences in risk for deep vein thrombosis (RR 6.89), dislocation (RR 4.96), blood transfusion (RR 1.22), hematoma (RR 1.34) and mortality (RR 0.64). THA had a statistically significant increased risk for any adverse event (RR 1.12). The proportion of THAs performed in this patient sample increased significantly over time in patients younger than 80 years old.

Level of Evidence: Therapeutic Level III.

Introduction

The incidence of geriatric hip fractures is increasing. In 2050, there is expected to be over six million hip fractures worldwide, up from 1.6 million in 2000.[1] It is predicted that over 500,000 adults in the U.S. over the age of 50 will incur a hip fracture in the year 2040.[2] This projection can be attributed to the growing proportion of the U.S. population that is 65 years or older, increasing life expectancy, and rising prevalence of osteoporosis.[1, 3, 4] The importance of identifying the optimal treatment for hip fractures is underscored by the risk of mortality, decrease in life expectancy, and considerable treatment-associated complications.[5] There is also a staggering financial burden associated with hip fractures. Hip fractures have an estimated annual health-care cost of at least $9.8 billion.[2] To the patient, lifetime attributable costs of a hip fracture can rise to over $82,000, with up to $20,000 due to hospital fees and much of the remainder of the costs directed toward post-discharge nursing services.[6, 7] Determining the best method to surgically treat hip fractures will result in a better quality of life for the patient, a lower individual financial burden, and reduced national health care costs.

While the optimal approach for managing non-displaced femoral neck fractures (Garden I and II) has been established, consensus for treatment of displaced femoral neck fractures (Garden III and IV) in the elderly has not yet been reached.[8] In the past, hemiarthroplasty (HA) was considered the preferred management option for displaced geriatric femoral neck fractures. Factors favoring HA include decreased operative time, blood loss, and dislocation rate, as well as ease of procedure and similar short-term outcomes compared to total hip arthroplasty (THA). Conversely, several prospective clinical trials and single center studies have demonstrated better clinical outcomes with THA, including improved pain, walking and function scores, as well as decreased revision rate.[9–13] However, other recent studies have results favoring HA over THA.[4, 14] Thus, the optimum treatment of displaced femoral neck fractures remains debated, and dependent on patient and surgeon factors.

Previous studies analyzing trends in treatment of the femoral neck fracture from 1990–2001 demonstrated a decrease in THA utilization[15] and Miller et al. concluded there to be little change in surgical treatment of FNF from 1991–2008 in Medicare patients.[16] Many studies have included adults with minor comorbidities or excluded patients based on payer, which prevents generalizability. By utilizing a national database, the patient cohort in this analysis will better represent the U.S. population, generating more broadly applicable results.

The purpose of this study is to use a large database to compare the relative morbidity, mortality and complication rates of HA and THA for the treatment of displaced femoral neck fractures to inform physician decision making. A secondary aim is to examine contemporary trends in usage of HA and THA based on age.

Methods

Database

A retrospective cohort study of patients with displaced femoral neck fractures that underwent a hip arthroplasty procedure during the years 2002 to 2015 (through Quarter 3) was performed using the National (Nationwide) Inpatient Sample (NIS). The NIS, developed under the Healthcare Cost and Utilization Project (HCUP), collects more than 300 data elements from over seven million hospital stays each year. In 2012, the NIS underwent a design change to improve national estimates. Prior to 2012, NIS was designed to include 100% discharge information from a sample of participating hospitals. Beginning in 2012, the NIS included data from a 20-percent stratified sample of discharges from every participating U.S. community hospital, excluding rehabilitation and long-term acute care hospitals.[17]

Patient Population

The patient cohorts were obtained by first identifying patients who underwent a single primary hip replacement procedure, total hip arthroplasty (ICD-9 code 81.51) and hemiarthroplasty (ICD-9 code 81.52), while excluding revision arthroplasty (ICD-9 codes 00.70, 00.71, 00.72, 00.73) and conversion hip arthroplasties as identified by the removal of hardware in addition to a THA or HA procedure (ICD-9 code 78.65). Next, cases corresponding to the diagnosis of femoral neck fractures (ICD-9 codes 820.1 and 820.0) were selected. Exclusion criteria included diagnosis of metastatic disease of the pelvis or femur (ICD-9 code 170.7), infections of the hip or thigh (ICD-9 codes 730.05, 730.15, 730.25, 730.75, 730.85, 730.95), and pathologic fractures (ICD-9 code 733.1).

Patient Demographics

From the selected cohorts, patient demographic information was extracted. The characteristics identified were age, gender, body mass index, tobacco use, and primary payer. To analyze age-related trends, patients were sub stratified by age: 21–59 (patients under the age of 21 would be included in Kids' Inpatient Database), 60–69, 70–79, 80–89, and 90+ years. In order to perform a complete case analysis, patients who were missing demographic information were removed from this study. A comparative analysis on the demographic percentages was performed prior to removing patients who were missing race categorization from the cohort.

Patient Comorbidities

The Charlson Comorbidity Index (CCI) was calculated for patients in the cohort and the scores were categorized into groups: CCI = 0, 1, 2, and 3+.[18, 19] The formula for the CCI is found in Table 1.

Patient Outcomes

Patient outcomes were categorized into medical and surgical complications. The following medical complications were analyzed: pneumonia, urinary tract infection, deep vein thrombosis, pulmonary embolism, ileus, death, reintubation. The following surgical complications were analyzed: surgical site infection, hematoma, blood transfusion, dislocation, and need for irrigation and debridement/secondary surgery. The length of stay variable was extracted from the database and was dichotomized by defining extended length of stay as greater than the 75th percentile length of stay (>7 days). The discharge level of care to home healthcare and to entry into a skilled nursing or intermediate care facility was tabulated.

Table 1. Comorbidity Indices Definitions*

Point	Condition
1	Myocardial infarction
1	Congestive heart failure
1	Peripheral vascular disease
1	Cerebrovascular disease
1	Dementia
1	Chronic pulmonary disease
1	Connective tissue disease
1	Diabetes (uncomplicated)
1	Peptic ulcer disease
1	Mild liver disease
2	Hemiplegia
2	Moderate-severe renal disease
2	Diabetes with end-organ damage
2	Any tumor
2	Leukemia
2	Lymphoma
3	Moderate severe liver disease
6	Metastatic solid tumor
6	AIDS

*CCI = Σ points, range 0–26.

Statistical Analysis

Statistical analyses were conducted using Stata version 13.1 (Stat Corp LLP, College Station, TX) and SAS 9.4 (SAS Institute, Cary, NC).

For both patient cohorts, the analysis included chi-square tests on the categorical variables for each arthroplasty procedure to identify statistically significant relationships. The associations between arthroplasty procedure, and medical and surgical complications were tested through multivariate regressions, which adjusted for preoperative factors including age, tobacco use, primary payer, gender and CCI. The regression technique utilized was Poisson regression with robust error variance, an alternative to log-binomial regression that enables direct estimation of relative risk in cohort studies.[20] The Cochran-Armitage trend test was used to analyze the statistical significance of the trend in THA utilization by age categories in the time period 2002–2015. Statistical significance was defined as $p < 0.05$. All reported p-values are two-sided and have not been adjusted for multiple comparisons.

Results

A total of 117,073 patients who underwent a THA or HA were found to meet inclusion/exclusion criteria. Of these, 105,296 patients (89.94%) had HA procedures and 11,777

patients (10.06%) had THA procedures. The demographics for both patient cohorts are presented in Table 2. The mean age for THA patients was 75.03 years (SD 11.84), 69.91% were female, 2.60% were obese, 18.34% used tobacco, and the majority of patients (76.45%) were enrolled in Medicare. The mean CCI score was 1.14 (SD 1.40, range 0–13). For HA patients, the mean age was 81.03 years (SD 9.32) 72.81% were female, 1.73% were obese, 13.66% used tobacco, and a majority of patients (88.99%) were enrolled in Medicare. The mean CCI score was 1.42 (SD 1.58, range 0–14). Based on the large sample size of this study, there were significant differences in all demographic variables. In order to account for the differences in baseline characteristics before assessing the procedure effect, propensity score matching was performed using age, gender, BMI, tobacco use, primary payer, and CCI score. Following matching, the patient demographics and CCI scores were no longer significantly different ($p < 0.05$).

Prior to propensity score matching, several adverse event rates were significantly different between the two cohorts (Table 3). THA patients experienced higher rates of hematoma and dislocation, and lower rates of pneumonia and urinary tract infections. HA patients had a higher rate of mortality. There were also significant differences in hospital discharge metrics. THA patients had a lower average length of stay, a lower rate of discharge to a skilled nursing or intermediate care facility and a higher rate of discharge to home. Following propensity score matching, differences in rates of six adverse events were found to be statistically significant. The THA patient cohort had higher rates of urinary tract infections, deep vein thrombosis, hematoma, blood transfusion, and dislocation. Mortality (2.46%) was higher in the HA cohort. The difference in the hospital discharge metrics remained statistically significant. HA patients had the higher rate of extended of length of stay, a higher rate of discharges to a skilled nursing or intermediate care facility, and a lower rate of discharges to home.

Poisson regressions with robust error variances revealed differences in risk for several adverse events and hospital discharge metrics. Overall, undergoing a THA is associated with an increase in risk of any adverse event by 12% (95% CI 1.09–1.15, $p < 0.001$; Figure 1) and an increase in risk of surgically related adverse events by 22% (95% CI 1.17–1.26, $p < 0.001$; Figure 1). Surgical adverse events include surgical site infection, hematoma, blood transfusion, dislocation, and need for wound debridement.

As seen in Table 4, THAs are associated with a higher risk of deep vein thrombosis (RR 6.89, 95% CI 3.66–12.97,

Table 2. Patient Demographics

	Before Propensity Score Matching			After Propensity Score Matching	
	Hemiarthroplasty (n = 105,296) Percent (%)	Total Hip Arthroplasty (n = 11,777) Percent (%)	Chi-Square p-Value	Hemiarthroplasty (n = 11,777) Percent (%)	Chi-Square p-Value
Age					
<60 years	3.20	11.21		11.23	
60–69 years	8.21	19.93	<0.001	19.88	1.000
70–79 years	24.26	26.94		26.97	
80–89 years	46.60	32.61		32.61	
≥90 years	17.73	9.31		9.31	
Gender					
Female	72.81	69.91	<0.001	70.09	0.754
Male	27.19	30.09		29.91	
Obesity					
BMI <25 kg/m^2	97.86	95.95		96.18	
BMI 25–30 kg/m^2	0.32	0.45	<0.001	0.4	0.765
BMI 30–35 kg/m^2	1.41	2.56		2.39	
BMI >35 kg/m^2	0.41	1.04		1.04	
Tabacco Use					
No tobacco use	86.34	81.66	<0.001	81.8	0.774
Tobacco use	13.66	18.34		18.2	
Primary Payer					
Medicare	88.99	76.45		76.55	
Medicaid	1.81	2.73		2.65	
Private insurance	7.02	15.98	<0.001	15.76	0.957
Self pay	0.79	1.95		2.04	
No charge	0.10	0.30		0.27	
Other	1.30	2.60		2.73	
Charlson					
0	32.60	41.39		41.46	
1	30.63	29.32	<0.001	29.30	0.999
2	18.10	15.52		15.53	
≥3	18.67	13.77		13.70	

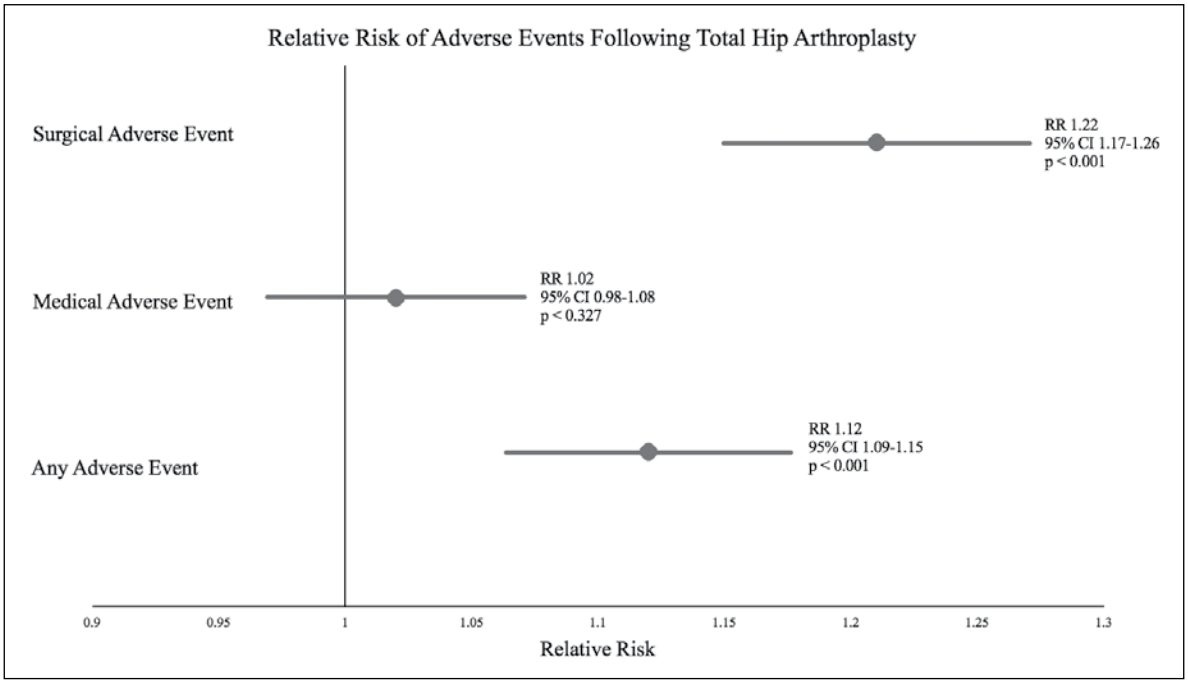
Significance at $p < 0.05$.

Table 3. Adverse Event and Hospital Discharge Metrics

	Before Propensity Score Matching			After Propensity Score Matching		
	Hemiarthroplasty (n = 105,296) Percent (%)	Total Hip Arthroplasty (n = 11,777) Percent (%)	Chi-Square p-Value	Hemiarthroplasty (n = 11,777) Percent (%)	Total Hip Arthroplasty (n = 11,777) Percent (%)	Chi-Square p-Value
Any Adverse Event						
Death	2.38	1.58	<0.001	2.46	1.58	<0.001
Pneumonia	5.25	4.27	<0.001	4.4	4.27	0.631
Urinary tract infection	18.79	14.72	<0.001	13.48	14.72	0.007
Deep vein thrombosis	0.64	0.65	0.985	0.09	0.65	<0.001
Pulmonary embolism	0.72	0.80	0.337	0.66	0.80	0.221
Ileus	1.34	1.24	0.359	1.31	1.24	0.642
Intubation	2.61	2.53	0.608	2.63	2.53	0.651
Surgical site infection	0.34	0.37	0.658	0.41	0.37	0.599
Hematoma	1.17	1.43	0.013	1.06	1.43	0.011
Blood transfusion	31.02	31.73	0.116	26.00	31.73	<0.001
Dislocation	0.02	0.21	<0.001	0.04	0.21	<0.001
Debridement	0.17	0.14	0.548	0.22	0.14	0.170
Hospital Discharge Metrics						
Extended length of stay (>7 days)*	23.02	21.32	<0.001	25.97	21.32	<0.001
Discharge to home health care	5.57	13.34	<0.001	8.53	13.34	<0.001
Discharge to skilled nursing facility or intermediate care facility	85.89	73.69	<0.001	76.63	73.69	<0.001

*Seven days corresponds to the 75th percentile.
Shading represents statistical significance at $p < 0.05$.

Figure 1. Impact of THA on Adverse Event Occurrence



$p < 0.001$), dislocation prior to discharge (RR 4.96, 95% CI 1.91–12.94, $p < 0.001$), hematoma (RR 1.34, 95% CI 1.07–1.69, $p = 0.012$), blood transfusion (RR 1.22, 95% CI 1.17–1.27, $p < 0.001$), and urinary tract infection (RR 1.09, 95% CI 1.03–1.16, $p = 0.006$). The risk of mortality associated with a THA procedure is decreased (RR 0.64, 95% CI 0.53–0.77, $p < 0.001$) relative to HA.

With respect to hospital discharge metrics, THA patients had a lower risk of experiencing an extended length of hospital stay (RR 0.82, 95% CI 0.78–0.86, $p < 0.001$) and of being discharged to a skilled nursing or intermediate care facility (RR 0.96, 95% CI 0.95–0.98, $p < 0.001$). THA patients were more likely to be discharged to home health care (RR 1.56, 95% CI 1.46–1.68, $p < 0.001$).

Within the 20% stratified sample of inpatient discharges from NIS participating hospitals, THA proportion increased substantially and significantly ($p < 0.0001$) for the 21 to 59 age group, from 0.153 (95% CI 0.109–0.205) in 2002 to

Table 4. Impact of THA Procedure on Risk for Adverse Events and Hospital Discharge Metrics

	Impact of Having THA on Risk for Adverse Events and Discharge Metrics		
	RR	CI	P-Value
Any Adverse Event			
Death	0.64	0.53–0.77	<0.001
Pneumonia	0.97	0.86–1.09	0.637
Urinary tract infection	1.09	1.03–1.16	0.006
Deep vein thrombosis	6.89	3.66–12.97	<0.001
Pulmonary embolism	1.21	0.89–1.63	0.221
Ileus	0.95	0.76–1.18	0.632
Intubation	0.96	0.82–1.12	0.638
Surgical site infection	0.90	0.59–1.35	0.598
Hematoma	1.34	1.07–1.69	0.012
Blood transfusion	1.22	1.17–1.27	<0.001
Dislocation	4.96	1.91–12.94	0.001
Debridement	0.65	0.35–1.20	0.17
Hospital Discharge Metrics			
Extended length of stay (>7 days)*	0.82	0.78–0.86	<0.001
Discharge to home health care	1.56	1.46–1.68	<0.001
Discharge to skilled nursing facility or intermediate care facility	0.96	0.95–0.98	<0.001

*Seven days corresponds to the 75th percentile.
Shading represents statistical significance at $p < 0.05$.

0.405 (95% CI 0.349-0.462) in 2015. For the 60 to 69 age group, THA proportion increased significantly ($p < 0.0001$) from 0.143 (95% CI 0.115–0.174) in 2002 to 0.317 (95% CI 0.286–0.350) in 2015. For the 70 to 79 age group, a small but significant ($p < 0.0001$) increase was observed, from 0.071 (95% CI 0.060–0.082) in 2002 to 0.159 (95% CI 0.141–0.177) in 2015. THA proportions for the 80 to 89 and 90+ age groups were functionally unchanged for the period. Collectively, these trends are consistent with the recent clinical practice of performing THA procedures on younger, and presumably, healthier patients (Figure 2).

Discussion

As the number of hip fractures rises, it is becoming increasingly important to create an evidence-based treatment algorithm for displaced femoral neck fractures to optimize patient outcomes and minimize treatment costs. The current decision-making process for choosing between hemiarthroplasty and total hip arthroplasty is subjective and non-standardized. Previous work has identified hemiarthroplasty as the preferred procedure for older patients and patients with multiple comorbidities as this procedure will provide adequate functionality for these patients.[21] Several other single center studies have provided evidence that even in older patients, total hip replacement is more beneficial, especially considering the decreased rate of revisions and improved functional outcomes.[22] While there is conflicting evidence, the applicability of these studies is limited by several factors. Many previous studies used local cohorts, excluded patients based on age, payer or comorbidities, and/or have sample sizes of less than 200 (which may introduce Type II errors). This study addresses these shortcomings and utilizes a large and national cohort to compare postoperative outcomes and identify the trend in usage among different age categories.

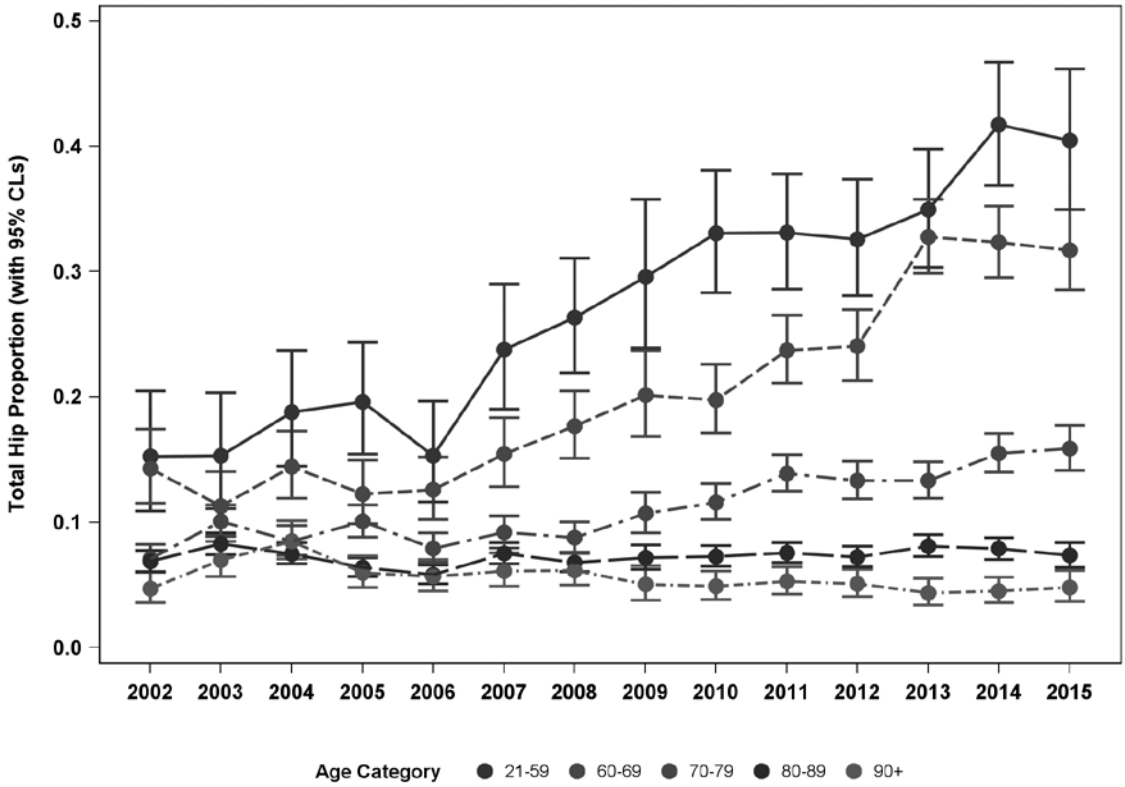
The primary goal of this study was to compare the relative inpatient morbidity, mortality and complication rates of HA and THA for the treatment of displaced femoral neck fracture. Before propensity score matching, the patient cohorts had significantly different CCI scores, with a greater proportion of patients with higher CCI scores (3+) undergoing HA. This aligns with accepted standard that HA remains the preferred treatment for patients with significant medical comorbidities.[21] Probing into the adverse events and hospital metrics (Table 3), both before and after propensity score matching, several adverse events occurred at a higher rate in THA patients as compared to HA patients. Following propensity score matching, the most striking associations of adverse event rates between THA patients compared to HA patients are deep vein thrombosis and dislocation prior to discharge. Healthcare professionals can use this knowledge to help guide post-operative care by suggesting changes to the chemoprophylaxis or mechanical prophylaxis regimen. While the elevated risk of dislocation aligns with the literature,[9, 13, 23] improvements can be made to mitigate this risk by selecting alternative surgical approaches or instituting hip precautions.[23] In our study, the overall risk of adverse events following a THA procedure was 12%. Interestingly, in our study, the risk of mortality is negatively associated with a THA procedure. While there is no definitive explanation for this observation, we postulate that this is due to unadjusted confounding factors.

After propensity score matching, THA patients were less likely to have an extended length of hospital stay and were more likely to be discharged to home than HA patients. This is consistent with the current practice of performing THA procedures on healthier and younger patients.

While the current study demonstrates that there are some increased rates of adverse events associated with THA as compared to HA for displaced femoral neck fractures, the overall risk of an adverse event following a THA procedure is low, particularly when considering literature support of the long-term benefits of improved functional, pain, and mobility scores with THA.[24] In addition, with increased awareness of the adverse events that are more likely to occur following each procedure as identified by this study, postoperative care can be directed toward early detection and prevention of such events. With better knowledge of the associated complications and outcomes, physicians and patients can use a more objective decision-making process in determining how to surgically treat displaced femoral neck fractures.

Strengths of this study include the use of a national dataset, a large cohort size, and more than a decade of data. The cohorts also included patients of all payer types and those with less healthy profiles. There was a rigorous statistical

Figure 1. Trend in Total Hip Replacement by Age



analysis including multivariate logistic regression to determine which outcomes were independently influenced by the type of procedure. Limitations of the current study include the bias introduced when using a national dataset and removing patients based on inadequate data collection methods, and the use of the propensity score algorithm. In addition, this study only comments on complications and hospital metrics recorded prior to discharge as the NIS dataset does not allow for the identification of adverse events following discharge or quality of life metrics following hospital visits.

Conclusion

Although the overall usage of THA for displaced femoral neck fractures is on the rise, controversy still exists regarding the optimal surgical treatment of displaced femoral neck fractures in certain patients. Creation of an evidence based decision-making treatment algorithm would improve patient care and reduce overall costs. Based on national data, this study revealed that the two surgical options, THA and HA, have relatively comparable short-term outcomes, with a few adverse events identified as areas related to each procedure that should be carefully monitored. In our study, after propensity score matching, THA was associated with a higher risk of deep vein thrombosis, dislocation, hematoma, need for transfusion, and urinary tract infection. Meanwhile, HA was associated with a greater risk of mortality, extended length of hospital stays and discharge to SNF.

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Original Research

Thigh Compartment Syndrome: Injury Characteristics, Complications, and Patients Most at Risk

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Abstract

Objective: Thigh compartment syndrome (TCS) is a rare orthopaedic emergency. However, there is limited data concerning the types of injuries that are most at risk for developing TCS.

Method: To better define the injury patterns that lead to TCS, we did a retrospective study examining 35 patients who developed TCS during a 10-year period at a Level 1 trauma center.

Results: The average age was 33.9 years. Ipsilateral femur fracture was present in 65.7% of patients. Vascular injury was present in 25.7% of patients. Patients with femur fractures from GSW were 5.57 times more likely to TCS than those patients with femur fractures not related to GSW ($P < 0.001$). Fractures from AO/OTA Type B and Type C were significantly more likely to lead to TCS than AO/OTA Type A fractures. There was no statistical difference between the location of femur fractures and developing TCS.

Conclusion: Femur fractures due to gunshot wounds and highly comminuted femur fractures are at an increased risk of developing TCS.

Introduction

Thigh compartment syndrome (TCS) is a rare orthopaedic emergency.[1–6] There are many etiologies including external compression, femur fracture, blunt trauma, internal hemorrhage, knee arthroscopy, military antishock trousers, coagulopathy, and firearm injuries.[1, 7, 8] Identified risk factors for developing TCS include vascular injury, ipsilateral femur fracture, hypotension, and hypocoagulable state.[1, 2] Prompt diagnosis and immediate decompressive surgical fasciotomy are required to avoid the negative clinical outcomes, as the incidence of complications is related to the timing of the fasciotomy in patients with TCS.[5–7, 9, 10] It is important to clarify risk factors and causes of TCS to aid in rapid diagnosis and management.

Though investigators have previously examined the correlation between acute compartment syndrome (ACS) of the lower leg and forearm with location and level of comminution of associated fractures, far less information is available regarding compartment syndrome of the thigh.[7, 11–15] In many cases, TCS is associated with femur fractures, but fracture types most commonly associated with TCS have not been previously identified.[1, 2, 5] Anecdotal observations led the authors to believe that patients with femur fracture caused by gunshot wounds (GSW) are more likely to develop TCS than patients with non-GSW femur fractures, but previous studies have not fully evaluated this relationship. The paucity of data in this area limits the ability of orthopedic surgeons to identify patients most at risk for TCS and provide optimal care in an emergent situation. The goal of this retrospective chart review at an urban Level 1 trauma center was to identify risk factors for the development of TCS and characterize femur fracture types and etiologies that are most commonly associated with TCS. Our hypothesis is that GSW-related femur fractures and more highly comminuted femur fractures are more likely to lead to thigh compartment syndrome.

Methods

After IRB approval, inpatient records at a Level-1 urban academic trauma center were retrospectively reviewed over a 10-year period from August 2006 to July 2016 for a diagnosis of thigh compartment syndrome (TCS). Patients over the age of 18 were included if they underwent thigh fasciotomy for documented diagnosis of TCS. Diagnosis of TCS was made using a combination of previously described diagnostic criteria in conjunction with compartment pressure monitoring device (Stryker, Kalamazoo, MI) in cases where these measurements were deemed clinically relevant by the treating surgeons.[5, 6, 16, 17] Specific diagnostic criteria utilized in each case were dependent on the individual treating surgeon. When fasciotomy was indicated, thigh compartments were released using one or two incision technique and closure depended on individual surgeon preference. Patients who underwent thigh fasciotomies associated with, performed during, or acutely after revascularization without documented clinical findings of compartment syndrome, and without direct trauma to the thigh were considered prophylactic in nature and excluded. Thirty-five patients with a

diagnosis of thigh compartment syndrome met inclusion criteria. Patients were excluded from analysis of follow-up variables if they had less than 90 days follow-up, insufficient outpatient documentation, or death prior to discharge. Data collected by chart review included age, gender, symptoms, presence of hypotension, mechanism of injury, method of diagnosis (clinical and/or compartment measurement), time to skeletal traction, associated injuries, infection, complications (amputation, neuro deficit, infection, HO), compartment pressure value when available, time to diagnosis, time to fasciotomy, intraoperative findings, follow-up time, prothrombin time (PT), partial thromboplastin time (PTT), INR, and platelet count. Injury Severity Score (ISS) was calculated for all included patients. A total of 35 patients with TCS were identified, with 27 patients having sufficient follow-up to be included in analysis of follow-up variables.

Additional data was collected to determine which type of femur fractures according to AO/OTA classification and which mechanism causing femur fractures is associated with TCS. All patients with femoral shaft fractures treated during the same time period listed above were identified and fractures graded by the AO/OTA classification system. A total of 463 patients with femur fractures were identified.

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

Thirty-five patients with thigh compartment syndromes were identified. The average patient age was 33.9 ± 14.3; 97% were men (34/35). The primary mechanism of injury was penetrating trauma in 19/35 (54.3%). The other mechanisms of injury included blunt trauma in 11 patients (31.4%), external compression in two (5.71%) patients, hypocoagulable state in a patient on lovenox for treatment of a deep venous thrombosis (DVT), hypocoaguable state in a patient who developed Heparin Induced Thrombocytopenia (HIT) while being treated with heparin for a DVT, and one case of arthroscopy fluid extravasation (Table 1). There was traumatic vascular injury in 9/35 (25.7%) patients, seven occurring in cases of penetrating trauma, and two in cases of blunt trauma. There was some degree of coagulopathy measured by lab values including PT, PTT, INR, or platelet levels at some point during admission prior to development of TCS in 10/35 (28.6%) patients. At time of admission, 11/35 (31.4%) patients were hypotensive (systolic blood pressure below 90 mmHg). Two (5.7%) patients required amputation. There were two (5.7%) mortalities in this series. Mean Injury Severity Score (ISS) was 17.0 ± 12.8.

Table 1. Mechanisms Leading to TCS

Ipsilateral femur fracture	65.7% (23/35)
Penetrating trauma	54.3% (19/35)
Blunt trauma	28.6% (11/35)
Traumatic vascular injury	25.7% (9/35)
Hypocoagulability	5.7% (2/35)
External compression	5.7% (2/35)
Arthroscopy fluid extravasation	2.9% (1/35)

Diagnosis was made clinically in all 35 patients. In 18 of the patients, compartment pressures were measured as well to assist in the diagnosis. Average maximum compartment pressures in these patients were 61.8 mmHg. Bilateral compartment syndrome was not noted in any of the patients. There were no identified cases of post-traumatic thigh compartment syndrome that were missed or did not undergo emergent fasciotomy.

In the 17 patients that were diagnosed while awake and alert, the documented symptoms included pain in 12 patients, tense compartments in nine patients, swelling in nine, decreased sensation in four, weakness in two, and inability to ambulate in one. Of the 15 patients that were either intubated or obtunded, documented signs included tense compartments in 13 patients, swelling in six patients, elevated CK in one patient, and difficulty passing an intramedullary rod in one patient. In three patients, there was concern for TCS while the patient was awake, with one patient experiencing pain, one with swelling, and one with tenderness and decreased strength on exam. The final diagnosis was made intraoperatively for these three patients with documented signs including increasingly tense compartments in all three, swelling in two, increased compartment pressure measurement from preoperative measurement in one, and decreased doppler signals distally in one. 15/35 patients had a new neurologic deficit in the affected limb at initial presentation, including seven patients with weakness, 11 patients with decreased sensation. 9/35 patients had associated calf compartment syndrome.

Sixteen patients were put in skeletal traction, with a mean time to skeletal traction of 3.93 hours. Mean time from admission to diagnosis was 18.0 hours. Mean time from diagnosis to fasciotomy was one hour. There was an associated calf compartment syndrome in 9/35 (25.7%) patients. There were portions of muscle that were not contractile at time of fasciotomy in 2/35 (5.7%) patients. A total of 4/35 (11.4%) had muscle described as dusky or poorly perfused. These four patients required debridement of muscle tissue. All 31 other patients had well perfused muscle. Wound closure was performed in 33/35 patients, as one patient received an amputation before closure and one patient died before closure. Delayed primary closure was performed in 26/33 (78.8%) patients, while split thickness skin graft was required in 7/33 (21.2%) patients.

There was infection in 11 patients, including five at the site of fasciotomy, two associated with orthopedic hardware, and four cases of pneumonia, two of which led to bacteremia and one of which led to sepsis.

Ninety day follow-up data was available for 23 patients, with a mean follow-up of 1.75 years. There were persistent

symptoms in 15/23 (65.2%) patients at final follow-up, including pain (11/23), sensory deficits (3/23), weakness/motor deficit (4/23), and limp/ambulatory function (5/23). There was neurologic deficit present in 8/23 (34.8%) patients at final follow-up (Table 2).

Table 2. Complications of TCS

Mortality	5.7% (2/35)
Amputation	5.7% (2/35)
Muscle necrosis	11.4% (4/35)
Neurologic deficit	34.8% (8/23)
Functional deficits	30.4% (7/23)
Persistent symptoms	65.2% (15/23)
Pneumonia	11.4% (4/35)
Fasciotomy wound infection	14.3% (5/35)
Orthopaedic hardware infection	5.7% (2/35)
Calf compartment syndrome	25.7% (9/35)

Fracture Characteristics

There was an ipsilateral femur fracture in 65.7% of the patients (23/35). During this time period, 461 femoral shaft fractures were treated at the same institution, including 266 classified as AO/OTA type 32A, 121 type 32B, and 74 type 32C. Further analysis showed that seven of 266 (2.6%) of 32A fractures developed TCS, 10 of 131 (8.3%) of 32B fractures exhibited TCS, and six of 74 (8.1%) of 32C fractures exhibited TCS (Figure 1). We conclude that there is a statistically significant association between AO/OTA classification and TCS. AO/OTA 32B fractures were significantly more likely to develop TCS than AO/OTA 32A ($P < 0.025$, OR 3.333, 95% Confidence Limits: 1.237, 8.981) and AO/OTA 32C fractures were significantly more likely to develop TCS than AO/OTA 32A ($P < 0.025$, OR 3.265, 95% Confidence Limits: 1.062, 10.032). There was no statistically significant difference between 32B and 32C fractures in developing TCS.

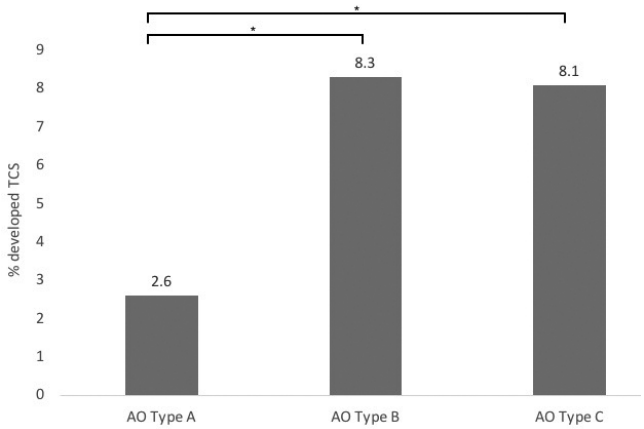

Figure 1. Percent of AO Classification fractures that develop TCS. Total number of Type A fractures was 266. Total number of Type B fractures was 121. Total number of Type C fractures was 74. Odds ratio for Type B vs Type A was 3.333 ($P < 0.05$). Odds ratio for Type C vs Type A was 3.265 ($P < 0.05$).

Ten of 163 (6.1%) of proximal third shaft fractures exhibited TCS, 10 of 182 (5.5%) of middle third shaft fractures exhibited TCS, and three of 118 (2.5%) of distal third shaft fractures exhibited TCS (Figure 2). We cannot conclude that there is a statistically significant association between location of fracture and development of TCS ($p = 0.359$).

GSW

Of all femoral shaft fractures treated during study period, 144 were caused by GSW while 319 were caused by non-GSW mechanisms. Of all GSW-related femur fractures, 16 of 144 (11.1%) exhibited TCS, while for the non-GSW fractures, seven of 319 (2.2%) developed TCS. A patient with a GSW fracture had a significantly higher likelihood of developing TCS than a patient with a non-GSW fracture ($P < 0.001$; OR 5.571, 95% CI limits 2.239–13.865). We conclude that there is statistically significant association between femur fractures caused by GSW and TCS.

Discussion

Overview

TCS is a rare clinical entity with a variety of causes ranging from motor vehicle accidents to blunt trauma to

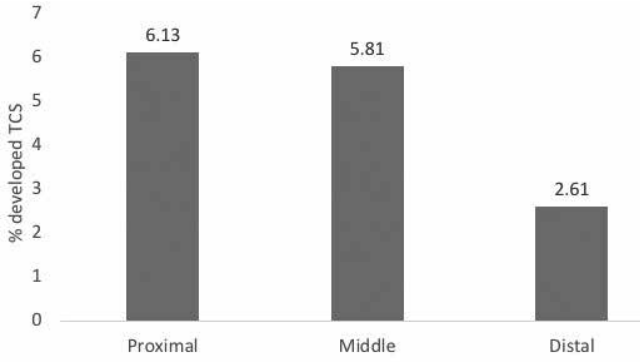

Figure 2. Percent of fractures based on location of femur fracture that developed TCS. No statistically significant difference between fracture location.

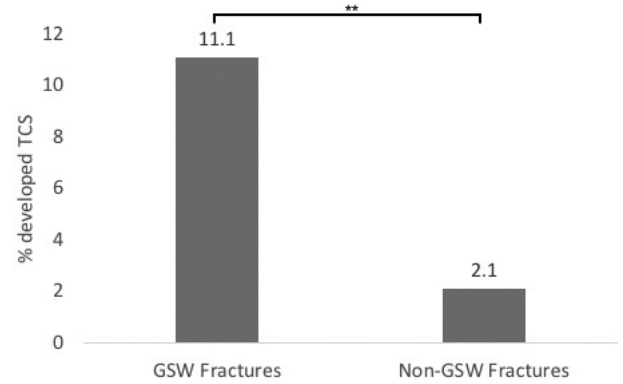

Figure 3. Percent of fractures from GSW vs fractures from non-GSW that develop TCS. Odds ratio for GSW fracture vs non-GSW fracture is 5.571 ($P < 0.001$).

penetrating trauma. With 35 patients identified with thigh compartment syndrome, this case series has the largest patient population to date.[1–3, 5, 8, 18, 19] Similar to previous studies, patients in the current series were most often young males who suffered traumatic injuries.[19] The high incidence of GSW TCS in the current series is similar to other series that were completed at urban level 1 trauma settings, while other centers that treat less patients with GSW were more likely to report TCS related to blunt trauma.[1, 19] Previous studies have identified ipsilateral femur fractures and vascular injuries as being associated with TCS, and the results of the current series are consistent with the previous findings, as 65.7% had ipsilateral femur fractures and 25.7% had vascular injuries.[1, 2, 19, 20]

The mortality rate in this series was 5.7% (2/35), which is on the lower end of the spectrum of the mortality rates from previous series that ranged from 0% to 47%.[1–3, 5, 8, 18]

Average ISS of patients in this series was similar to average ISS in previous series.[1, 3] Kanlic et al. had an average time from admission to operating room of 18 hours for the 23 patients in their series. This is comparable to our series with average admission to operating time of 19 hours for 35 patients.[2] The average time from diagnosis to fasciotomy of one hour in this series was faster than both Schwartz (four hours) and Knab (two hours).[1, 5] 8/23 of patients in the case series by Kanlic et al. had ischemic muscle changes compared to four in this series.[2]

In another previous series, neurologic deficits were the most common complication (16%, 13/81) after TCS.[19] This is below reported rate in the current series of 34.8% (8/23). Functional deficits at final follow-up were similar to previously reported data.[18]

GSW

Gun violence is currently a major public health issue in the U.S., with approximately half of these injuries developing fractures.[21–23] Studies have shown that compartment syndrome is an important sequela of fractures caused by GSW, with rates ranging from 2.03% to 2.6%.[7, 24, 25] Although previous studies have looked at the rates of developing TCS after gunshot wound injuries to the thigh, the rates for developing TCS after GSW femur fractures have not been compared to other fracture mechanisms. Branco et al. compared mechanisms of extremity fractures and their need for fasciotomy, showing that GSW extremity fractures required fasciotomy more so than fractures suffered from motor vehicle accidents.[26] Results from the current series are the first to show a significantly higher rate of TCS after a gunshot-related femoral shaft fracture, when compared to fractures from other mechanisms.

AO Classification

Studies of tibia and forearm fractures have shown that AO classified type B and type C fractures have a significantly higher rate of developing ACS than type A fractures, with no statistically significance between type B and type C fracutres.[14, 27] The data of this series is consistent with this previous data showing that type B and type C femur fractures are significantly more likely to result in TCS than type A fractures, and that there is and no significant difference between type B and C femur fractures.[14, 27]

Fracture Location

Previous studies have suggested that the level of a fracture plays a role in the rate of developing compartment syndrome in forearm fractures and tibia fractures.[11, 17, 27] Although one study has examined the correlation between level of femur fracture and development of vascular injury, to our knowledge, no study has looked at the association between location of femur fracture and relative risks of developing TCS.[28] We examined the relative risks of developing TCS between proximal, middle, and distal shaft fractures and found there was no statistically significant association between level and TCS.

Limitations

There are several limitations of this study. First, insufficient follow-up limited the number of patients that could be included in analysis of follow-up variables in this study. Next, as with all retrospective reviews, full delineation of factors contributing to a clinical decision is limited by specific findings that were documented. It is likely that additional variables beyond what is documented contributed to the diagnosis in specific cases. Lastly, there was non-standardized diagnosis criteria and management between different treating physicians. Since compartment syndrome is largely a subjective diagnosis that may or may not be supported by a variety of objective findings, variation between treating physicians may expand or limit the number of patients diagnosed with TCS in similar situations in the future.

In conclusion, based on data in current series, TCS remains an orthopedic emergency with significant risk for poor outcomes. Based on data in this series, we recommend monitoring for development of TCS for 24 hours in all patients with significant trauma to the thigh, especially those with vascular injury, highly comminuted femur fractures, and femur fractures caused by GSW.

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Original Research

A Pilot Study on the Effectiveness of Tranexamic Acid Administration at Time of Presentation in the Prevention of Blood Loss in Geriatric Hip Fractures

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Abstract

Objective: To evaluate whether tranexamic acid (TXA) administration at time of presentation can further minimize acute blood loss in geriatric hip fracture patients.

Design: Retrospective Case Series

Setting: Data collected from June 2017 to June 2018 at an urban, Level I academic trauma center.

Participants: Any patient whom sustained a femoral neck or intertrochanteric fracture was considered. Inclusion criteria: Low energy mechanism, >55 years of age. Exclusion criteria: high-energy mechanism, polytrauma, non-operative management, age <55 years, and patients who did not receive TXA. There were 38 patients total for evaluation (19 intervention, 19 matched controls).

Intervention: Patients received a TXA dose in the emergency room (ER) in addition to pre-operatively in the operating room (OR) and were compared to historical controls who presented prior to the initiation of our TXA protocol.

Outcome Measurements: Primary outcome: Change in hemoglobin (Hgb) at variable time points. Secondary outcome: blood transfusion rates and amounts.

Results: The change in Hgb decreased at all times periods evaluated, most significantly from OR to post-operative day 1. In control patients, 36.8% received a transfusion, whereas only 15.8% of TXA patients received transfusions, resulting in a 57% reduction in tranfusions.

Conclusion: Our study shows that dosing geriatric hip fracture patients at time of presentation in addition to pre-operatively with tranexamic acid decreases their transfusion rates beyond what has previously been demonstrated in the literature with traditional dosing, without increasing their adverse outcomes.

Level of Evidence: Therapeutic Investigation, Retrospective Level IV study.

Introduction

Hip fractures in the elderly are incredibly common, with greater than 250,000 Americans suffering from them each year.[1] A high level of morbidity is associated with these fractures, including deep venous thrombosis (DVT), urinary tract infections (UTI), pneumonia, decubitus ulcers, and blood loss anemia.[1] While it is known that blood loss after any long bone fracture is an issue,[2] very few studies have looked at properly identifying those who may be at greatest risk for anemia following injury. Studies have identified intraoperative blood loss is often underestimated with these types of fractures. Underestimates ranged from 550 mL to 1500 mL depending on fracture fixation type.[3] Intracapsular femoral neck fractures account for 45% of all hip fractures and 45% of all extracapsular fractures are classified as intertrochanetric.[1] Most blood loss is felt to occur preoperatively, and up to 80% of this blood loss may be unaccounted for by medical teams.[4, 5] Higher post-operative hemoglobin has been associated with better overall outcomes.[5] Furthermore, preoperative anemia is a risk factor for perioperative death.[6] This increased risk has been quantified as a 1.64 relative risk of mortality and 1.67 relative risk of myocardial infarction with anemia upon admission (<120 g/l).[7] Anemia is also important to correct on the postoperative period. Studies have shown decreased functional scores and ability to walk independently in patients with postoperative anemia.[8] This functional limitation could put the patient at greater risk for eventual nursing home admission, which is associated with overall poorer outcomes.[9]

Several studies have identified ways to help minimize this blood loss. Tranexamic Acid (TXA) has been around for decades as a safe, effective and cost-efficient method of preventing major hemorrhage.[10] This study will address whether the administration of tranexamic acid at unique times in the pre-operative time period can help counter act anemia and other associated morbidity commonly linked to these fractures.

Methods

This was a retrospective chart review conducted at an urban, Level 1 Trauma center from July 2017 to January 2018. The standard-of-care for treatment of geriatric hip fracture at our center included the administration of TXA in

both the emergency room and immediately pre-operatively in the operating room. Patients would receive TXA at a dose of 10 mg/kg, with renal dosing performed based on creatinine clearance. Renal dosing was not uniform and dependent on renal function, but followed drug FDA guidelines. Any patient who had sustained a femoral neck fracture or intertrochanteric fracture was considered. Inclusion criteria included: low-energy mechanism (i.e., fall from standing, stumble/trip down one step) in those >55 years of age. Exclusion criteria included: high-energy mechanism, subtrochanteric fractures, polytrauma (multi-organ involvement), non-operative management of fracture, age <55 years, inaccessible electronic medical record (EMR), no recorded hemoglobin at time of admission and surgical fixation, and patients who did not receive or had a contraindication to TXA administration [i.e., head injury, subdural hematoma, subarachnoid hematoma, current thromboembolic event (disseminated intravascular coagulation, DVT, PE), allergy, defective colour vision].

Patients were identified based on ICD-10 codes for diagnosis of femoral neck fracture or intertrochanteric fracture. Following that, the EMR was evaluated for inclusion and exclusion criteria as stated above. Following the application of exclusion criterion, there were 19 patients who had received the appropriate doses of TXA to be evaluated. These patients were compared to historical controls. They were cross-matched for age, side of fracture, fracture type, time to fixation, fixation method and co-morbidities at a 1:1 ratio for analysis. Data was collected on patients determined to fit inclusion criteria including: gender, age, fracture type, fracture side, fixation method, time to fixation, admission hemoglobin (Hgb), operative-day hemoglobin, discharge hemoglobin, discharge destination, blood transfusion rates, and amount of blood received. The same data was collected through the EMR for historical controls.

Statistical analysis undertaken for categorical variables used the Chi-Square test (or the Fisher's exact test, as appropriate). The data for change in Hgb from admission to POD1 and for change in Hgb from admission to discharge are normally distributed. Therefore, parametric analysis T-test was applied to these data. For change in Hgb from admission to OR, transfusion amount (all patients), and transfusion amount (only patients receiving transfusions), we conclude that these data are not normally distributed, and therefore the Wilcoxon methodology was applied. A p-value of <0.05 was used to signify statistical significance.

Results

There were 38 patients total for evaluation (19 intervention, and 19 matched controls). The change in Hgb from admission to the OR in the control group was a drop of 1.63 g/dL vs. 1.16 g/dL in the TXA group ($p = 0.56$). The change in Hgb from OR to POD1 in the control group was a drop of 2.23 g/dL vs 1.03 g/dL in the TXA group ($p = 0.0001$). The change in Hgb from admission to discharge in the control group was a drop of 3.19 g/dL vs 2.69 g/dL in the TXA group ($p = 0.27$). While all three values trended towards decreased blood loss in the TXA group, statistical significance was only achieved in the time period from OR to POD1. Results are summarized in Table 1.

In regards to transfusion reduction, 36.8% of the control patients received a transfusion, whereas only 15.8% of the TXA patients received a transfusion ($p = 0.14$), resulting in a 57% reduction in tranfusions. In spite of the relatively large difference in transfusion frequency the relatively small sample size results in low statistical power for this test. Results are summarized in Table 2.

Discussion

Our study effectively shows that the administration of TXA at an earlier interval to injury in geriatric hip fracture patients lends to advantages that have been previously shown in high-energy trauma patients. In recent years, it has been the focus of two major international studies focusing on its applications in the trauma setting. The CRASH-2 trial evaluated the efficacy of TXA and its cost effectiveness among 20,211 trauma patients admitted to 270 hospitals in 40 countries.[11, 12] CRASH-2 deduced that the usefulness of TXA at reducing the risk of death by hemorrhage is time sensitive. Therefore, early administration within three hours of injury is advantageous and those patients derive the most benefit from treatment.[11] The data also proved a statistically significant difference in death associated with blunt trauma when TXA is used as compared with penetrating trauma when TXA is administered.[11, 12] These benefits indicate that TXA is efficacious in higher-energy trauma and is worthy of further research and study for its application in low-energy blunt trauma. Our reduction in blood loss as demonstrated by decreased hemoglobin lab value decreases and transfusion rates are consistent with previous findings.

While randomized control trials evaluating the use of tranexamic acid in the geriatric hip fracture population do exist,[13–18] none have evaluated the effectiveness of providing TXA in the emergency room and how that affects blood loss. Where our study differs is administration within that vital three-hour time period, and our results show improved blood loss parameters over more traditional dosing methods. A systematic review evaluating the use of TXA in geriatric hip fracture papers show only seven high-quality studies exist.[19] Of those evaluated, they showed a 46% reduction in blood transfusions.[19] While these studies had variable dosing times for TXA, all patients received their first dose in the operating room and not at time of presentation.[19] A Cochrane review conducted by Henry et al. found a 39% reduction in blood transfusions when receiving TXA in the peri-operative period.[20] In addition, a study by Zufferey et al. showed an overall transfusion rate of 42% in their intervention group, compared to 60% in their controls.[13] With that in mind, our

Table 1. Summary Statistics and Testing for Various Changes in Hgb by Group

Classification Variable	N	Mean	Std Dev	Std Err	Median	p-Value	Statistical Method
Change in Hgb from admission to OR						0.5619	Wilcoxon
Control	19	16.3	1.52	0.35	1.50		
TXA	19	1.16	0.87	0.20	1.00		
Change in Hgb from admission to POD1						0.0001	t-test (Equal Vars)
Control	19	2.23	1.00	0.23	2.30		
TXA	19	1.03	0.71	0.16	0.80		
Change in Hgb from admission to discharge						0.2664	t-test (Equal Vars)
Control	19	3.19	1.53	0.35	3.30		
TXA	19	2.69	1.18	0.27	2.70		

Table 2. Summary Statistics and Testing for Transfusion Amount by Group

Classification Variable	N	Mean	Std Dev	Std Err	Median	p-Value	Statistical Method
Transfusion amount (all patients)						0.1053	Wilcoxon
Control	19	1.00	1.53	0.35	0.00		
TXA	19	0.21	0.54	0.12	0.00		
Transfusion amount (only patients receiving transfusions)						0.1853	Wilcoxon
Control	7	2.71	1.25	0.47	3.00		
TXA	3	1.33	0.58	0.33	1.00		

study demonstrated a transfusion rate of just 16% in those receiving TXA at the earlier time period in conjunction with the pre-operative dose, with a reduction in transfusions of 57% in those receiving TXA compared to historical controls. While not a statistically significant finding, if trends were to continue with larger population sizes, this would be the highest demonstrated transfusion reduction recorded.

Our overall complication rate in the intervention group was not higher than in our control group. Presence of post-operative anemia has been shown to correlate with incidence of all cause mortality and incidence of myocardial infarction (MI).[7] In addition, numerous studies have shown that increased transfusion rates can be attributed to increased incidence in post-operative wound infections.[21, 22] This falls in line with our study, which had two periprosthetic infections and one MI in the control group, with none in the intervention group. Our control group did have one subclinical pulmonary embolism (PE) picked up on incidental scan and two clinical thromboembolic events (one PE and one DVT). On further investigation into the intervention complications though, neither patient received appropriate post-operative anticoagulation upon their discharge from a non-orthopedic service and re-presented with blood clots in a delayed fashion.

Limitation of this study include its retrospective nature of data collection limiting how much can be extrapolated from the chart. Inherent bias may be present in those who received TXA as standard of care, as the sickest patients may have been excluded at time of presentation. While TXA was ordered for patients in some instances, it was not administered for unknown reasons, and those patients also had to be excluded, potentially skewing our data. In addition, the use of historical controls could lead to variability in overall management style of hip fracture patients through the years. We attempted to eliminate this by using controls who presented after the initiation of our regimented geriatric hip fracture protocol in hopes of homogenizing the data. Finally, the relatively small sample size limits the applicability to the general population, and while we did achieve statistical significance with some findings, a larger study would be more powerful and allow our trending results to become statistically significant.

Conclusion

Our study shows that dosing geriatric hip fracture patients at time of presentation in addition to pre-operatively with tranexamic acid decreases their transfusion rates beyond what has previously been demonstrated in the literature with traditional dosing, without increasing their adverse outcomes. We feel that this is a valid protocol for TXA dosing, and should be considered in geriatric hip fracture protocols. Plans for a randomized, control trial are underway at our institution to determine efficacy on a larger scale.

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Medical Student Research Project

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Return to Function Following ACL Reconstruction in Collegiate and Professional Football Players

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Abstract

Tackle football players tear their Anterior Cruciate Ligament (ACL) at both the professional and collegiate levels but after repair, however, not all return to their activity.

This study examines the reasons why those do not return to function after their injury and surgical reconstruction. Research was conducted through PubMed and the grey literature searches. Nine articles for the professional level and two articles for the collegiate level were selected for the basis of the paper with grey literature providing supporting research and statistics. We found that there are multiple external factors that can be used to predict if a player is going to return to play such as position on the field, depth chart position, other aspirations outside of football, etc. At both the professional and collegiate levels, the return to play after an ACL injury is about 80%, and it is concluded that even if the physician does a "perfect job" of repairing the ACL, other external factors may limit the ability to make the return a 100%.

Introduction

Football requires constant change of direction which often results in structural damage to the knee. Anterior cruciate ligament (ACL) injuries can potentially be a career threatening injury both at the collegiate and professional level. Over the past six seasons in the National Football League (NFL), there has been an average of 58.5 ACL tears per season.[1] In nine seasons from 2004 to 2013, there was an average of 57 ACL injuries per season in National Collegiate Athletic Association (NCAA) football.[2] Surgery needs to be performed to restore stability to the knee so the athlete can focus on getting back on the field and aiming to achieve maximum athletic performance.[3] Theoretically, with a successful knee ACL replacement surgery, there should eventually be a 100% return to play (RTP), but research shows the numbers are only 82.4% in the NFL[4] and 82% in the NCAA.[5] This study aims at accessing the factors that prevent the other 28% from returning to play and whether anything can be done to reduce that number.

Methods

All the data used was publicly available and Institutional Review Board approval was not required. PubMed was used as the primary source of data for this literature review. The search terms used for data on the professional football teams was "ACL" or "anterior cruciate ligament" and "National Football League" or "NFL" and "return to play." This yielded 23 articles, of which the nine that focused specifically on return to play after only an ACL injury were read. For the collegiate level, the following search terms were used "ACL" or "anterior cruciate ligament" and "NCAA" or "National Collegiate Athletic Association" and "football." This resulted in 15 articles and the only two that were read dealt with return to play. Outside of scientific journals, grey literature was used to get quick facts such as the rates of ACL injuries over the years and the names of individual athletes with the injuries. A google search of the phrase "Return to play after ACL injuries in football" led to accessing data from newspapers, the NFL website, the NCAA website and other forms of popular press.[1, 3, 6, 7]

Results

NFL: There are many factors that affect whether a football player is going to return after having an ACL reconstruction. With the violent nature of the sport, the careers of football players are not long compared to other sports. The average career of an NFL player is only 3.3 years[8] and this statistic is considered in that after return from an ACL reconstruction, the average years played is 2.1 years.[4] This number means that depending on how many years a player is along in their career, that after an ACL injury, their playing days are reduced. However, there are many factors that go into predicting how many more years a player will play.

The most important factor regarding return is the player's position. Quarterbacks exhibit the highest return to play.[9–11] The position doesn't require a lot of lower body speed and

explosiveness unless you are a mobile quarterback, which is why return to play is very optimistic. Quarterbacks returned to the NFL at a mean of 13–3.9 months following their ACL tear. Following surgery, they also showed no significant differences in any in-game performance variables compared to preinjury and did as well as the controls did over the remainder of their careers.[12] Defensive players are not as fortunate as the quarterbacks in that 74% of defensive players who underwent ACL reconstruction returned to play at least one NFL game, while 61% successfully returned to play at least eight games in a season. Compared to preinjury, however, these players showed a significant drop as percentage of games started, combined tackles per game, solo tackles per game, and interceptions per game.[13] The return-to-play percentages of individual positions has been published by multiple studies.[9, 10, 13–16]

Concomitant injuries occur along with the ACL injury in some players. Other structures commonly affected with a knee injury are the medial collateral ligament and medial meniscus. These additional injuries have been shown to add major setbacks to the recovery rates of athletes. Those players undergoing a combined ACL reconstruction and meniscectomy had a shorter career in games started and games played upon return, compared to those who underwent either surgery alone.[17] Prior injuries also had a negative effect. A previous ACL injury, for example, can hinder an athlete's return, causing him to play less games and seasons after reinjury compared to before the injury.[18]

Other factors that have been documented include draft round,[9–11, 14, 18, 19] with higher draft picks showing a better rate of return than later draft picks; money,[19] with a players earning less than $2 million per year less likely to return; player experience,[14] with more experienced and established athletes more likely to return and skilled players returning at a slightly higher rate than unskilled.[10]

Collegiate: College football players are in a unique situation because they are only allowed four years of NCAA eligibility; thus, players injured later in their career have less time to be assessed because they have a limited amount of time left to play. The highest return rate was sophomores and juniors compared to seniors and 5th-year seniors.[5] Since there is only a 4.7% chance making it to the NFL,[20] players towards the end of their collegiate careers have more personal and academic decisions to make regarding what they want to do post football. Similar to the NFL, players who were starters before their injury came back sooner than players less utilized and those who barely played. Those players on scholarship also returned at a higher rate than that not on scholarship.[5]

The most influential negative factors that kept athletes from returning included: other interests, lost interest in sport, other life interests, fear or reinjuring, physical symptoms, advice from medical professionals, and loss of speed or strength.[21]

Discussion

More research is needed to determine the reason we don't have everyone who suffers an ACL injury returning to play. When both professional and collegiate orthopaedic surgeons were surveyed, it seems like both groups seem to prefer the same surgical technique, i.e., bone-patellar tendon-bone autograph[22] and this could be a contributing reason to why both groups have similar injury rates. Other factors that need to be looked into are the psychological factors and postoperative rehabilitation. Psychologically, after going through a serious injury, many players may think twice before they do the same things on the field that used to come naturally to them. The importance of rehabilitation after surgery is very important because the athlete is trying to get back as close to normal from an injury that changes the mechanics of the knee.

Since this topic has been researched for many years, the discussion might have to start shifting to looking at the current return-to-play percentages as not a failure because a lot of extrinsic factors are out of the players hands that reduce the percentages. A surgeon can repair an ACL perfectly but if the player did not get that many minutes in a game or was a low-round draft pick or doesn't have much eligibility left in college, then the player's faith on the football field is out of his hands.

Conclusion

Return to play after ACL injury remains at around 80% in both the NFL and NCAA. Although reasons can be multifactorial, some of the common reasons players don't return are depth chart position, how much money being invested in the player such as dollar value of contract or scholarship awarded, and previous injuries. Unique to the NFL, players are easily replaceable because of a yearly draft and older players playing for as long as they can. Unique to the NCAA is the issue of four years of eligibility and how a majority of players are not going professional, so they may not have a great incentive to return to play.

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Evolution of the Surgical Management for Recurrent Anterior Shoulder Instability: Latarjet, Bristow, and Eden-Hybinette

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Abstract

Background: Surgical intervention may be recommended for recurrent anterior shoulder instability, especially when there is a bony defect to the glenoid. When this defect is larger than 20%, a bone block procedure may be the preferred operation.

Purpose: The purpose of this study was to follow changes in surgical management of anterior shoulder instability specifically comparing the Latarjet, Bristow, and Eden-Hybinette procedures. This study also follows changes in recommendations among the procedures and reports trends in current surgical management for anterior shoulder instability.

Study Design: Descriptive Study

Methods: Initial search with PubMed was done using the key terms "Latarjet," "Bristow," "Eden-Hybinette," and "Iliac Crest AND Shoulder." Search results were limited by human studies dealing with the shoulder. The search was done through each decade from 1940-present to note changes in volume of publications among each procedure. For the recommendations of surgical management, various articles and orthopaedic textbooks were consulted.

Conclusion: As with eponymous terms, the Latarjet, Bristow, and Eden-Hybinette procedures hardly resemble the original operation described. The Bristow procedure has been done with success, yet concurrent operations may be needed to address Hills-Sachs lesions or the labrum. Thus, the Latarjet procedure has gained popularity in that it addresses the bony defect, the labrum, and an engaging Hills-Sachs lesions without the need for concurrent operations. Recently, favor has been placed on the Eden-Hybinette procedure since the use of an iliac crest autograft can maintain shoulder anatomy and can repair larger defects (>40%) of the glenoid. Overall, the surgical management of shoulder instability has seen a decrease in open procedures with an increase in bone block procedures over the last two decades.

Key Terms: Latarjet, Bristow, Shoulder Instability, Bone Block

Introduction

The glenohumeral joint is unique in that it can maintain reliable and consistent contact between the humeral head and the glenoid fossa through a wide range of motion. This balance of stability is maintained through dynamic and static forces. Several factors may contribute to instability of the shoulder such as ligament laxity, shallowing of the glenoid curvature, or rotator cuff weakness.[1] In the instance of traumatic dislocations, an anteriorly-directed force is exerted on the arm while the shoulder is externally rotated. The shoulder is the most commonly dislocated major joint in the body with an annual incidence of 24 cases per 100,000 reported in 2010.[2] Anteroinferior shoulder instability is the most common pattern accounting for over 90% of cases.[1] Nearly half of all anterior shoulder dislocations occur in persons aged 15 to 29 years with the incidence being three times higher in males.[2] Recurrence rates have been reported as high as 96% in young athletes treated nonoperatively.[1, 3] This presents an issue as there remains little consensus for the surgical management of shoulder instability despite an abundance of peer-reviewed literature.

Many procedures have been proposed for anterior shoulder instability ranging from capsulolabral repairs (Bankart) to bone augmentation procedures (Bristow, Latarjet, and Eden-Hybinette).[1] Arthroscopic capsulolabral repair remains the first line surgical management for the majority of patients. However, younger patients (<22 years), male gender, competitive-level sporting activity and glenohumeral bone loss have been identified as risk factors predisposing patients to recurrent anterior shoulder instability after nonoperative and arthroscopic Bankart repair.[4] Bony defects of the anteroinferior aspect of the glenoid can occur acutely or gradually over time with recurrent instability. Glenoid bone loss has been reported in up to 22% of initial dislocations

and up to 86% in cases of recurrent instability.[5, 6] Inferior glenoid bone loss from recurrent instability results in an inverted pear-shaped glenoid. Burkhart and De Beer[7] found that capsulolabral repair alone in the setting of an inverted pear glenoid led to a 67% failure rate and 89% recurrent instability in contact athletes treated with soft tissue stabilization alone.[8]

There has been a trend towards increased utilization of bone block procedures among recently-trained orthopaedic surgeons with the Latarjet and Bristow procedures remaining most popular.[9] The Latarjet and Bristow procedures have undergone many revisions and hardly resemble the technique initially described resulting in little continuity among the literature.[10] Without a thorough description of the procedure referenced, it is difficult to decipher if the surgeon is performing the original procedure, a variation, or a new procedure entirely. Furthermore, several authors have combined the two techniques and now refer to it as the Latarjet-Bristow procedure.[11–17] Recently, there has been an increase in iliac crest bone graft (ICBG) procedures for glenoid reconstruction. This procedure, which was originally described by Eden and Hybinette in 1918, has also undergone various changes. The Eden-Hybinette procedure has been used for revision procedures for failed Latarjet procedures but has recently increased in popularity as the primary procedure for anterior shoulder instability. This paper aims to clarify these three procedures, their progression and modifications, and the current trends in surgical management of anterior shoulder instability. Understanding the evolution of procedures and where they fit among various other surgical interventions can greatly aid in surgical outcomes and the refinement of techniques.

Methods

Initial search done through PubMed with the following key terms, "Latarjet Procedure," "Humans," "English," and "Shoulder," yielded 230 results of which 44 papers were included. No exclusion criteria were defined regarding case reports, biomechanical studies, systematic reviews, or clinical trials. Another PubMed search with the following key terms, "Bristow," "Humans," and "Shoulder," yielded 150 results, most of which also appeared in the previous "Latarjet search." All publications included from the "Bristow" search appeared in the "Latarjet" search. Any duplicate articles were excluded.

Searches to find trends in the number of procedures performed was done using PubMed with a search for "Latarjet trends" (five results), all of which were included in this study, and "Bristow trends" (zero results). Trends in publications were observed through the number of publications during each decade from 1940, 1950, 1960, 1970, 1980, 1990, 2010, to present (17 July, 2018). Searches for each decade were done four ways: "Latarjet AND Shoulder AND Human," "Bristow AND Shoulder AND Human," "Eden-Hybinette AND Shoulder AND Human," and "Iliac crest AND Shoulder AND Human."

Results

Historical Revisions of the Latarjet and Bristow Procedures

Michele Latarjet originally described a coracoid bone block technique for recurrent anterior shoulder dislocation. He reported osteotomy of the coracoid process between the pectoralis minor and the conjoint tendon insertions.[18] In order to facilitate glenoid exposure, he performed a subscapularis tenotomy and achieved graft fixation with one inferior screw with the coracoid process oriented with the coracoid inferior surface against the anterior glenoid rim. The subscapularis tendon is then routed over the coracoid process and sutured to the attached conjoint tendon.[17] In 1980, Patte and Debeyre sutured the anterior joint capsule to the stump of the coracoacromial ligament.[19] Furthermore, they described the mechanism by which the coracoid process transfer contributed to glenohumeral stability. The "triple-blocking procedure," which restored the glenoid arc through glenoidplasty, formed a sling with the intact lower third of the subscapularis, and resutured the capsule to the coracoacromial ligament.[19] Later in Randelli's textbook, "Surgical Techniques for the Shoulder" published in 1995, there is mention of using two screws to fix the coracoid process to the glenoid.[17] Following Nisset's cadaveric study proving a successful arthroscopic Latarjet operation, Lafosse describes a five-step process of performing an arthroscopic Latarjet procedure in 2007.[20] The procedure underwent another major revision in 2009 with De Beer proposing the "congruent arc" method, where the coracoid process is rotated 90 degrees along the longitudinal axis so that the lateral portion of the coracoid is in contact with the rim of the glenoid.[21] This forms a continuous surface between the glenoid and the inferior curve of the coracoid. Biomechanical studies have shown the inferior curve of the coracoid process is anatomically similar to the curve of the glenoid fossa.[22] The rectangular nature of the coracoid process allows repair of a larger osseous defect with this congruent arc method.[23–26] Currently, the use of suture anchors to repair the joint capsule is recommended, although Latarjet himself

Table 1. Publications Involving the Latarjet Procedure Increased the Most of the Four Searches

Decade	Latarjet	Bristow	Eden-Hybinette	Iliac Crest and Shoulder
1940–1950	0	0	0	1
1950–1960	4	0	0	0
1960–1970	3	4	8	8
1970–1980	1	6	3	9
1980–1990	18	40	2	14
1990–2000	19	26	5	32
2000–2010	59	34	3	68
2010–7/17/18	208	49	4	88

Figure 1. Historical Progression of the Latarjet, Bristow, and Eden-Hybinette Procedures with Modifications

makes no mention of this step.[27] Further technical revisions have been proposed such as the use of bioabsorbable screws,[28] the use of cortical buttons rather than screws,[29] and the use of a Titanium Nickelide prosthesis rather than the coracoid process.[30]

In 1958, Helfet[31] published results using a similar procedure that he attributed to his mentor W. Rowley Bristow 19 years prior. Bristow proposed osteotomizing the proximal 2.5 cm of the coracoid process and suturing it to the anterior part of the scapular neck medial to the glenoid rim through a vertically orientated subscapularis split.[31] McMurray modified the Bristow procedure by securing coracoid process graft to the glenoid rim with a cortical screw in place of sutures. Then in 1970, in addition to McMurray's modification, May performed a subscapularis split with a vertical incision and divided the muscle parallel to its fibers to allow direct visual placement of the graft.[16] May coined this variation the modified Bristow procedure.[16] In 1983, Hovelius notes the similarity of the two procedures and jointly refers to the Latarjet-Bristow procedure.[32] Later, the procedure undergoes further revision as Torg et al. report on their experience transferring the coracoid process with an intact conjoint tendon over the superior border of the subscapularis, naming it the modified Bristow-Helfet-May procedure.[33] Torg et al. proposed that this increased exposure allowed for easier repairs in revision surgery and maintained the entire subscapularis tendon and muscle providing a "sling effect" as previously described by Patte.[33–35]

In 1918, Eden[36] and Hybinette[37] independently described transferring a free autologous portion of the iliac crest.[38] The original description placed the graft under the anterior glenoid periosteum of the anterior rim of the glenoid without fixation.[39] In 1948, Eyre-Brook proposed using a screw to fix the iliac crest bone graft (ICBG) to the glenoid.[40] This proce-

dure was further revised in 1951 by Avik, who proposed removing the anterior portion of the labrum. With use of an osteotome, a groove was made in the anterior aspect of the scapular neck, and the ICBG was "jammed" into the groove without fixation.[40, 41] A 0.5–1.0 cm portion of the graft was left prominent, expanding the curvature of the glenoid roughly 1 cm.[41] In 1976, Cobey proposed strengthening the construct with sutures; however, this technique did not become popularized.[42] Bodey and Denham in 1983 advised inserting the ICBG into the anterior portion of the glenoid with no further fixation and no repair of the subscapularis or capsule.[42] Their argument is that by removing the hardware, there is a reduced risk of failure.[42] In 2000, Lazarus and Harryman propose placing capsular sutures between the ICBG and the glenoid, then using two lag screws to firmly attach the graft to the glenoid.[43] Currently, the procedure is often performed by splitting the subscapularis along its fibers, fixing the ICBG to the anterior glenoid with two screws and repairing the subscapularis and capsule.[1, 44, 45]

Surgical Trends

Initial procedures for treating anterior shoulder instability emphasized preventing further dislocations rather than restoring the anatomy. Such procedures as the Putti-Platt and the Magnusson-Stack proved successful through shortening the subscapularis muscle and limiting external rotation. Other non-anatomical procedures such as the Latarjet and Bristow used the coracoid process as a bone block to stabilize the shoulder. These procedures proved successful in limiting further dislocation yet showed limited postoperative external rotation and increased osteoarthritis.[46–48] Some surgeons moved toward arthroscopic repairs to mitigate these adverse outcomes, yet the use of staples and transglenoid sutures led to a high failure rate. In 1990, the switch to suture anchors to repair the labrum greatly increased the success of arthroscopic repair making it more favorable than the open, non-anatomical interventions of the past. Currently, arthroscopic Bankart repairs remain the most common surgical procedure for anterior shoulder instability and recommended to treat first time dislocations in young athletes (<25 years of age) wishing to return to sport.[1, 49]

Analysis of failed Bankart repairs has demonstrated the importance that glenoid bone loss plays in recurrent shoulder instability. Glenoid bone loss has been reported in up to 22% of initial dislocations and up to 86% in cases of recurrent instability.[5, 6] Unaddressed glenoid bone loss is a known risk factor for failure after arthroscopic soft-tissue stabilization. Therefore, it was recommended to perform a Bankart repair to address the labrum in combination with a Bristow procedure to address the glenoid defect.[50] With the increased recognition that glenoid bone loss plays in recurrent instability, the Latarjet procedure increased in favor compared to the Bristow procedure. The Latarjet procedure has been shown to outperform the Bristow procedure when addressing bone loss.[29, 47] The bone graft placement in the Latarjet procedure allows for greater surface contact and thus better bone healing than in the Bristow procedure.[29] When used to address glenoid bone loss, a biomechanical analysis showed the Latarjet procedure to better restore glenohumeral joint stability and have fewer dislocations than the Bristow procedure.[47] Furthermore, proponents of the Latarjet procedure favor its triple-blocking effect and ability to address the glenoid deficiency, the Bankart lesion, and an engaging Hill-Sachs lesion that often accompanies anterior shoulder instability compared to a Remplissage procedure which only addresses the engaging Hill-Sachs lesion.[46, 51] Therefore, in 2008, the Latarjet procedure was proposed as the preferred bone block operation for anterior shoulder instability.[52]

Currently, the Latarjet procedure is recommended as the primary procedure in patients with critical bone loss of >25%[45, 53] and as a revision procedure for failed Bankart repairs.[44] Recent debate has shifted to quantifying the glenoid defect size warranting glenoidplasty. It is generally accepted that bone augmentation procedures should be considered in glenoid defects greater than 20%. However, recent research has demonstrated defects as low as 13.5% may warrant bone augmentation when in an active military population.[54] Between 2012 and 2015, the number of Latarjet procedures performed for anterior shoulder instability in a military population increased from 1.7% to 3.56%, which may be attributed to the increase in the use of advanced imaging and computed tomography to recognize the presence of bone loss.[55] A similar study found the number of Latarjet procedures increased 950% between 2003 and 2014.[56] One study has shown the Latarjet procedure has increased in incidence by 15% each year.[57]

The Eden-Hybinette procedure has remained popular in Scandinavian nations. Its popularity has increased recently although it is rarely referred to by this name. At times, it is referred to as the Latarjet procedure with an iliac crest autograft. The procedure replaces the coracoid process autograft with an iliac crest autograft used in fixation. The Eden-Hybinette procedure has proven successful as a revision surgery for failed bone block procedures.[44, 58] Recently, it has increased in favor as a primary treatment for surgeons aiming to maintain the anatomical contour of the glenoid.[45] Due to a greater portion of bone available in the iliac crest, the Eden-Hybinette procedure has been recommended for large glenoid defects that approach 40% bone loss.[53] However, the need for a fresh humeral head allograft or talar osteochondral allograft may also be considered.[51] For glenoid defects of 20%, the Latarjet procedure is recommended as first-line treatment with an iliac crest autograft or distal tibial allograft recommended as a revision procedure.[51] The use of a distal tibia allograft has been mentioned, yet autografts are favored for greater availability, greater healing potential, and less potential for resorption.[53]

Surgical trends continue to change as new technology becomes available and procedures are revised. Surgeons differ in their preference of the congruent arc method, popular-

ized by Burkhart and De Beer, over the classic Latarjet procedure. The use of bioarbsorbable screws have resulted in an increase in resorption and recurrence rates compared to cortical screws.[28] The use of button sutures demonstrated greater surface contact between the coracoid graft and the glenoid rim.[29] Furthermore, the use of a titanium nickelide graft has shown to be successful in repairing the osseous defect and maintaining the anatomy of the shoulder.[30]

Current Trends

Zhang et al. identified 23,096 cases of shoulder stabilization between 2004 to 2009 using the PearlDiver Patient Record Database. They found that there was a stepwise decrease in total open procedures performed, which is largely attributed to the decrease of open Bankart repairs from 700 cases (4.48 per 10,000 patients) in 2004 to 432 cases (2.42 per 10,000 patients) in 2009.[49] In the same population, coracoid process bone block procedures increased from 27 cases (0.17 per 10,000 patients) in 2004 to 78 cases (0.4 per 10,000 patients) in 2009.[49]

Bonazza et al. used the MarketScan database to identify 66,564 surgical shoulder stabilization procedures, 1,623 of which were open bone block procedures, between 2008 to 2012.[59] They found the number of bone block procedures has increased each year from 174 cases in 2008 to 484 cases in 2012; the percent of open Bankart repairs has decreased from 1,061 cases in 2008 to 864 cases in 2012.[59]

Arthroscopic stabilization was the most broadly-used shoulder stabilization procedure (87%) followed by the Bankart repair (7%) and the Latarjet repair (2.6%) according to a retrospective study analyzing Current Procedural Terminology codes in a publicly available national insurance database.[57] However, throughout the course of the study, the incidence of arthroscopic stabilization and the Latarjet repair increased 8% and 15% per year, respectively.[57] The incidence of the open Bankart repair decreased 9% per year.[57] There is discrepancy on the approach to the subscapularis with some surgeons incising the superior portion of the subscapularis tendon and others splitting the muscle.

Conclusion

The management of anterior shoulder instability continues to change as technology further improves upon techniques. Currently, arthroscopic Bankart repair remains the most common procedure done for anterior shoulder instability. However, the Latarjet procedure continues to prove effective in addressing glenoid defects and is now the preferred bone block procedure, especially over the formerly-recommended Bristow procedure. Furthermore, a historic procedure, Eden-Hybinette, is seeing a resurgence as the iliac crest is replacing the coracoid process for bone block procedures.

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Medical Student Research Project

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Fatal and Near Fatal Asthma Attacks in Young Athletes: A Literature Review of Incidence, Risk Factors, and Guidelines

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Abstract

Asthma is a prevalent medical condition among young athletes, but there is limited literature on the incidence of near fatal and fatal asthma attacks during sports. The objective of this study is to review the current literature on the topic and identify risk factors with the intent to reduce mortality in this demographic. Out of 29 initial results, six articles that primarily focused on near fatal asthma attacks in athletes were selected for review. A common finding across all articles was the poor or non-adherence to asthma medications that preceded the near fatal asthma attacks. An additional significant finding was the inefficient screening of athletes who experienced exercised-induced asthma and related asthma attacks. Further research is required to fully elicit the epidemiology and risk factors associated with near fatal asthma in addition to the most effective treatment methods to reduce mortality in the young athletic population.

Introduction

The most recent asthma public health report estimated that 382,146 children had lifetime asthma in the state of Pennsylvania, including 13.4% of all children between the ages of 10 and 14.[1] This is a significant number considering children within this age range are increasingly engaged in team sports.[2] Near fatal asthma exacerbations can occur in all children with asthma but they are more common in those with severe asthma, defined as patients who require high dose oral or inhaled glucocorticoids to maintain symptom control.[3] Although there is literature about athletes who have asthma and exercise-induced asthma, there is limited information specifically about the epidemiology of near fatal and fatal asthma attacks in this particular demographic. There is evidence that demonstrates that sudden fatal asthma attacks can occur in recreational and competitive athletes.[4] This information would be helpful for pediatricians, general practitioners, and sports medicine specialists to reduce mortality in this demographic.

There is no formal definition of near fatal asthma, but it usually involves the following: dyspnea that prevents speech, decreased consciousness, hypercapnia (>50 mm Hg of CO_2), a prior ICU admission, respiratory or cardiopulmonary arrest, orotracheal intubation and mechanical ventilation.[3, 5, 6] Not all children with asthma participating in strenuous activity present in this way. Many experience a milder exercise-induced asthma or bronchoconstriction, which is the transient narrowing of the airways during exercise.[7, 8] Although this most commonly occurs in those with a history of asthma, it can also occur in athletes without it.[7, 9] This milder manifestation of the disease can be a precursor to severe asthma and near fatal attacks. This literature review attempts to compile information about the epidemiology and risk factors of near fatal and fatal asthma attacks during sports over the past 10 years. First, we attempt to review the specific risk factors for near fatal asthma attacks. Then, we provide an overview of the epidemiology of asthma in the athletic population. Finally, we provide the most current guidelines for the management of these patients.

Methods

This literature review was collected using an electronic search on the PubMed database. In order to find specific information pertaining to the epidemiology and risk factors of fatal asthma attacks in young athletes, an initial search was done with the terms "asthma mortality," "sports." Articles were screened by reading the title and abstract. They were subsequently chosen if they specifically discussed asthma and athlete mortality. Of 29 initial results, six were chosen for in depth review. While the authors acknowledge other leading causes of mortality in the young athletic population such as congenital cardiac anomalies and sudden cardiac death, this review focuses specifically on near fatal asthma. As such, articles were excluded if they discussed

cardiac causes of mortality. The references provided in the papers reviewed were also analyzed and some were included in the subsequent discussion.

Various additional searches were also performed to ensure important publications were not omitted from discussion. One initial search used the terms "athletes," "asthma," which yielded 592 articles. Twenty-six of these were screened based on title and abstract and 10 were selected and reviewed in depth. Papers published earlier than 2008 or in a foreign language were excluded from analysis. In all, 16 articles were utilized for this literature review.

Results

Review of Fatal and Near Fatal Asthma Attacks in Young Athletes

A 2004 study by Becker et al. specifically explored fatal asthma attacks in young athletes. Between July 1993 and December 2000, 61 cases of asthma-related deaths were analyzed. Results from this publication demonstrate that young adults can die from asthma exacerbations while participating in sports. The authors conclusions strongly suggest that those with asthma have an increased risk of fatal asthma attack triggered by athletic activity.[4] Although 90% of those who died were known to have asthma, only 5% of them were using long-term respiratory medications to control their asthma. Most of these athletes only had mild to moderate untreated asthma. The authors concluded that the athletes who died from asthma often underestimated the severity of their condition.

Both cardiology and pulmonology physicians were consulted about the nature of sudden death in young athletes. They concurred that while cardiovascular-related deaths are common in adult patients, children and young adults more commonly die from hypoxia related to asthma. The specialists speculate that hypoxia in younger patients can cause dysrhythmia, tachycardia initially followed by late stage bradycardia, which can lead to cardiac failure and ultimately death. This phenomenon is corroborated by prior clinical research.[10]

This study highlighted the difficulties in obtaining information related to asthma-related deaths due to differences in recording and reporting fatalities in different jurisdictions. It also demonstrated that HIPAA personal health information restrictions limit further study into the topic because it requires disclosure of the information pertaining to an individual's death.

Risk Factors for Fatal and Near Fatal Asthma Attacks

Lang et al. studied trends in fatal asthma attacks in athletes across Australia, New Zealand, Canada, and the US in the early 2000s.[6] According to their data, risk factors for fatal asthma include prior severe, life-threatening exacerbation, oral steroid dependency, respiratory failure requiring ventilation, rapid oscillation between normal and abnormal lung function. Cofactors that increase risk are poor asthma control, atopic allergy, and non-adherence to asthma therapeutics.[6]

Serrano-Pariente et al. studied molecular level characteristics of patients who experienced near fatal asthma.[3] Increased granzymes and perforins were found in pulmonary tissue of patients who experienced near fatal asthma. This post mortem tissue also contained high levels of the cytokine IL-8 in addition to increased CD-8 T-cells. Another risk factor the authors listed was exposure to aeroallergens, which can cause sudden near fatal asthma attacks regardless of whether an individual has pre-existing asthma. This is particularly relevant for young athletes with asthma who participate in outdoor sports.[3] In general, athletes who participate in summer sports such as baseball are more likely to be exposed to airborne allergens whereas those who participate in winter sports such as football are more likely to be exposed to cold air. Swimmers are frequently exposed to chlorine compounds. All of these exposures can worsen asthma and could lead to a fatal asthma attack.[11]

The most important risk factor for near fatal asthma listed by authors was poorly-controlled asthma from poor adherence to anti-inflammatory and asthma therapeutics.[3, 5, 6] Near fatal asthma most commonly occurs in patients who have severe and poorly-controlled asthma as well as evidence eosinophilic inflammation that is slow to respond to therapy.[5] A retrospective cohort study done by Gullach et al. in Denmark reached similar conclusions.[12] This study examined the death certificates of those who had uncontrolled asthma. Uncontrolled asthma was defined as previous hospital admission due to an exacerbation or when asthma was believed to be the cause of death. Out of 625 cases of sudden, unexpected death of all causes, 49 individuals were found to have uncontrolled asthma.[12] Of those 49 individuals, 27% of them died from a fatal asthma attack.[12]

Epidemiology of Asthma in Athletes (Exercise-induced Bronchoconstriction)

Exercise-induced bronchoconstriction, EIB, is the transient narrowing of the airways during exercise characterized by chest tightness, wheezing, coughing, and unusual shortness of breath.[13] It is triggered specifically by exercise and while 90% of athletes who have asthma are affected by this phenomenon, it can also manifest in athletes without documented asthma.[13] Such symptoms can trigger an asthma attack and, as shown by Becker et al., can be fatal if severe. Almost half of the athletes in Burnett's study self-reported that they experience exercised-induced bronchoconstriction.[13] An important revelation in this study was that 25% of athletes (14 out of 56) who had a history of asthma or EIB self-reported that they were not taking any asthma medication. This data raises concern because these athletes regularly engage in strenuous activity and may not have been screened appropriately. This disparity was highlighted by

Parsons et al. when he analyzed the prevalence of exercise-induced bronchoconstriction at one higher education institution:

"Eleven athletes had a history of asthma. All athletes, including the 11 athletes with asthma, had normal spirometry at rest and were able to meet American Thoracic Society standards for forced vital capacity measurement," the maximum volume of air that can be forcefully expired after maximal inspiration.[8] However, "42 of 107 athletes (39%) had positive Eucapnic Voluntary Hyperventilation (EVH) tests, which indicated that they had EIB."[8] This test is an indirect bronchoprovocation test similar to the exercise challenge. The athletes in this study inspired dry or dry and cool air that was comprised of 5% CO_2, 21% O_2, and some N_2 for six minutes at 85% predicted maximum voluntary ventilation.[14] Athletes who have EIB would have difficulty continuing for six minutes and would show a decrease in their forced expiratory volume in one second.[14] This test is considered more sensitive than testing for EIB in the field setting.[14] "Sixteen of 22 sports represented in the trial had at least one EIB-positive athlete.[8] Of the 42 EIB-positive athletes, 36 (86%) had no prior known history of asthma or EIB.[8] Only three of 107 athletes were on any type of asthma medication, and all three were EIB positive."[8] The study reported that some athletes dismissed their symptoms as a "poor conditioning day" or "bad training" and did not relate their symptoms to asthma.[8] This is potentially dangerous considering many athletes did not know they had EIB and are not taking any asthma medication.

Modern Guidelines for Young Athletes with Asthma

Based on the literature, the following are the most up to date guidelines for athletic staff monitoring athletes with asthma. It is important to note that based on the prior discussion, it is possible that some individuals who are at risk for EIB may be under identified using the current guidelines:

- It is recommended that athletes who have a known history of asthma or are suspected of having asthma should have a thorough medical examination.[15] Even if the athletes appears to be well, a second EIB or asthma test during the extensive physical examination should be done.[13]
- Staff must also educate athletes who have asthma about using their medications prophylactically before exercise and recognizing the signs of symptoms.[15]
- Athletes with asthma must undergo the warmup activities to prevent attacks.[15] Warming up prior to exercise reduces exercise-induced bronchoconstriction.[11]
- A common recommendation is that athletes with asthma should use an inhaled corticosteroid prior to participating in sport activity.[11]
- When training, athletes with asthma must start off at a lower intensity level and gradually increase over time.[15]
- In the event of an acute asthma exacerbation, the athlete should immediately use a short acting β_2 agonist. If the attack is severe, multiple doses must be given. If the attack is not relieved after three administrations, the athlete must be sent to a nearby facility.[15]
- After an asthma attack, the athlete must be completely asymptomatic before returning to play.[15]

Conclusion

A common conclusion across all the papers reviewed is that there is a need for more efficient screening for asthma in young athletes. It is possible that a more ubiquitous use of EVH, for example, could lead to more individuals at risk for near fatal asthma being identified early. This would enable the practitioner to implement appropriate treatment and reduce mortality. Another important conclusion is the need to educate patients and families on the importance of strict adherence to asthma treatment. This would lower the prevalence of uncontrolled asthma. With appropriate treatment and management, fatal and near fatal asthma attacks can be prevented. Current advancements in asthma medication and treatment allow asthmatic athletes to participate at the collegiate, Olympic, and professional level.[16]

While this review focuses on mortality from asthma, it should be noted that the increased risk of death associated with asthma during sports is, in reality, very small.[16] Although the concern is valid, having asthma should not discourage young individuals from participating in sports.[16] It is not fully known whether asthma attacks are a facilitator of sudden death in young athletes. As demonstrated herein, there is a paucity of information in the medical literature. Further research is required to fully elicit the epidemiology and risk factors associated with near fatal asthma in addition to the most effective treatment methods to reduce mortality in the young athletic population.

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Medical Student Research Project

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Are There Factors Responsible for Selected Predisposition to Concussion, Prolonged Recovery, and Chronic Traumatic Encephalopathy in Athletes?

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Abstract

Concussions are highly prevalent sports-related injuries that usually result in brief neurological dysfunction. Certain groups seem to experience these injuries more frequently with recovery that can last a month or longer and long-term complications such as the debilitating neurodegenerative disease Chronic Traumatic Encephalopathy (CTE). A literature search was performed to investigate factors that may increase one's risk for concussion and poor outcomes. The results of this review identified numerous risk factors but history of TBI is the only one consistently associated with an increased risk suffering a concussion, experiencing prolonged recovery and developing CTE. The remainder of the literature has identified useful areas to explore further with more robust, prospective studies explicitly investigating these risk factors. Future findings will have significant implications regarding the management and prognosis of concussion injuries.

Introduction

It is estimated that up to 3.8 million sports-related traumatic brain injuries (TBI) occur each year.[1] Concussions are the most commonly reported TBI, especially among participants of contact sports.[1] The ubiquity of these injuries poses a serious public health concern. A concussion is defined as a mild form of TBI resulting in a rapid onset of transient neurological dysfunction.[2] Associated symptoms, such as headache, emotional lability, slowed reaction time, amnesia and insomnia, typically resolve spontaneously after 10–14 days.[2] However, some individuals experience persistent symptoms that delay their recovery past the expected time.[2] This prolonged recovery is often referred to as postconcussion syndrome and is generally diagnosed in those whose symptoms persist for more than four weeks.[3] With repeated trauma to the brain, individuals can experience debilitating sequelae. The most severe of these outcomes is Chronic Traumatic Encephalopathy (CTE), a neurodegenerative disease accompanied by behavioral, cognitive and motor deficits.[4]

There is an increasing amount of awareness regarding the connection between contact sports and the neurological health of participants, due in part to the recent deaths of several former athletes presumed to be linked to CTE.[5–7] In a recent post-mortem study of American football players at various levels, 87% of the observed brains were determined to have CTE.[8] While the incidence of concussion is relatively high, the associated negative outcomes following injury are not universally present in all individuals who experience brain trauma.[9] Certain individuals experience concussion, prolonged recovery and other sequelae more than others. Researchers have been investigating the potential risk factors that might be responsible for this predisposition to poorer outcomes. Given that the pathophysiological bases of concussion and CTE are not completely understood, it is necessary to look for other factors that may help identify individuals who may be at a higher risk. A deeper understanding of these factors has significant implications on the ways in which we currently manage concussion in athletes. It may also help to prevent undesirable outcomes by identifying at-risk populations. This review will report on the genetic, environmental and behavioral risk factors present in the literature.

Methods

For this literature review, an initial search was performed using the terms "Concussion," "Post Concussion Syndrome" and "Chronic Traumatic Encephalopathy" on the point of care databases UpToDate and Dynamed Plus. After a base of knowledge was established, a more organized database search was performed using PubMed to find relevant articles. On 7/9/2019, three separate queries were performed. The first search used the terms "concussion risk factor athlete" and returned 296 total items. The following search used the terms "postconcussion syndrome risk factor sports" and

returned 49 total items. The final search used the terms "chronic traumatic encephalopathy risk factor sports" and returned 52 total items. All articles available in English published prior to the search date that either reported primary data or reviewed studies that reported primary data were considered. Articles that did not explicitly include athletes in their sample were not considered for this review. The results and discussion sections of selected articles were closely reviewed to identify the risk factors that may predispose individuals to concussion, prolonged recovery following injury and CTE. The references sections of selected articles were used to identify relevant studies that did not appear in the primary literature search.

Results

The primary search performed for this review returned 397 total articles and after close assessment of the literature, 102 articles were selected. The risk factors identified are listed in Tables 1, 2 and 3. The selected articles include an assortment of study types and measured their outcomes using varying standards. The findings have been presented below in aggregate to provide a general overview of the literature.

Concussion

A prior concussion was described in several studies as an important factor that increases one's risk for subsequent concussion.[3, 10, 11] Several researchers observed that athletes with a history of concussion had a risk of subsequent injury up to 11 times higher than comparison groups.[12, 13] This risk factor was implicated in various sports, including rugby, ice hockey, soccer and American football.[14] In a study of American football players, it was reported that athletes with three or more concussions were three times more likely to experience subsequent concussion.[15] Even after adjusting for several factors, including sport contact level, body mass index and year in high school, a prospective study on teen athletes in North Carolina found that history of concussion remained a strong risk factor.[16]

Similarly, premature return to competition following concussion was also associated with an increased risk of subsequent concussion.[17] One group of researchers suggested that a "window of vulnerability" for future injury may exist, though no epidemiological data exists to support this.[18] This time frame may be as long as 10 days and as short as the duration of one competitive event in which a participant experiences two separate impacts to the head.[19]

Table 1. Risk Factors for Concussion

History of concussion
Premature return to competition
Female sex
Lower age
Less physical maturity
History of ADHD
History of learning disability
History of migraine/headache
Treatment for headache
History of mood disorder
Treatment for psychiatric illness
Baseline report of dizziness, headache and neck pain
In-game fatigue
Lower strength of neck muscles
Preseason activities (American NCAA football)
Participation in games and matches
Increased amount of contact and protective equipment
Participation in American football (male) and soccer (female)
Participation in contact sports
Participation in Division III American football
Total number of matches played
Lower altitude
Impact to the top or temporal region of the head
Player-to-player contact
Lack of helmet use (soccer and rugby)
Aggressive behavior
Allelic variants of ApoE, ApoE promotor, tau protein and IL-6 receptor genes

Table 2. Risk Factors for Prolonged Recovery

History of concussion
Concussions within close proximity
Additional impact within 24 hours
Double hit injury
Female sex
Concussions suffered in a non-helmeted sport
Early return to vigorous activity following injury
Continued participation after display of symptoms
Delayed resumption of pre-injury activities
Number and severity of acute symptoms
Delayed symptom onset
Worsening symptom burden
Pre-existing sleep disorders
Sleep disturbances and low sleep quality
History of birth trauma, pediatric head injury or intracranial pathology
Experiencing cognitive deficits, insomnia, drowsiness, noise sensitivity, headache, fatigue, nausea, visual disturbances, emotional changes and loss of balance
History of ADHD
History of learning disability and lower cognitive ability
Personal and family history of mood disorder
History of migraine and headache
Treatment for headache
ApoE ε4 genotype
Belief that symptoms may have negative effects on QoL
History of seizures
History of neurodevelopmental disorder
Pre-existing motion sickness
Improper helmet fit
Lack of facial protection (ice hockey)
Need for initial hospitalization

Table 3. Risk Factors for CTE

History of brain trauma
Length of career
Age of exposure to brain trauma
Participation in contact sports
Chronic systemic inflammation
ApoE allelic variants
Lower cognitive reserve
Developmental and demographic factors
Drug and alcohol abuse
Surgeries and anesthesia
Sleep difficulties

The results from several studies indicate a greater incidence of concussion among female athletes across all ages and sports.[10, 14, 20–22] This finding was not universal as some studies found no association between sex and incidence of concussion.[14] Several studies reported that male athletes were at higher risk for concussion when comparing different sports.[14, 19] One group of researchers noted that male athletes were more likely to participate in high-collision sports which may bias the comparison between sexes.[14] Studies investigating concussion rates for sports in which the rules and contact levels are generally equivalent between sexes found that female athletes appear to be at greater risk.[10, 14, 19, 23, 24]

When comparing across age, younger age was identified as a risk factor for sustaining a concussion.[10, 11, 14, 19, 20, 25, 26] Similarly, the observation that athletes playing in leagues grouped by age were at higher risk if they were smaller than their peers[14, 27] suggests that lacking physical maturity may be a risk factor for concussion as well. Researchers suggested that larger heads relative to body size, relatively weaker necks,[11] and differences in brain developmental status[25] were predisposing factors for concussion in this population of younger, less physically-mature athletes. However, other studies indicate a higher risk for older athletes,[12, 26, 28] potentially due to the increased amount of force they may be subjected to.[14]

Certain comorbidities have been proposed to be risk factors for concussion. A history of migraines has been reported to increase the risk for concussion,[19] although the overlap between the symptoms of migraine and concussion may make it difficult to distinguish the two.[25, 26] A history of treatment for headaches also increases risk for concussion.[3] A history of Attention Deficit Hyperactivity Disorder (ADHD) has been reported to be correlated to an increased risk of concussion.[3, 29, 30] However, it remains unclear whether increased interaction with healthcare providers leads to more symptom reporting or if a more direct relationship between disease processes exists.[11, 29, 30] A history of learning disability has also been reported to increase one's risk of concussion.[3] Although no studies have shown a correlation between diagnosis of a mood disorder and increased risk for concussion, a correlation has been noted between treatment for psychiatric illness and increased risk for concussion.[25]

Baseline report of symptoms such as dizziness, neck pain and headache was identified as a risk factor for concussion in a study of one youth hockey league.[31] It has been suggested that fatigue plays a dual role in predisposing athletes to concussion. Because the pathophysiology of concussion is thought to be related to be an energy crisis, researchers have proposed that athletes who are more energy depleted may be at a higher risk of injury.[19, 32] Additionally, as fatigue is known to reduce one's reaction time and ability to respond efficiently to a dynamic playing environment, this may also lead to a higher risk for injury.[14] Greater overall neck strength was shown to decrease risk of concussion.[33]

Concussion rates in collegiate American football were found to be higher during the preseason when compared to the regular season and postseason.[34] This observation held true when stratified by contact level and amount of equipment worn.[35] When comparing games to practices, several studies found that participation in games was associated with a higher risk of concussion,[10, 14, 26, 28, 36] indicative of a relationship between intensity of play and injury risk.[14, 35] Cheerleading was the only sport in which practice rates of injury were higher.[16] Similarly, increased amounts of protective equipment worn and increased levels of contact were both correlated with higher rates of concussion. American football players experienced the highest rates of concussion during live-contact, fully-padded practices and scrimmages.[34, 35] Comparable findings were reported for ice hockey.[10, 14, 37]

Participation in any sport is an evident risk factor for sustaining a concussion.[36, 38] When comparing the rates of concussion in different sports, many studies reported that football had the highest rate of injury for male athletes[10, 11, 20, 23, 39] and soccer had the highest rate of injury for female athletes.[10, 20, 22, 26, 39] In general, contact sports like ice hockey, football, and lacrosse carry a higher risk of injury.[3, 16, 20, 25, 26, 38] Lower rates of concussion were noted in non-contact sports like baseball, volleyball, gymnastics, and softball.[36, 39] There are hypotheses that different positions in each sport carry varying risks of injury due to differences in playing time and opportunities for collision.[11] However, due to inconsistent findings, this proposition is not yet conclusive.[14] Collectively, the studies selected for this review did not agree on any position in American football to be at increased risk for concussion.[14, 25, 26, 39–41] In rugby, the studies selected for this review either showed no difference or conflicting findings.[14, 26, 39] In soccer, goalies and defensive players were most often identified as being at the highest risk of concussion.[12, 26, 42] In ice hockey, defenders and forwards were reported to be at the highest risk of injury.[14] Level of play only led to an increased risk of concussion when Division III collegiate football was compared to Division I and Division II.[14, 34] Other studies found no difference when comparing rates of concussion between professional and college athletes, and athletes in different divisions of a professional league.[14, 24] The total number of matches played was positively correlated with concussion incidence in one study of Australian football players.[43]

Geographic altitude was inversely correlated with risk of concussion,[44, 45] believed to be due to decreased intracranial compliance at higher altitudes which may provide the brain with a tighter intracranial fit.[45] Impacts to the top[37] and temporal[14] regions of the head were identified as risk factors for sustaining a concussion. In several studies, a substantial portion of concussions were found to be due to player to player contact; more specifically, these collisions involved contact directly to the head or helmet.[25] A number of studies investi-

gated the use of protective equipment and the effect on concussion rates. In several sports, it was observed that players who wore headgear had a reduced risk of sustaining a concussion.[12, 14, 26, 39] Visors and mouthguards were not shown to carry the same protection.[14] However, some authors reported an increased concussion rate in helmeted players proposed to be due to increased risk-taking behavior.[11, 14] Aggressive behavior was also correlated with increased risk for concussion. It was noted that football players who used illegal tackling techniques,[18] taekwondo athletes who used fewer defensive techniques and hockey players who played the sport for tension relief[14] were all at increased risk for injury.

Genetic predisposition has been suggested to play a role in predisposition to concussion. Allelic variants of the genes for Apolipoprotein E (ApoE) and its promoter region have been implicated due to the role this protein plays in certain neurological disease processes.[46] Many studies focus on the ApoE ε4 variant. However, most studies show no correlation between this genotype and increased risk for concussion.[11, 14, 47–49] One study in a pediatric population even showed a decreased risk of injury.[1] Other recent studies have showed that individuals carrying a combination of the ApoE ε2 and ε4 alleles or the T allele for the G-219G/T ApoE promoter gene were more likely to experience concussion injuries.[48, 49] There are specific genotypes for IL-6 receptors and Tau proteins that have also been suggested to increase risk for concussion.[1, 48] No single gene was found to be responsible for a susceptibility to concussion. These findings are supportive of the notion that a complex interaction between multiple genes may influence predisposition to injury.[1]

Prolonged Recovery

The most influential predictor of prolonged recovery following concussion is prior history of concussion.[11, 12, 15, 18, 20, 25, 26, 50–52] Although two studies found no correlation,[53, 54] several studies reported that athletes with prior concussions were found to have a greater risk of suffering from postconcussion syndrome.[55–59] Researchers have suggested that athletes who suffer separate concussions within close proximity are at risk for prolonged recovery.[55] Individuals subjected to additional significant head trauma within 24 hours of a concussion[60] or those who experience a double-hit injury (i.e., helmet-to-helmet followed by helmet-to-ground impact)[55] are also at increased risk for prolonged recovery. The literature also suggests that female athletes are at risk for longer recovery times.[21, 25, 57, 61, 62]

Concussions suffered while playing low-contact sports have been associated with a higher risk of prolonged recovery following concussion.[57, 63] Sex-stratification indicated that the higher prevalence of prolonged recovery in low-contact athletes was due to an increased risk in female athletes,[63] indicative of some interaction between these two risk factors.

Early return to vigorous activity following concussion and continued participation in physical activity after injury have been associated with prolonged recovery.[17, 25, 55, 61, 64] Conversely, immediate removal from activity has been associated with shorter symptom duration.[64] However, researchers have suggested that closely monitored gradual resumption of regular pre-injury activities can reduce the risk of prolonged recovery.[64] Delayed resumption of physical activity can be associated with worse outcomes.[65]

Much of the literature indicates that the number and severity of symptoms at presentation is predictive of prolonged recovery.[18, 20, 22, 25, 26, 50, 61, 66–70] Researchers have observed a relationship between female sex and higher symptom reporting, which places these athletes at higher risk of prolonged recovery.[26] One study found that when stratified by results, only female athletes who reported a higher initial symptom burden were observed to have statistically significantly longer recovery times.[22] Greater symptom burden assessed via computerized neuropsychological tests has shown to be associated with longer recovery as well.[26, 53, 71] While the total number of symptoms is an important prognostic factor, delayed symptom onset[59] and worsening symptoms[61] are also predictive of longer recovery. In particular, experiencing the following symptoms were correlated with longer recovery: amnesia,[18, 20, 26, 50, 56, 61, 63, 70, 72–74] general cognitive issues or fogginess,[18, 25, 26] difficulty concentrating,[50, 56, 63, 72, 73] disorientation or confusion,[26, 63] insomnia,[56, 63] drowsiness,[50] noise sensitivity,[50, 63, 73] light sensitivity,[50, 56, 73] headache or migraine,[18, 25, 26, 53, 66, 69, 72, 75] fatigue,[18, 25, 26] nausea,[50, 73] depression,[66] vestibulo-ocular dysfunction,[63, 70] dizziness[25, 76] and emotional changes.[61, 73] Loss of consciousness has been presumed to be a proxy for severity of injury and thought to be a negative prognostic indicator.[20, 69, 72] However, weak evidence supports this notion[26] and it is no longer believed to be correlated to prolonged recovery.

History of ADHD is thought to be correlated to the prognosis following concussion due to the influence of ADHD on many of the neurocognitive domains in which concussions are evaluated.[20, 29, 57, 77] Due to conflicting evidence in the literature,[53] it is unclear whether the prolonged symptomology is related to the disorder itself or if worsening attention may alter neurocognitive testing results.[77] Some evidence exists that correlates persistent post-concussive symptoms to individuals with a history of learning disabilities and lower cognitive ability.[20, 26, 39, 59] Prior history of mood disorders, such as depression, anxiety and other psychiatric illnesses, has been suggested to be related to prolonged recovery following concussion.[20, 59, 66, 74] Family history of psychiatric illness was also linked to increased risk for prolonged symptoms.[59, 78] Individuals with both personal and family history of psychiatric illness are believed to be at even higher risk.[78] Additionally, those with significant life stressors have a higher risk for prolonged recovery.[59] History of migraines and headaches has been correlated with prolonged recovery following concussion.[20, 59, 61, 66, 79] When stratified by sex, one study found that this increased risk was only significant for female athletes,[79] indicating an interaction between sex and

migraine history which may further prolong recovery for female athletes.[21] In one study, simply being prescribed acute headache rescue therapy and chronic headache treatment was correlated with longer recovery times.[80] Pre-existing sleep disorder has been associated with prolonged recovery.[20] Low sleep quality and sleep disturbances are correlated with prolonged recovery from concussion as well.[81] History of pediatric head injury, birth trauma[20] and intracranial pathology on neuroimaging have been reported to predispose individuals to prolonged recovery.[39]

Many studies suggest that younger individuals may be at risk of longer lasting cognitive deficits and symptoms when compared to their adult counterparts.[11, 18, 25, 26, 66, 69, 82–85] Some studies have either indicated no correlation between prolonged recovery and age below 18 years[26] or an increased risk with increasing age.[25]

The ApoE ε4 allele has been associated with longer recovery time and greater cognitive deficits following concussion.[82] Research also suggests that individual beliefs may influence recovery following concussion. In one study, individuals who believed that their symptoms would have negative effects their lives were more likely to experience persistent symptoms at three months following injury.[86] Other risk factors identified in the literature include history of seizures and neurodevelopmental disorders,[20] pre-existing motion sickness,[20] improper helmet fit,[68] lack of proper facial protection in ice hockey,[39] and need for hospitalization following concussion.[69]

CTE

History of TBI is the only risk factor identified that is consistently associated with CTE.[86] All pathologically diagnosed cases of CTE have come from individuals with a reported history of brain trauma.[82] Research supports the notion that repetitive brain trauma in particular is responsible for the development of CTE[46, 52, 58, 87–90] but it is unclear whether a single event history of TBI is sufficient to initiate the cascade of events leading to CTE.[91–94] One study found that individuals who suffered a single traumatic event were found to have tau and beta-amyloid protein deposition in their brains that mirrored the changes associated with CTE,[95] so this area of research requires further exploration. Available data also suggests that repetitive brain trauma below the threshold for concussive injury or structural damage can be enough to cause the pathological changes associated with CTE.[27, 82, 92, 93, 96] In accordance with these findings, there has been a positive correlation identified between length of career and severity of CTE pathology and symptoms.[37, 89, 95, 97, 98] One study found that American football players who began their careers before age 12 had greater cognitive deficits, suggesting that early exposure to repetitive brain trauma may contribute to the development of CTE.[90] Young football players with no history of concussion also exhibited evidence of tau protein deposition,[27] further supporting the notion that early exposure may confer greater risk for development of CTE.[95] Given the fact that all individuals with repetitive brain trauma do not end up with CTE and not all the individuals diagnosed with CTE have a history of concussion,[52, 99] it is presumed that other risk factors may be at play.

Participation in contact sports such as American football, ice hockey, boxing, rugby and professional wrestling is considered a risk factor for CTE as it exposes individuals to repetitive brain trauma.[37, 87, 94] Within American football, it has been suggested that certain positions may be associated with a higher number of head impacts and higher risk of head injury.[90, 95] Boxers who had a history of being knocked out, were considered to be "sluggers"[98] or had poor performance in their career[37] had an increased risk of CTE while amateur boxers had a lower risk. However, due to small sample sizes and prevalence of CTE in a variety of athletes, these findings require more investigation.[95]

Researchers have suggested that the chronic inflammation caused by certain health conditions such as obesity, hypertension, diabetes mellitus, atherosclerosis and heart disease may influence the extent of neurodegeneration and the brain's ability to compensate for the damage.[91]

Several studies have investigated whether genetic factors may modulate the environmental effects of repetitive brain trauma.[1, 46] One classic study of boxers found that the ApoE ε4 allele was correlated with worse CTE symptomology while the ApoE ε2 allele seemed to confer protection as it was found in boxers with fewer indicators of CTE.[100] In more recent research, ApoE ε4 was present in athletes who had pathologically confirmed CTE at rates higher than the general population and age-matched controls, suggesting a possible genetic link to the development of disease.[94, 101, 102] ApoE ε4 genotype was also associated with greater beta-amyloid deposition in individuals with CTE, which correlated with worse pathological outcomes.[103, 104] Additionally, one study found that 70% of the athletes in a CTE cohort had the ApoE ε3 genotype.[95] Other studies have shown no difference in prevalence of ApoE ε4 genotype between individuals diagnosed with CTE and the general public.[86, 105, 106] Similarly, other researchers have found no correlation between the ApoE ε4 genotype and CTE pathology.[107] Consequently, more research is needed to determine if a genetic predisposition to CTE exists.[108]

Cognitive reserve, defined as the resilience to the clinical presentation of underlying neuropathologic disease, is thought to provide some protection from the manifestation of CTE symptoms.[91, 101] One specific study noted that of the three individuals who were diagnosed with CTE but exhibited no symptoms, two had advanced degrees and successful careers outside of football.[9] Due to an extremely small sample size, the generalizability of these findings is limited and requires more explicit investigation.[9] Other risk factors mentioned in the literature that require further investigation include developmental and demographic factors, neurodevelopmental disorders, normal aging, adjusting to retire-

ment, drug and alcohol abuse, surgeries and anesthesia and sleep difficulties.[99]

Conclusion

The results of this literature review have identified numerous environmental, behavioral and intrinsic risk factors proposed to increase the odds of an athlete suffering a concussion injury, experiencing prolonged recovery and developing CTE. One hundred two articles were selected, and of note, history of TBI is one risk factor consistently associated with all three domains. The remainder of the pertinent literature is robust but limited by discordance and a shortage of large-scale, prospective cohort studies explicitly investigating these risk factors. Lack of certainty around the disease process of concussion and CTE also limits the ability to draw reliable conclusions. The current literature has identified important areas to explore further. Investigation of these topics is necessary to identify individuals who may be at increased risk for suffering negative sequelae of concussion and improve the management and prognosis following these injuries.

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Medical Student Research Project

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Indications/Contraindications for the Use of Schedule II Controlled Substances in an Orthopaedic Practice

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Introduction

Opioids have been shown to be an effective treatment option in cases of acute, postoperative, and cancer-related pain.[1–3] However, the therapeutic use of prescription narcotic analgesics for chronic non-cancer pain (CNCP) is becoming increasingly controversial. The propensity for opioid dependence and addiction is high and the prevalence of the iatrogenic narcotic addiction syndrome (INAS) is a largely unrecognized and growing problem.[4, 5] Jonasson et al. sampled 265 patients and reported 22% of orthopedic and chronic pain patients suffered from analgesic use disorders, and thus concluded patients using narcotic analgesics were at considerable risk for developing addictive tendencies.[6] Although many in the pain management community promote the aggressive use of narcotics for treating nonmalignant pain,[7, 8] others are calling for more conservative prescribing of addictive substances.[9, 10]

To date, no selection strategy has surfaced as a gold standard to guide the prescribing of schedule II controlled substances. Physicians rely on subjective pain rating indices rather than specific pathological indications. In this review, the aim is to better define both the indications and contraindications for the use of these drugs in an orthopaedic practice, and to develop a novel algorithm designed to improve the efficacy of pain management while decreasing drug diversion and addiction.

Materials and Methods

A systematic review of the literature using PubMed, MEDLINE, Google Scholar, and Cochrane databases was conducted to design and develop a novel algorithm for prescribing schedule II narcotic analgesics.

Background

Physical pain, whether acute or chronic, can range in severity from mild discomfort to debilitating agony. Pain, sometimes referred to as the "fifth vital sign," has been the subject of much debate and controversy over the past decade. Caudill-Slosberg et al. reported that while the number of office visits for musculoskeletal pain over the past two decades remained relatively constant, the use of prescription opioid narcotics for chronic pain continues to rise.[11] Opioid analgesics have the capacity to induce physical dependence, tolerance, and addiction and many argue that the abuse potential is so high for these drugs that increasing the frequency of their use will inevitably increase the rates of their abuse.[12, 13]

Current research shows an alarming increase in the rates of prescription drug abuse[14, 15] and there is significant evidence of opioid abuse in conjunction with or without illicit drugs. Among narcotic medications, oxycodone and hydrocodone have the highest prevalence of abuse.[16] The definition and distinction between physical dependence and addiction still remains to be clearly defined and accepted in the literature. This has led to confusion and a less than adequate measure for the diagnosis of addiction.[17] Despite this, surveys show physicians express little concern about problems of addiction, tolerance, and dependence when prescribing narcotic analgesics.[18] Furthermore, the increased use of prescription narcotics based on subjective complaints rather than objective pathology justifies the need for more uniform guidelines and clearly-defined indications for these drugs.

Diagnosis and Classification of Pain

To effectively treat pain, the underlying pathological condition should first be diagnosed and treated. Chronic pain, however, is defined as "pain that extends beyond the period of tissue healing and/or with low levels of identified pathology that are insufficient to explain the present and/or extent of pain."[19] Although the distinction can often be nebulous, it is necessary to distinguish between acute and chronic pain. Opioids remain the standard of care in acute, perioperative, postoperative, and cancer-related pain. Short-term opioid treatment has been found to be highly effective and associated with negligible rates of addiction, and ongoing research continues to support their use.[20–22]

The success of the short-term application of opioids has led to an increase in their use in chronic pain patients, but studies on their efficacy have at best yielded varying results. There are numerous reasons for this disparity. Chronic noncancer pain (CNCP) is a multifactorial problem with bio-

logical, psychological, and environmental factors.[23] Chronic pain patients commonly present with psychiatric comorbidities such as depression, anxiety, substance abuse disorders, somatization, and personality disorders.[22] All patients with chronic pain should therefore undergo careful screening and evaluation for psychopathology related or otherwise unrelated to their pain.[9] Clinicians must consider multiple and integrative therapeutic modalities to treat chronic pain and its accompanying comorbidities. For instance, cognitive-behavioral therapy has been widely studied and consistently shown to be an effective treatment option for CNCP.[24–25] A second reason for the disparity is the difference in the pathophysiology of acute and chronic pain. Namaka et al. reported that patients with well-established chronic pain "may be refractory to analgesia from narcotics" as a result of constant overstimulation of descending pain pathways.[26]

What Are the Specific Pathological Indications and Contraindications for Narcotic Analgesics?

After a systematic review of the literature, the answer to this question remains elusive, specifically in regards to the treatment of chronic pain. For example, some clinicians prescribe narcotic analgesics for fibromyalgia, presumably based on subjective pain complaints. After a current review of the literature, we are unaware of any study that promotes narcotic analgesics in this case, and in fact at least one study suggests they should be avoided.[27]

Currently, opioids are being prescribed for tension-type headaches and migraines, both in outpatient and emergency room settings.[28] However, some reports suggest that opioid therapy is ineffective in the treatment of migraines and that narcotic medications prescribed for chronic tension headaches are often overused leading to problems such as addiction.[28–29] Other contraindications in addition to fibromyalgia and headache include multiple sclerosis, persistent low back pain of any etiology, and complex regional pain syndrome.[30–33] Opioid narcotics have been studied and suggested as therapeutic modalities in conditions such as sickle cell disease, herpes zoster, rheumatoid arthritis, degenerative lumbar spinal stenosis, phantom limb pain, pain syndromes in HIV patients, and neuropathic pain.[26, 34–40]

Even in these circumstances, opioid narcotics are indicated as second line options which should be administered sparingly and, in conditions such as rheumatoid arthritis, only at severe end-stage disease. Currently, the research and literature on specific indications is limited and there is little evidence to support the safe and effective prescribing of high dose narcotic medications. Table 1 summarizes the pathological indication and contraindications of prescription narcotic medications in an orthopaedic practice.

Assessment of Risk and Use of Alternative Therapeutic Options

Patients with acute pain and those with chronic pain whom have been screened for psychiatric illness may be potential candidates for prescription narcotics. General contraindications listed in Table 2 should be thoroughly examined in addition to screening for the risk of addiction. Several instruments and screening criteria for addiction have been developed; however, none are currently recognized as the gold standard.[17] Nonetheless, The American Academy of Pain Medicine and the Society of Addiction Medicine characterize addiction by the '4 Cs:' 1) impaired control over drug use, 2) compulsive use, 3) consequences or continued use despite harm, and 4) craving.[41] Patients with a past history of substance abuse, especially polysubstance abuse, and those that are young or have psychiatric disorders make poor candidates for opioid therapy.[42–44]

However, these conditions alone do not constitute an absolute contraindication and in some cases these patients can be candidates for opioid therapy with increased monitoring, counseling, documentation, and therapy.

To effectively manage and treat chronic pain, different therapeutic modalities should be implemented and these can include: 1) pharmacologic interventions using non narcotic medications (e.g., COX-2-type nonsteroidal analgesics), 2) anti-depressive drugs, NMDA-antagonists, a2-agonists, antiarthythmic sodium channel blockers, 3) antiepileptic drugs, or local anaesthetic drugs, 4) physical therapy, 5) biofeedback, 6) relaxation, 7) transcutaneous electrical nerve stimulation (TENS unit), and 8) cognitive-behavioral and behavioral interventions.[14, 25] Prescription opioid therapy should only be considered after the documented failure of two or more of these non-opioid interventional techniques.[15] Lastly, it is recommended that physicians refer chronic pain

Table 1. Indication and Contraindications for Prescription Narcotic Medication

Indications	Pathologic Contraindications
1) Peri-operative preparation	1) Low back pain of any etiology
2) Postoperative pain management	2) Spondylosis, spondylolisthesis
3) Fracture pain	3) Chondromalacia patellae
4) Cancer-related terminal pain	4) Knee pain of any etiology
	5) Ankle sprain
	6) Ankle pain of any etiology
	7) Rotator cuff tendonitis/tear
	8) Shoulder pain of any etiology
	9) Tennis elbow
	10) Elbow pain of any etiology
	11) Acute gouty arthritis
	12) Arthritis of any etiology
	13) Traumatic myositis
	14) Muscle injury of any etiology
	15) Gastroc-soleus tear
	16) Tendon injuries of any kind

Table 2. General Contraindications for Opioid Analegesics

1) Patients with a known hypersensitivity to the particular narcotic analgesic
2) Respiratory conditions: severe asthma, respiratory depression, or airway obstruction
3) Pregnancy category C (oxycodone is pregnancy category B)
4) Possible contraindications: patients with previous addiction/dependency, psychiatric illness, immunocompromised patients

patients to pain specialists before dispensing prescription narcotic analgesics. Limiting the spectrum of physicians that prescribe narcotic analgesics will help decrease drug diversion and the number of new addicts.

Prescribing and Dispensing Schedule II Narcotics

Prescribing schedule II narcotics should only occur once a clinician has properly assessed and screened a patient and deemed them appropriate candidates. Physicians should counsel their patients on the possible side effects of these medications such as summarized in Table 3. About one in 10 patients develop challenging complications as a result of opioid therapy.[45] Counseling should also include: (1) proper informed consent, (2) warnings about transient and long-term cognitive impairment that may affect work and driving safety, (3) warnings about the highly addictive nature, and the high abuse potential related to narcotic analgesics, (4) information pertaining to opioid use and altered innate and adaptive immune system functioning, and (5) a chronic opioid therapy (COT) contract signed by both the physician and patient that indicates the goals, risks, dosage, time course of the intended treatment, and definitions of physical dependence, addiction and tolerance.[9, 15]

Patients with CNCP often present with neuropathic-type pain associated with neuronal hyperexcitability. Opioids should never be the first-line analgesics used in these patients, and even after the failure of other therapeutic modalities, opioids should be used in conjunction with other treatments. Chronic administration of high dose narcotic analgesics is associated with opioid-induced neurotoxicity. It is highly recommended, although not currently mandated, that all prescriptions for potentially addicting substances be made using electronic prescribing. In a recent report, the DEA estimated that $72 billion a year is spent on claims for fraudulent prescriptions and in the treatment of addicts.[46] Electronic prescribing will have an immediate impact, and is one part of the solution in limiting the diversion of prescription narcotic analgesics.

Drug Adherence and Surveillance Monitoring

All patients being prescribed schedule II controlled substances should be evaluated for drug adherence and undergo surveillance monitoring, especially those with a history of abuse. Fishman et al. define adherence as the self-administration of medications in prescribed amounts at prescribed intervals.[47] Escalation of dosage, hoarding, prescription forgery, and diversion all constitute forms of poor adherence.[47] In addition to monitoring patient adherence, previously referred to in the literature as compliance, physicians should monitor the subjective outcomes of chronic opioid therapy. This includes both pain intensity and level of functioning. In summary, chronic opioid therapy (COT) requires monitoring of the four As: Analgesia, Activity, Adverse effect, and Aberrant behavior.[15]

Table 3. Side Effects of Opioid Analgesics

1)	Drowsiness, sedation, sweating
2)	Impaired cognition
3)	Convulsions, myoclonus, muscle rigidity
4)	Nausea, vomiting, constipation
5)	Delayed gastric emptying
6)	Sexual dysfunction
7)	Respiratory depression
8)	Rash, hives, pruritus
9)	Bradycardia, hypotension, miosis (↓ sympathetic drive)
10)	After chronic use: withdrawal symptoms, hormonal and immune system effects, abuse and addiction, tolerance, and hyperalgesia
11)	Overdose symptoms: respiratory depression, somnolence progressing to coma, skeletal muscle flaccidity, cold and clammy skin, bradycardia, hypotension, circulatory collapse, cardiac arrest and death

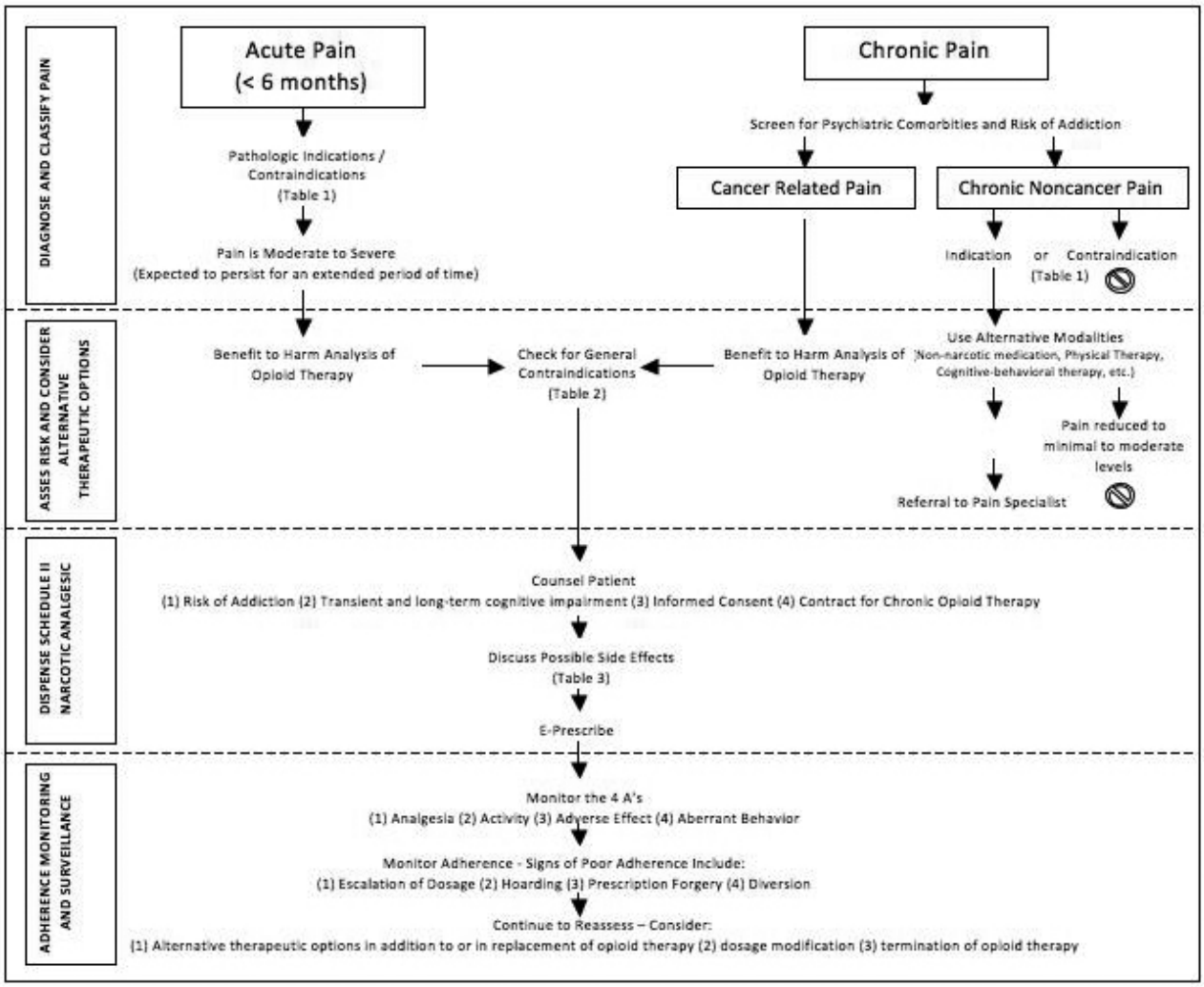
The American Medical Association and the Pain Society of the UK define addiction to opioids as "the compulsive use of opioids to the detriment of the user's physical and/or psychological health and/or social function. Signs of compulsive use include preoccupation with obtaining and taking opioids, apparently impaired control over their use, and reports of craving."[48] It is estimated that 3% of the US population misuses or abuses psychoactive medications with severe consequences.[49] In patients with a history of substance abuse, or those who have been screened and deemed at risk for developing addiction, periodic drug screens should be ordered to monitor adherence. Data pertaining to the efficacy of long-term opioid treatment is unclear, but problems related to its use have been well documented in the literature. Patients on this therapeutic regimen should therefore be extremely well monitored throughout the duration of their treatment.

Discussion

To our knowledge, this is the first study to present guidelines and specific pathological indications/contraindications for the use of narcotic analgesics in an orthopaedic practice setting. The information compiled in this paper was summarized in the form of a logical treatment algorithm for prescribing narcotic analgesics. It is imperative that healthcare professionals remain cognizant of the challenges and the risks inherent to narcotic prescription medication. It is our belief that narcotic analgesics play an important role in pain management; however, irresponsible prescribing by some clinicians has led to an increase in the number of iatrogenic narcotic addiction syndrome cases.

This algorithm was designed to provide a sequential, yet flexible, therapeutic guide from the point of diagnosis all the way through to adherence monitoring. The pathological indications and contraindications were compiled from previous research and from the experience of resident and attending orthopaedic surgeons at Temple University Hospital. Examples of consent forms, chronic opioid therapy contracts, and addiction screening tools are not included in this

Figure 1



review as they are readily found in the current 2009 American Society of the Interventional Pain Physicians' (ASIPP) guidelines.[15]

Conclusion

The depth of scientific research into specific indications and contraindications is very limited and more research is necessary before chronic opioid therapy can be deemed safe and efficacious for a particular indication.

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Medical Student Research Project

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Football-Induced Cervical Quadriplegia: Current Status

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Abstract

Objective: To analyze and report on the occurrence of axial load injuries to the cervical spine which resulted in quadriplegia in high school and collegiate football players.

Methods: Study consisted of a comprehensive literature review and analysis of current survey data for catastrophic sports injuries.

Results: Football regulation changes implemented in 1976 by the NFHS and NCAA prohibited the type of head-on collision defined as "spearing," in which a player uses the top or crown of their helmet as an initial point of contact. Effective enforcement of this rule helped to mitigate the occurrence of quadriplegia in student athletes from 34 cases in 1976 to 18 cases in 1977.

Of concern is that reliable, but unpublished, data from the National Center for Catastrophic Sports Injury Research (NCCSIR) show a consistent increase in the incidence of cervical quadriplegia associated with spearing in student athletes, predominantly in those at the high school level.

Conclusion: It is our recommendation that with football policy revision and proper coaching which emphasize the debilitating effects of spearing, the occurrence of cervical spinal injuries in student athletes can be significantly reduced. The physical, emotional, psychological and financial burden of life-long paralysis in this particularly vulnerable population requires national attention and consideration.

Introduction

Football is one of the most popular sports played in the United States and according to the National Federation of State High School Associations (NFHS), an estimated 1,036,842 high school participants engaged in this high-contact activity during the 2017–18 academic year.[1] Furthermore, it has been reported that the Pop Warner league engages approximately 250,000 youth football players ages 5–15 each year, making football also one of the most popular sports for child athletes.[2] Although participation in physical activities such as football can provide an excellent form of exercise and help young people achieve a healthy lifestyle, this sport has long been documented as one of the leading causes of catastrophic sports injuries among young people.[3–4] Catastrophic injuries sustained during football, particularly those to the head and neck, have been a topic of intense study and debate for many years.

The National Center for Catastrophic Sport Injury Research (NCCSIR) defines catastrophic sports injury as "football injuries which resulted in brain or spinal cord injury or skull or spine fracture."[5] The center further categorizes these injuries and any resulting fatalities as "direct" or "indirect" depending on varying causative factors. According to the NCCSIR report, catastrophic sports injuries including cervical quadriplegia account for a relatively small proportion of the total injuries sustained during football; however, the consequences of these injuries are often permanent and quite devastating.[5] Studies show that the risk of catastrophic spinal injury incurred during play appears to increase with age with the annual risk of cervical quadriplegia occurring at a rate of 0.50 per 100,000 high school players and 0.82 per 100,000 collegiate players.[2]

Severe cervical spine injuries are largely attributed to compressive forces generated by the mechanism of axial loading. In 1990, Torg et al. reported that axial loading occurs when the neck is slightly flexed at a 30° angle, causing the normally extended lordotic cervical spine to be converted into a straight segmented column (Figure 1).[6]

Flexion of the cervical spine and the resultant vertical alignment of the vertebra, intervertebral discs, and supporting ligaments place these structures in a prime position by which they are subject to injury when initial contact occurs with the top or crown of the helmet. This form of direct contact or tackling, defined as "spearing" (Figure 2), was banned by the NCAA and NFHS regulation committees in 1976 following reports published by Torg et al. in 1979.[7] The authors demonstrated a significant increase both in the overall number of cases of cervical spine injuries and the particular instances which resulted in cervical quadriplegia caused by

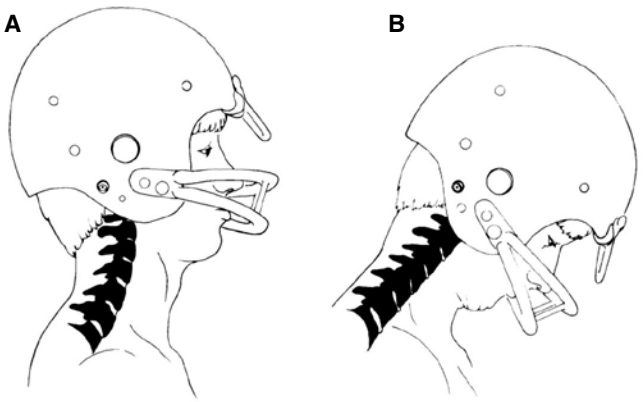

Figure 1. A) When the neck is in a normal, upright, anatomical position, the cervical spine is slightly extended because of the natural cervical lordosis. **B)** When the neck is flexed slightly to approximately 30°, the cervical spine is straightened and converted into a segmented column.[6]

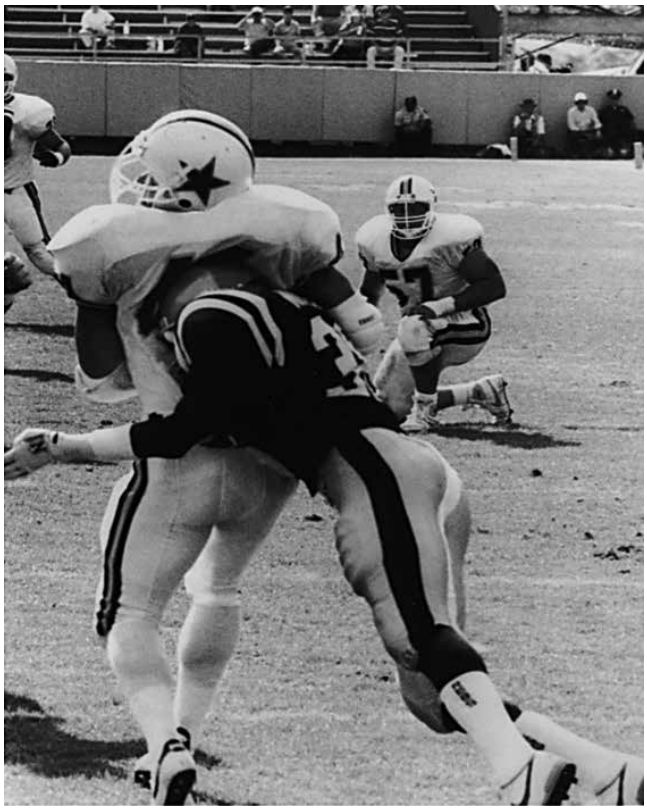

Figure 2. A college defensive back (wearing dark jersey) is shown "spearing" an opposing player with his head, resulting in severe axial loading of his cervical spine. The defensive player sustained fractures of the fourth, fifth and sixth cervical vertebrae and was rendered quadriplegic.[8]

"spearing" in young athletes: 204% increase and 116% increase respectively, from 1971–1975.[7]

When contact is initiated at the crown of the helmet, the straightened cervical spine experiences a compressive load force which quickly leads to compromised integrity of the cervical segment. Vertical alignment of the cervical spine when in flexion allows for an excessive amount of force to compress this region at an orientation in which the paravertebral muscles and ligamentous components of the neck are unable to effectively dissipate such force.[6] This results in compression and deformation of the discs, buckling of the vertebrae, bone fracture, dislocation, subluxation or ligamentous tearing, leaving the cervical spine unstable and the spinal cord vulnerable to compressive injury (Figure 3).[6, 9–10] In 1975, White et al. defined clinical instability of the cervical spine to be a minimum of 3.5-mm horizontal displacement of one cervical segment on another.[11]

Effective enforcement of the spear-tackling ban newly enacted by the NCAA and NFHS in 1976 helped to mitigate the recurrence of cervical quadriplegia in student athletes from 34 cases in 1976 to 18 cases in 1977. Annual rates continued to see a gradual decline with only four cases occurring in the year 1998.[6] Most recently, the NCAA removed the word "intentional" to describe the mechanism of "spearing" within the 2005 rule book in an effort to make these particular plays easier for referees to call.[12]

Of concern is that reliable published and unpublished data has documented a real and alarming increase in the occurrence of football-induced cervical quadriplegia in the period of 1991–2008 observed most dramatically at the high school level.

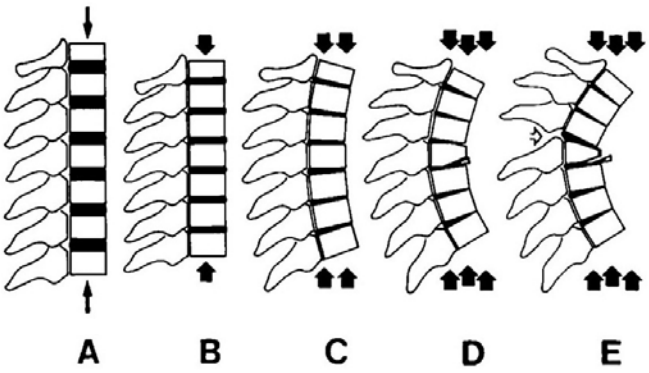

Figure 3. Biomechanically, the straightened cervical spine responds to axial loading forces like a segmented column. The sequence of events are as follows: **A)** There is compressive deformation of the intervertebral discs. **B)** Energy inputs increase until maximum compressive deformation is reached leading to angular deformation and buckling. **C)** The spinal tissue components begin to fail in the flexed position leading to **D)** and **E)** resulting fracture, subluxation, or dislocation and potential permanent damage to the spinal cord. This can occur in as little as 8.4 msec.[6]

Purpose/Research Question

The purpose of this study is to analyze and report on the occurrence of axial load injuries to the cervical spine of high school and collegiate football players which resulted in quadriplegia. These data closely reflect rules and regulations enacted by the NFHS and NCAA, most notably those which first prohibited "spear tackling" in 1976. Our research questions are as follows: How do current trends in cervical quadriplegia of young athletes compare to those published immediately following the establishment of the anti-spearing rules? How do high school football leagues define spearing

in their rule books and is it emphasized well enough to convey the significance of these injuries?

Materials and Methods

A comprehensive review of the literature regarding football-induced cervical quadriplegia was conducted using the PubMed database. Various combinations of key search terms were used including "high school and college football," "youth football," "neck injury," "cervical quadriplegia," and "catastrophic sports injury." To ensure the search included all relevant articles, medical subject headings (MeSH) were utilized when necessary. Inclusion criteria for review included studies involving human subjects, participants engaging in football in the United States of America and specifically non-professional players in high school and college. This review provided the necessary information included in the background and introductory sections of the present study.

Additional searches were conducted online to obtain unpublished incident data of cervical quadriplegia reported by the National Center for Catastrophic Sports Injury Research (NCCSIR). The NCCSIR has been collecting and monitoring the incidence of cervical quadriplegia in the United States since 1977. The authors compiled this information along with the assistance and cooperation of high school and college coaches, athletic directors, school administrators, physicians, athletic trainers, executive officers of state and national athletic organizations, sporting goods dealers and manufacturers' representatives, on-line search engines, newspaper journalists, and professional associates of the researchers.[13]

Results

Prohibition of spear tackling in 1976 by both the NCAA and NFHS helped to mitigate the recurrence of cervical quadriplegia in student athletes from 34 cases in 1976 to 18 cases in 1977. Annual rates continued to see a gradual decline with eight cases reported in 1987.[6]

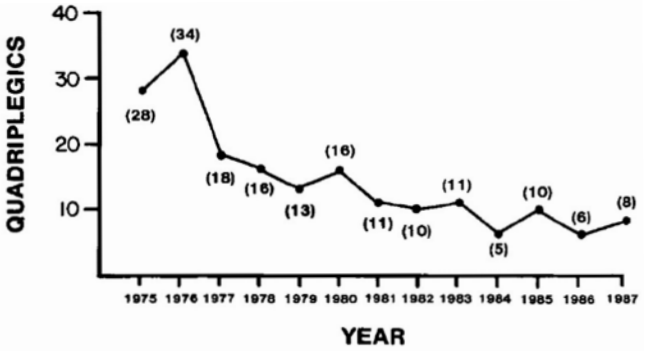

Figure 4. The yearly incidence of permanent cervical quadriplegia for all levels of participation (1975–1987) decreased dramatically in 1977 following the initiation of the rule changes prohibiting the use of head-first tackling and blocking techniques.[6]

Most recent survey data was conducted by the Annual Survey of Catastrophic Football Injuries, 2012 which also documented and reported on the occurrence of cervical cord injuries at all levels of skill. The present study seeks to highlight trends observed from the early 1990s through to the 2000s. Figure 5 shows a progressive increase in the annual raw numbers of cervical quadriplegia in youth players from a single injury in the year 1991 to 11 injuries in 2008. These data included a total of 122 injuries in high school and 13 at the collegiate level from 1991–2008 (an average of 6.7 cervical cord injuries annually in high school and 0.72 at the collegiate level).[13]

Of note, Gill and Boden (2008) reported that participation numbers in high school football teams has increased dramatically while the number of collegiate players has remained largely the same.[14] Each year, an estimated 1.1 million high school students engage in football teams compared to about 73,000 collegiate players.[1, 14] Variations in participation number in addition to many other factors regarding the physicality of the players may contribute to the reduced incidence rate per 100,000 players documented by annual surveys in collegiate players and should also be taken into consideration.

Most notable findings in the current survey data demonstrate that despite the awareness of the dangers regarding spear tackling, there has been a small but consistent increase in the incidence of cervical quadriplegia associated with this tackling technique seen in recent years at the high school level (Figure 6).

Discussion

Catastrophic injuries in young football players have been a topic of intense concern and debate for many years. In the early 1970s, the rise in catastrophic injuries initially led to the construction of more protective helmets worn by American football league players. Unfortunately, the modernized head gear inadvertently created a false sense of invincibility in many players and the use of the head as an initial point of contact became a common tackling technique.[15] This head-first tackling technique, also known as "spearing," led to an increase in injuries involving the cervical spine and a spike in players rendered quadriplegic. Reports published by Torg et al. in 1977 led to the prohibition of spearing by the NCAA and NFHS rules committees in 1976.[7, 16] Modification of the rules, in addition to widespread support to inform players of proper tackling techniques, led to a significant reduction in the cases of quadriplegia through the 1980s and early 1990s.

Analysis of the incidence of quadriplegia illustrates that the official stance of youth football leagues regarding spearing as outlined in the annual publication of their rule books has the potential to shape how players, coaches and referees regard these issues. Implementation of the initial anti-spearing rule in 1976 effectively reduced the cases of cervical quadriplegia by 50% in a single year.[6] The increase in

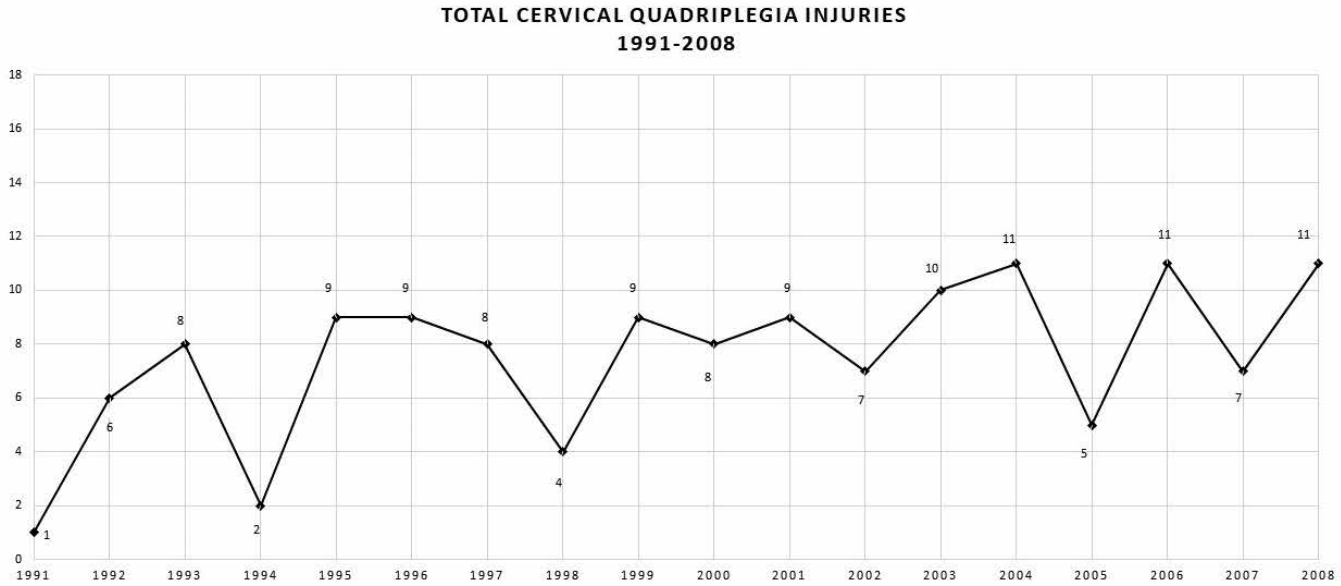

Figure 5. Generated with unpublished data: NCCSIR, Mueller and Cantu, 2012. Annual Survey of Catastrophic Football Injuries: 1977–2012.[13]

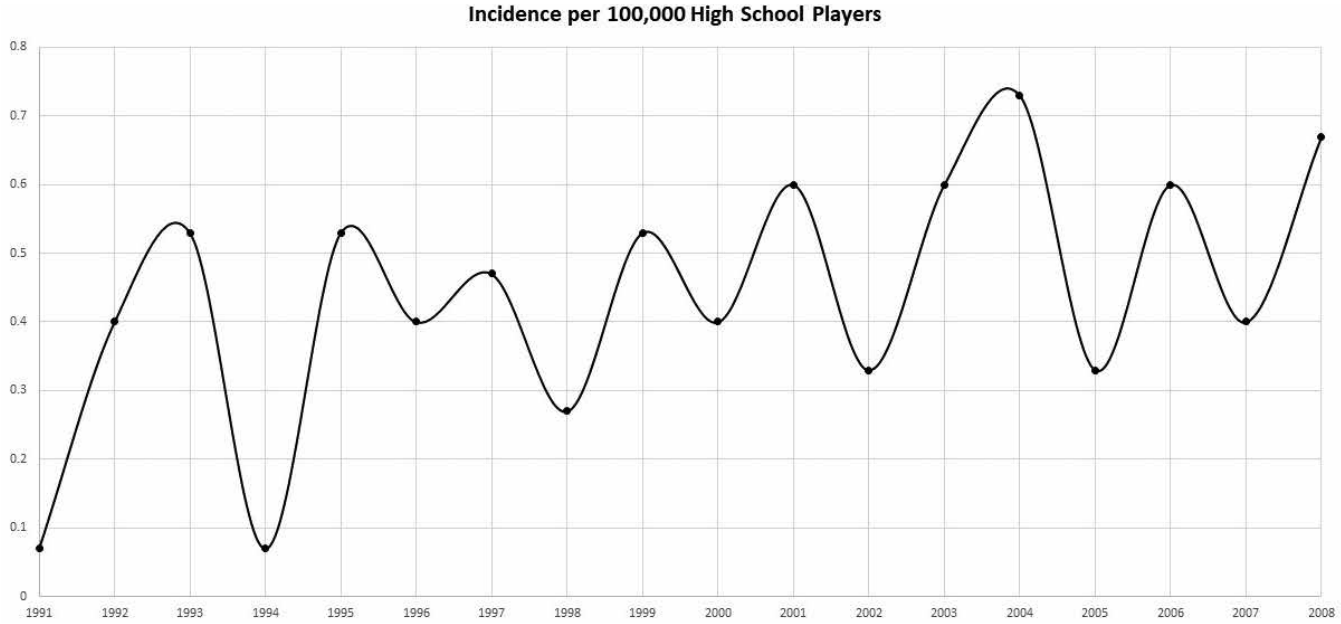

Figure 6. Generated with unpublished data: NCCSIR, Mueller and Cantu, 2012. Annual Survey of Catastrophic Football Injuries: 1977–2012.[13]

cervical quadriplegia observed in more recent years may indicate the need for a change in the stance of the major leagues once again to ensure the safety of young non-professional players, particularly those at the high school level.

According to the 2018 NFHS rule book for high school football, the most severe penalty given to a player who spears an opponent is a loss of 15 yards for their team (NFHS 2018 Rule Book Section 4).[17] Additionally, within the NFHS "Points of Emphasis" section, the authors fail to include spearing as a topic of focus for the league. This is in direct contrast to the 2018 rule book published by the NCAA for the collegiate level in which the authors do include spearing within their "Points of Emphasis," and clearly state that the penalty for spearing will consist of a personal foul and potential disqualification from the game (NCAA Rule 9-1-3).[18] Moving forward, it is most prudent for the NFHS to adopt a stance similar to that of the NCAA and enforce spearing with more stringent penalties in an effort to create an environment within the high school league that regards the severity of these injuries. Furthermore, it is our recommendation that the NFHS rule book provide a more thorough definition of spearing and head-first tackling, which explicitly outlines the mechanism in which these injuries occur as well as the consequences of permanent spinal cord injury.

Currently, the National Center for Catastrophic Sport Injury Research (NCCSIR) is the only organization which regularly publishes incident data on football-induced cervical quadriplegia for high school and collegiate players. The most recent report made available to the public regarding these injuries was placed on the NCCSIR online database in the year 2012. Since then, no other official survey focused on cervical quadriplegia has been generated. The NCCSIR report is also authorized by both NCAA and NFHS, which raises question as to why these two leagues have elected not to publish these data in any official sports journal or news outlet. It is our recommendation that these organizations reexamine the incidence of these injuries and continue to update their records concerning these matters.

The permanent and debilitating nature of cervical spine injuries also raises inquiry as to why these cases are currently not surveyed by the National Institutes of Health, Center for Disease Control or any other government sponsored research institution. The lack of reliable data concerning these injuries may suggest that the true burden of football-induced cervical quadriplegia has yet to be fully realized. The physical, emotional, psychological and financial cost of life-long paralysis caused by spear-tackling in football requires national attention and consideration.

Addendum

New data from the 2019 NCCSIR report illustrate that between the year 2013 and 2017, there has continued to be a significant increase in the occurrence of catastrophic cervical spine injuries in young athletes. These new data provide raw numbers of injuries to the cervical spine which took place while the participants were engaged in organized football (Figure 7). This alarming increase in paralytic spinal fractures emphasizes the severity of this issue and the need to incorporate proper football tackling techniques as part of a nationwide public health intervention.

Conclusion

Current data suggests that there has been a persistent and increased occurrence of football induced cervical quadriplegia incidents among high school football players since the year 1991. It is our recommendation that with proper coaching which emphasizes preventive techniques, the occurrence of these injuries can be significantly reduced. Additionally, the failure of the NFHS to explicitly define initial contact with the crown of a player's helmet as a high-penalty technique requires explanation and policy revision. In view of the severity of cervical injuries, we believe that current evaluation of the status of these injuries is necessary with emphasis on prevention in this particularly vulnerable population.

Year	Number of Cervical Spine Injuries
2013	15
2014	11
2015	30
2016	9
2017	15

Figure 7. Generated with unpublished data: NCCSIR, 2019. Annual Survey of Catastrophic Football Injuries: 2013–2017.[24]

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Medical Student Research Project

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Infection Rates on Re-Admission for Total Joint Surgery: Are Five Showers with Chlorhexidine Versus Skin Wipes More Effective in Preventing Infection Following Total Joint Surgery?

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Abstract

Objective: Infections after total joint arthroplasty (TJA) are a devastating complication that can significantly affect a patient's quality of life post-operatively. The study site established a new protocol in June 2016 instructing patients undergoing total knee and total hip arthroplasty (TKA, THA) to conduct five consecutive showers with 4% chlorhexidine gluconate (CHG) antiseptic soap prior to surgery. The previous protocol prior to June 2016 instructed patients to use two 2% CHG cloths for pre-operative prep for TJA. The goal of this study is to compare the infection rates on re-admission for each protocol to determine the outcomes and effectiveness of the preoperative antiseptic preparation methods.

Methods: Two 18-month periods were identified for a retrospective chart review to identify patients that had undergone a primary TKA or THA. Demographic data was collected with various operative factors. The primary outcome measured was presence of infection upon readmission.

Results: The infection rate was found to be greater in the wipes protocol (4.7%) compared to the shower protocol (2.2%) but did not reach statistical significance ($p = 0.1106$). In both protocols, time in surgery was found to be statistically significant for infection ($p = 0.0068$).

Conclusions: The results of this study demonstrate that there is no conclusive difference between the wipes and shower protocol in preventing infections in total joint arthroplasties. Factors that were predictive of infection included time in surgery, discharge location, and Foley catheter presence. Further studies are required to conclusively determine an efficacious difference between protocols.

Introduction

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are procedures that provide patients with an improved quality of life through reduced pain and improved strength and motion of the joint.[1–3] Since 2010, there have been more than 658,000 primary lower extremity joint arthroplasties performed each year in the United States.[4, 5] In addition, there has been more than 80,000 revision lower extremity joint arthroplasties in the United States alone.[4] As the "baby boomer" population continues to age, the rate of total joint arthroplasty will continue to rise. Over four million primary and revision lower extremity arthroplasties are projected to occur in the United States alone in the year 2030.[4] As the demand for lower extremity arthroplasties rise, so does the incidence of infections as a complication. Surgical site infections are said to occur in 1% to 2.5% of all total joint arthroplasties and are often associated with poor outcomes and increased costs to the patients, physicians, and hospitals.[6, 7–10] There are many preoperative risk factors that have been identified with regards to infection including BMI, ASA score, diabetes mellitus, hemoglobin A1C levels, hypertension, smoking, renal disease, hypothermia, and nutritional status.[11–18] In addition, intraoperative risk factors such as time in surgery have also been shown to be associated with infection rates in arthroplasties.[19]

As hospital costs related to surgical site infections are projected to rise to $1.6 billion by 2020,[8] it is imperative to establish protocols that reduce the incidence of infections in total joint arthroplasties. Advanced preoperative skin antisepsis is a strong recommendation (category 1B) from the Center of Disease Control (CDC) in order to prevent surgical site infections.[20] This preventative measure commonly uses chlorhexidine gluconate (CHG) as a skin antiseptic that is a broad-spectrum biocide.[21] Whole-body cleansing with 2% and 4% CHG concentrations have been shown to be effec-

tive reducing the levels of normal skin flora,[22–24] but there is no consensus on its impact on infections.[25–30]

Prior to June 2016, the study site provided patients with packets of pre-medicated 2% CHG impregnated wipes to use the night before and the day of surgery prior to elective joint reconstruction for total joint arthroplasties. Patients were instructed to shower with warm water and soap one to two hours before using the cloth the night before surgery. Once completely dry, they were instructed to open a packet that contained six individual wipes to be applied to the neck and trunk, arms, hips and groin, legs, back, and buttocks. Patients were warned not to use the cloths on the face, genital area, or open wounds. After application, the patients were told to allow the areas to dry, dress in clean clothes, and to not apply any lotions, powders, deodorants, perfumes, or moisturizers. Additionally, patients were instructed not to shower before using the wipes the morning of surgery. On the day of surgery, 2% CHG wipes were used in the pre-operative area for final decolonization.

In June 2016, the study site switched the protocol to a 4% CHG liquid skin cleanser to use during showers or baths for five consecutive days prior to the date of surgery. Patients are currently instructed to apply a generous amount of the 4% CHG to a cloth and scrub the neck, trunk, arms, legs, hips, back, and buttocks. Patients are also warned not to use the cloths on the face, genital area, or open wounds. After application, patients are instructed to wait one minute before washing the skin cleanser off the body, and to dress in clean clothes without applying any lotions, powder, deodorants, perfumes, or moisturizers. On the day of surgery, 2% CHG wipes were used in the pre-operative area for final decolonization.

This quality improvement project will compare the infection rates on re-admission for each protocol in primary THAs and TKAs to determine outcomes and effectiveness of the updated protocol of using 4% CHG soap during showers or baths by evaluating its effectiveness in primary THA and TKA.

Materials and Methods

Study Design

The Infectious Disease Department at the institution provided a list of all patients that fell under the CDC guidelines of surgical site infections for both TKA and THAs from January 2015 to June 2018. The control group was identified using the online surgical booking system for the orthopaedics department during the same time period. Two 18-month periods were used to compare the two protocols. Patients that had their procedure done between December 1, 2014 to May 31, 2016 were included as part of the 2% CHG wipe protocol. Patients that had their procedure done between September 1, 2016 to February 28, 2018 were included as part of the 4% CHG shower protocol. A total of 190 lower extremity arthroplasties were identified in the 18-month pre-protocol period and 356 lower extremity arthroplasties in the post-protocol period of review. Procedures were performed at Temple University Hospital using vertical laminar control rooms and body containment suits. Patients that had a hemi-arthroplasty or a revision THA or TKA were excluded from this study. Institutional Review Board permission was not required for this study because this was an internal quality improvement project designed to reduce rates of surgical site infections.

Variables

The following data on patient demographics were collected: age, gender, body mass index (BMI), and American Society of Anesthesiologists (ASA) score. The co-morbidities identified in each patient were hemoglobin A1C, hypertension, diabetes mellitus, renal disease, albumin levels, and smoking status. Smokers were defined as current smokers if they had smoked in the past six months. Intraoperative measures collected were time in surgery, core body temperature, tourniquet time for TKAs, need for blood transfusion, and presence of a Foley catheter. Time in surgery was measured from time of incision to closure. Postoperative measures included discharge location, length of stay, and presence of wound drainage or post-operative hematoma.

The primary outcomes measured were positive cultures of infection upon readmission following TJA. Electronic medical records were reviewed by members of the clinical research team for clinician diagnoses of post-operative infections.

Data Analysis

Statistical analysis was performed by institution statistician. The analysis included a Student's t-test for comparison of the continuous variables and the Chi-Square test and Fisher's Exact test for the selected categorical variables. A logistic regression analysis was also performed to analyze the outcome from the categorical and independent variables and potential odds ratio for relative infection risk. Statistical significance was determined with a p-value less than 0.05.

Results

Demographic Information

Demographic information for both the wipes and showers groups were recorded for this study including age, BMI, albumin measured within three months of surgery, HbA1C within three months of surgery, sex, ASA status, procedure type, history of hypertension, history of diabetes mellitus, history of renal disease, and smoking status. Among these variables, ASA status, and history of renal disease had statistically significant differences between the wipes and shower groups. The percentage of patients with ASA status of one or two were different in the wipes compared to the shower (42.4%, 18.9%), as were percentage of ASA 3 (76.8%, 55.6%) and ASA 4 (4.2% vs 2.0%). These differences were

statistically significant using Chi-Square testing (p = 0.0001). Renal disease was more prevalent in the shower group (23.9%) vs the wipe group (6.8%) and this was statistically significant (p = 0.0060) using Chi-Square testing (Tables 1 and 2).

Table 1. Continuous Variable Comparison Data for Wipes and Shower Groups

	Wipes	Shower
Age	62.0 ± 10.4	62.0 ± 10.1
BMI	32.5 ± 6.9	31.8 ± 5.9
Albumin	3.9 ± 0.3	4.0 ± 0.5
HbA1C	6.3 ± 0.8	6.2 ± 0.7

*Data given as mean with standard deviations.

Table 2. Categorical Variable Comparison Data for Wipes and Shower Groups

	Wipes	Shower
Sex (female)	61.1%	62.1%
Sex (male)	38.3%	38.9%
ASA 1 or 2*	18.9%	42.4%
ASA 3*	76.8%	55.6%
ASA 4*	4.2%	2.0%
Procedure (THA)	38.4%	43.0%
Procedure (TKA)	61.6%	57.0%
Hypertension	71.1%	73.3%
Diabetes mellitus	25.8%	26.4%
Renal disease**	6.8%	14.9%
Smoker	28.9%	23.9%

Data given as percentages.
*ASA status was found to be statistically significantly different between groups using Chi Square testing (p < 0.0001).
**Presence of renal disease was found to be statistically significantly higher in the shower group (p = 0.0060) using Chi Square testing.

Categorical Variables

Categorical variables were recorded including: preoperative prep group, sex, smoking status, history of hypertension, history of diabetes, history of renal disease, procedure type, ASA status, use of blood transfusion intraoperatively, use of Foley catheter intraoperatively, presence of postoperative hematoma, presence of surgical and wound drainage, discharge location, length of hospitalization, and preoperative antibiotic type. Association with infection was tested using Chi-Square or Fishers Exact testing. Among these categorical variables, procedure type, presence of postoperative hematoma, presence of wound drainage, use of Foley catheter and discharge location were associated with higher rates of infection (Table 3).

The primary categorical variable that was being investigated in this study was infection rate among primary THA and TKA patients who underwent preoperative antiseptic skin preparation with either 2% CHG "wipes" or 4% CHG "shower." While the infection rate in the "wipes" group (4.7%) was higher than the "shower" group (2.2%), the numbers did not reach statistical significance on the Chi-Square analysis (p = 0.1106). In a multivariate logistic regression, when controlling for both presence of Foley catheter and procedure, the odds ratio was 2.625 (95% CI: [0.964, 7.145]) and p value was 0.059.

Table 3. Testing of Select Categorical Variables with Infection

Attribute	Infection	No Infection	p value
Pre-op prep group			0.1106
Wipes	9 (4.7%)	181 (95.3%)	
Showers	8 (2.2%)	348 (97.8%)	
Procedure			0.0474
THA	11 (4.9%)	215 (95.1%)	
TKA	6 (1.9%)	314 (98.1%)	
Foley catheter			0.0498
Yes	4 (8.5%)	43 (91.5%)	
No	13 (2.6%)	486 (97.4%)	
Wound drainage			<0.0001
Yes	17 (33.3%)	34 (66.7%)	
No	0 (0.0%)	522 (100%)	
Discharge location			0.0421
Home	6 (1.7%)	344 (98.3%)	
Rehab	1 (5.3%)	18 (94.7%)	
SNF	10 (5.6%)	167 (94.4%)	

*Data given as number in variable with (%).

THA (4.7%) was associated with an increased infection rate compared to TKA (1.9%) which reached statistical significance (p = 0.0474). Time in surgery was also associated with procedure type, with THA having a longer mean time in surgery versus TKA (135.3 ± 43.3, 127.0 ± 34.1, p = 0.0172).

Operations that used a Foley catheter had a statistically significantly (p = 0.0498) higher infection rate (8.5%) compared to those that did not (2.6%). Upon multivariate logistic regression analysis, when controlling for both prep group protocol and procedure, the odds ratio for infection with use of Foley catheter was 3.679 (95% CI [1.088–12.440]) and the p-value was 0.0361 which was statistically significant.

Continuous Variables

Several continuous variables including age, BMI, albumin, and HbA1C levels within three months of surgery, time in surgery, tourniquet time, core body temperature, and length of surgery were compared among the pre-operative prep groups and tested for association with infection. Mean time in surgery was higher in the wipes group (140.8 ± 44.5) compared to the "shower" group (124.9 ± 33.5, p < 0.0001). Core body temperature in the "wipes" group was 97.1 ± 1.1 and in the "shower" group was 96.0 ± 1.1 with a p-value of <0.0001. Of those variables, only time in surgery was also associated with a higher infection rate. The data showed that the mean time in surgery in the group with infection (160.6 mins) was higher than in the group without infection (129.4 mins). These values of time in surgery did reach statistical significance with a p-value of 0.01134.

A logistic regression analysis was performed considering both pre-operative prep group and time in surgery relative to infection. Prep group did not meet the threshold of statistical significance with a p-value of 0.2947, but time in surgery

was found to be statistically significant with a p-value of 0.0068. The odds ratio for time in surgery was found to be 1.012 (95% CI 1.003,1.020).

Sub-group analysis was performed with exclusion of renal disease patients. Infection rate between wipes (4.5%) and showers (1.7%) changed when excluding these patients but there was still not statistical significance (p = 0.0802). Time in surgery was higher in the group with infection (159.5 ± 60.3) than the group without infection (129.5 ± 38.4) and this difference reached statistical significance (p = 0.0299).

Discussion

Surgical site infections are a rare but devastating complication of total joint arthroplasty. While there is no current CDC recommendation on the optimal timing of the preoperative agent, number of applications, or the use of CHG washcloths, our study was conducted to evaluate the efficacy of five 4% CHG soap showers compared to two 2% CHG cloths.[20] There have been various studies to determine the efficacy of skin decolonization of the wipes and cloths but no definitive evidence on whether it impacts infection rates.[25–30] Edmiston et al. has shown that the there was no significant difference in skin surface antimicrobial activity between two or three applications 4% CHG soap.[23] However, Moroski et al. was able to demonstrate that five baths with 4% CHG was able to reduce colonization rates with methicillin-sensitive and methicillin-resistant *Staphylococcus aureus*.[31] Due to the lack of evidence and clarity in reducing infection rates following TJA, further research is warranted to establish the most effective preoperative measure.

The statistical analysis determined that there is no significant difference between the wipe and shower protocol (p = 0.1106). Though the p-value was not significant, the infection rate was greater in the wipes protocol compared to the shower protocol (4.7% vs. 2.2%) and the odds ratio indicates that there is a 2.625 times increased risk of infection with wipes (OR = 2.625). However, the odds ratio also does not reach significance according to the confidence interval (95% CI [0.964–7.145]). Another study by Edmiston et al. supported the use of 2% CHG wipes due to significantly greater microbial reduction at all time intervals compared to the 4% CHG soap.[32] Our results show that there is currently no significant impact on infections with five showers using the 4% CHG soap compared to 2% CHG wipes.

When comparing demographic data, we saw a significantly higher percentage population of patients with renal disease in the shower protocol compared to the wipe protocol (6.8% vs 14.9%, p = 0.0060). However, the presence of renal disease was not significant in regard to infection (p = 0.1379). In order to see if the presence of renal disease was a confounding variable for prep group with regards to infection, a subgroup analysis excluding renal disease patients was conducted. The infection rate dropped in both protocols, but prep group was still not a significant factor for infection (4.5% vs. 1.7%, p = 0.0802). This displays that this difference in demographics did not impact the results of our study.

Another demographic difference between protocols was an increased percentage of ASA 3 and 4 patients in the wipes group (76.8%, 4.2%) compared to the shower group (55.6%, 2.0%). Although this demographic difference was statistically significant (p = 0.0001), there was no statistically significant association between ASA status and infection rate (p = 0.6831). Because of this, we conclude that higher preoperative morbidity among the wipes group was not the driving force behind the higher infection rate in the wipes group.

Length of time in surgery was shown to be statistically significant for risk of post-operative infection (p = 0.0362). There was an average difference of 31 minutes between those that were infected and those that were not infected with higher infection rates in patients who experience longer surgery times. There was also a correlation that the wipes protocol had a significant increase in the total time in surgery for TJA compared to the shower protocol (140.8 vs. 124.9 min, p < 0.0001) which may be associated with the higher infection rate in the wipes group. In addition, when specifically reviewing time in surgery between THA and TKA, it was found that there were longer surgery times in THA (135.3 vs 127.0 min, p = 0.0172) which was shown to be statistically significant (p = 0.0474) with a higher rate of infection. There was an addition to the surgical staff at the study site, which may have contributed to the decrease in mean surgical time in the shower protocol group. When controlling for prep group, time in surgery was found to be statistically significant in both protocols (p = 0.0068), with each additional minute in surgery increasing the risk of infection by 1.012% (OR = 1.012, 95% CI [1.003, 1.020]). Similarly, a study conducted by Anis et al. also found that longer surgery times in arthroplasties were associated with periprosthetic join infection (PJI) and SSI.[19] This is a physician-controlled variable that surgeons should be aware of to ensure lower infection rates.

When controlling for both prep group and procedure, it was found that the presence of the Foley catheter was statistically significant in relation to infection (p = 0.0361). In addition, the odds ratio indicates that patients that had a Foley catheter had 3.679 times the risk of infection compared to that of a patient who did not (OR = 3.670, 95% CI [1.088, 12.440]). Foleys are typically reserved for cases that are more complex or difficult. Not surprisingly, patients that had a Foley catheter had a statistically significant increase of 43 minutes in mean surgery time (169.9 vs 126.7 min, p = .000175). This reinforces the idea that time in surgery is a major factor in determining infection rates. Clinicians should be mindful about attempting to minimize operating times even in patients with a Foley placed.

Another important finding in this study was that the presence of wound drainage was strongly correlated with infec-

tion and was statistically significant ($p > 0.0001$). Wound drainage, at the very least, indicates a communication of the subcutaneous tissues with the outside environment. This puts the patient at a much greater risk for developing a postoperative infection and is often the first sign that an infection is present. Clinicians should be aware of this sign of infection in the postoperative period.

Next, another important finding in this study is that there is an association with the patient's discharge location and infection occurrence. In the wipes protocol, it was shown to be statistically significant ($p = 0.0004$) that more patients were discharged to both acute inpatient rehabilitation (6.8% vs 1.7%) and skilled nursing facilities (SNF) (37.9%, 29.5%) compared to home. When relating discharge location to infections, we saw a statistically significant difference in their discharge locations ($p = 0.0421$), with patients being discharged to SNF or acute rehab having a higher infection rate. Patient discharge location should be taken into consideration as a study by Bini et al. also found that patients discharged to SNF have a higher risk of developing complications and hospital readmission for those that undergo lower extremity TJA.[33] This could be a potential risk factor for the infection rate being increased in the wipes protocol.

Limitations of this study include the retrospective nature of the data collection and the narrow sample size where there is a limited occurrence of infection. Furthermore, due to an addition of an orthopaedic surgeon to the study site in August 2016 that also conducts total joint arthroplasties, the sample size of the two populations are not identical. Moreover, there is no method to confirm if patients were compliant with either wipe protocol or to control for application methods.

In conclusion, the results of this study demonstrate that there is no conclusive difference between the wipes and shower protocol in preventing infections in total joint arthroplasties. Predictors of increased infection rate include variables such as time in surgery, use of Foley catheter, and patient discharge location. While there are various associations that were discovered throughout the study, more research must be conducted to conclusively determine an efficacious difference between 2% CHG wipes and 4% CHG showers in relation to infection rates. Skin preparation is important for reducing infection risk but is not the sole driver for infection rates.

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Medical Student Research Project

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Implementation of QuickDASH for All New Patients in Hand Clinic

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Abstract

This study evaluated the practical adoption of the QuickDASH functionality questionnaire within a hospital-based hand clinic. The value of the metric to providers in terms of clinical decision making, outcome measurements, and longitudinal assessment of treatment was examined and confirmed. To best gather patient data while retaining fluidity within the clinic, considerations of interest were method of administration (paper vs electronic), timing within the patient visit to obtain responses, scoring modalities, and incorporation/synergy with the electronic health record (EHR). Results showed minimal difference in time or patient response burden when administering QuickDASH by paper or iPad tablet, though the latter allowed for ease of scoring and data comparison with the general population and when following the same patient over time. Results suggested that integration of the survey would be best achieved with a mechanism in place by which results could be instantly uploaded to the electronic health record for provider review and data consolidation. Without this capability, neither paper nor iPad administration mesh well with the flow of the clinic.

Introduction

The rapid pace and high patient volume of a typical hand clinic necessitates efficiency to ensure consistent and acceptable delivery of care. With the expanding capabilities of the EHR, data collection and analysis per patient is gaining more traction among physicians who seek to embrace technological trends. For hand and upper extremity specialists within the field of orthopaedic surgery, one such opportunity for gathering actionable patient data exists in the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH). Developed in 1996, the DASH score, based on patient response to 30 questions, has been examined and verified as a viable measure of functionality in a variety of upper extremity conditions including, but not limited to, de Quervain's tenosynovitis, wrist osteoarthritis, epicondylitis of the elbow, and traumatic injuries such as amputations or fractures.[1] Scores range from 0–100 with a higher score indicating greater disability. For ease of administration and to save time, an abbreviated version of the DASH questionnaire is available in the form of the QuickDASH, which produces a score on the same 0–100 scale as the full DASH but does so using 11 focused questions.[2] With some allowances for over- and underestimation regarding specific areas of clinical importance (symptoms, pain, general function, etc.), the QuickDASH score compares well to not only the full DASH,[3, 4] but also other validated scoring methods within the field of hand surgery.[5]

Previous literature supports the practicality of DASH and QuickDASH scoring and the applications of the metric in tracking postoperative outcomes,[6, 7] predicting response to treatment or lasting disability,[8] and serving as actionable data in the clinical decision-making process.[9] Beyond musculoskeletal assessment, Izawa et al. showed evidence for its benefit in measuring strength and function following cardiac surgery.[10] With this tool available, the central questions become how best to distribute the questionnaire and how best to use the data therein obtained. Considerations for score collection include both mode of administration, either via paper or tablet computer, timing during the course of a patient encounter, and procedure for data consolidation and delivery to the provider. Functional capacity poses a unique concern in a hand practice when instructing patients to complete a written survey. This potential limitation, along with evidence of less consistent completion rates when using paper, suggests that an iPad or tablet is optimal for efficient QuickDASH scoring.[11] A balance must be achieved between minimizing inconvenience to the clinical staff and easing responder burden on patients, which appears to be best achieved through electronic surveys rather than pencil and paper. Score interpretation remains largely at the discretion of the provider, as standardized protocols for management based on DASH scores has not yet been established.[12]

The primary aim of this study was to identify a means of QuickDASH administration for the practice that produced the least disruption to clinic activities and patients while also maximizing data collection and interface with the EHR.

While Yaffe et al. determined that the iPad iteration of QuickDASH took more time on average to complete, the number of scorable surveys and user satisfaction with the electronic format was preferable to paper.[11] With regard to timing, we hypothesized that patients would be best able to complete the questionnaire via tablet-based administration prior to being roomed. Theoretically, this protocol would also cause the least interference with other components of the patient visit. Particular attention was paid to both the validity of the DASH and QuickDASH scores as well as avenues for their use and interpretation in the hopes that this study can serve as inspiration and direction for more widespread adoption of electronic patient response surveys in other clinical practices.

Materials and Methods

Participants in this study were a cohort of new patients to a single hand surgery practice. The QuickDASH questionnaire was administered to 62 individuals over an eight-week period, with 31 completing the paper version (Fig. 1) and 31 using the DASH Outcome Measure mobile application given via iPad mini 2 running iOS 11 (Fig. 2). Conditions of use and scoring methods were followed per established guidelines.[13] As patient demographics were neither retained nor analyzed, and given that the purpose of the study was to assess a standard of care protocol, there was no oversight by an Institutional Review Board necessary. Surveyed patients were timed as they completed the paper or iPad QuickDASH questionnaires. Prior study has established an average completion time of 2.5 minutes on paper and 3.3 minutes on iPad.[11]

Paper QuickDASH scores were tabulated by a researcher (EJ) while the score was automatically produced by the application when iPad administration was employed. Results were printed and subsequently uploaded into patient charts for physician review and establishment of a scoring record such that patient functionality may be assessed over time. iPad scores were first printed using a secure wireless printer with direct connection to the iOS device for protection of private health information. It is notable that omission of more than one question out of 11 makes the questionnaire unscorable.[13] Patients completing paper formats were not prompted or given further instruction if they responded to fewer than 10 items so as not to invalidate the findings. Conversely, the tablet format prevents the score from being submitted unless all 11 items are addressed. Verbal administration was provided upon request and considered valid for inclusion in the findings of this study based on prior evidence of fidelity with self-completed surveys.[14]

During a given new patient encounter, QuickDASH was administered either alongside intake forms for 10 subjects or shortly after initial rooming for 52 subjects. It was the goal of the investigators to reduce responder burden and present QuickDASH in a period of time that generated the smallest perturbation to existing clinic flow. To assess the burden of QuickDASH administration to clinic staff, total time for 24 administrations was recorded from entry into patient room to placement of a completed and scored QuickDASH report into the physical patient chart. Per provider preference, an additional copy of each score was printed for eventual upload into the EHR, though this process was difficult to monitor and was performed at staff convenience.

Results

Upon comparison between paper-based and iPad-based administration, patients averaged completion times of 2.21 minutes and 2.25 minutes, respectively. Whether statistical significance can be achieved from these mean values is beyond the scope of this study. Much more provocative were the findings related to the handling of a completed QuickDASH based on format and timing of administration. Paper surveys required manual scoring, a process which took an average of 48 seconds to complete with the aid of a calculator. iPad scoring was automatic and provided additional data for clinical use (Fig. 3), though it was necessary to expend time printing copies of the score and manually transferring these hard copies to the patient's paper chart and eventually scanning into the EHR.

In evaluating the additional time burden associated with QuickDASH administration on clinical staff, total time for task completion as outlined above averaged 3.8 minutes per patient. Printing time for iPad-derived scores was nearly identical to the time it took to score paper versions manually, though a practiced researcher would likely be capable of producing a score from the Likert equation with more comfort and rapidity than clinical staff. Additional patient-based limitations on ease of administration encountered during the course of this study were foreign language barriers, patient literacy, and difficulty manipulating a writing utensil or handheld electronic device due to existing pathology in the hand or upper extremity.

Discussion

This study illuminated a number of benefits as well as a number of challenges associated with QuickDASH and its viability in a high volume hand clinic treating a largely underserved healthcare population. Initial hypotheses favored the iPad form of the survey over paper given ease of patient use and higher quality of data.[11] However, without a time-saving interface between the tablet and electronic health record, its practical use does not differ from paper administration. Scores can be better obtained and tracked over treatment periods using the digital application (Fig. 4), but associated cost, personnel, and security considerations would favor paper questionnaires administered largely unsupervised in advance of a given patient being roomed. This method has its own potential drawbacks, however, as the score will still require calculation by a staff member and reliability of the data therein obtained is reduced when no verbal instructions are provided.

Figure 1. Paper Format of QuickDASH

The Disabilities of the Arm, Shoulder and Hand Score(QuickDash)

Clinician's name (or ref) _____ **Patient's name (or ref** _____

INSTRUCTIONS: This questionnaire asks about your symptoms as well as your ability to perform certain activities. Please answer *every question* , based on your condition in the **last week**. If you did not have the opportunity to perform an activity in the past week, please make your *best estimate* on which response would be the most accurate. It doesn't matter which hand or arm you use to perform the activity; please answer based on you ability regardless of how you perform the task.

Please rate your ability to do the following activities in the last week.

1. Open a tight or new jar	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
2. Do heavy household chores (eg wash walls, wash floors)	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
3. Carry a shopping bag or briefcase	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
4. Wash your back	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
5. Use a knife to cut food	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (eg golf, hammering, tennis, etc)	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ Unable
7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?	○ Not at all	○ Slightly	○ Moderately	○ Quite a bit	○ Extremely
8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?	○ Not limited at all	○ Slightly limited	○ Moderately limited	○ Very limited	○ Unable

Please rate the severity of the following symptoms in the last week

9. Arm, shoulder or hand pain	○ None	○ Mild	○ Moderate	○ Severe	○ Extreme
10. Tingling (pins and needles) in your arm, shoulder or hand	○ None	○ Mild	○ Moderate	○ Severe	○ Extreme
11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand?	○ No difficulty	○ Mild difficulty	○ Moderate difficulty	○ Severe difficulty	○ So much difficulty I can't sleep

Thank you very much for completing all the questions in this questionnaire.

Ultimately, the most effective conceivable protocol for making use of QuickDASH in the hand clinic would be by interfacing the tablet form of the survey with the EHR (Epic Systems for this hospital network). This would eliminate the need for printing, scanning, and score tabulation and place actionable information regarding patient functionality in the hands of the provider as quickly as it was made available. Administering staff could be the rooming medical assistant, physician assistant, or resident physician, depending on the preferences of the attending physician. This is a promising tool with considerable potential to benefit the field of orthopaedic hand surgery provided it can be well-married into the flow of daily clinic activities.

Limitations of this study resided primarily in the quantity of new patients to whom the survey could be administered over the eight week span, subject to the schedule of the provider and the multiple locations at which he practiced (all data was collected at a single clinic location). Other practices have been noted to use email systems to administer patient surveys such as QuickDASH, though this method was explored and rejected as a possible avenue for this practice. The patient population of the clinic and hospital cyber security barriers present other limitations and possible challenges, and practices seeking to adopt this functionality metric will need to examine their own objectives and mechanisms of care delivery for optimal integration.

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Figure 2. iPad Format of QuickDASH

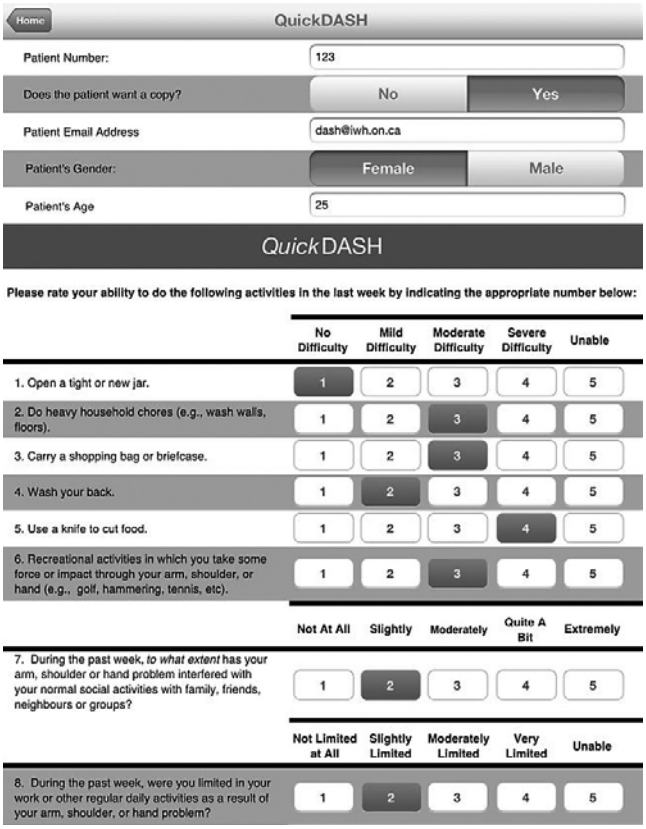

Figure 3. QuickDASH Score Report Produced by iPad Application

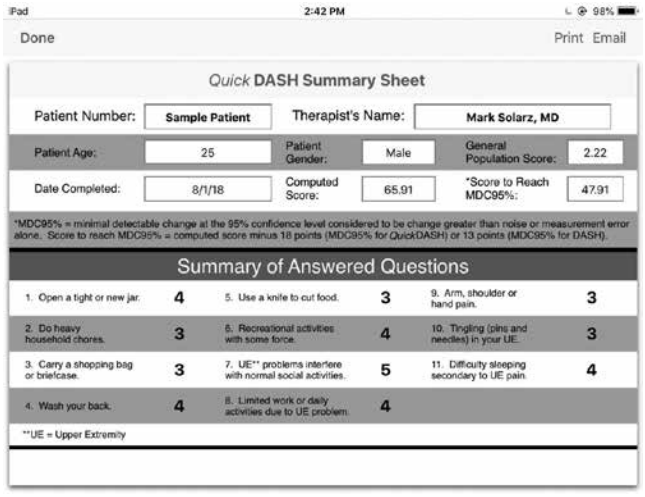

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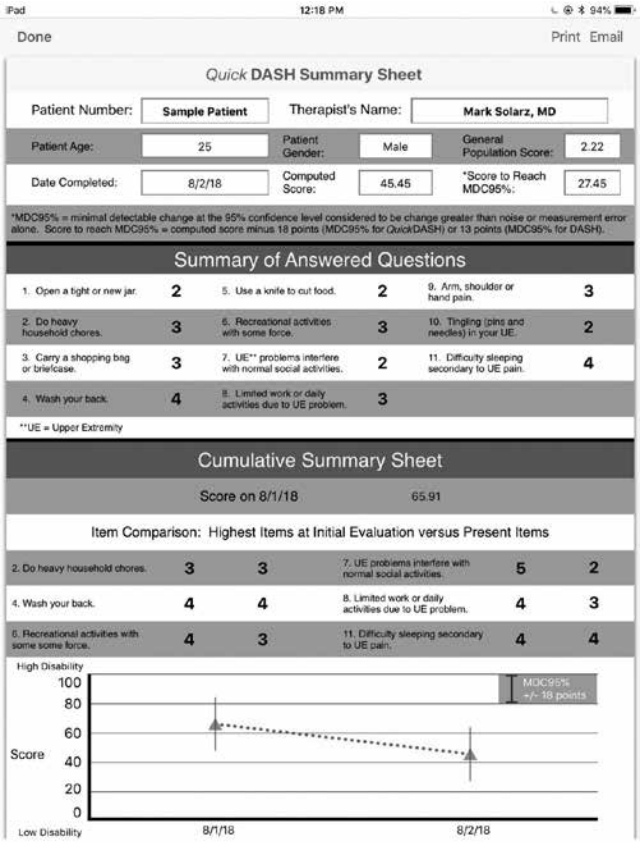
Figure 4. Example of Longitudinal QuickDASH Measurements in Outcome Tracking



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Case Report

Bilateral Simultaneous Proximal Hamstring Tendon Rupture: Surgical and Post-Operative Management

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Abstract

Due to the unique mechanism of injury, proximal hamstring avulsions are relatively uncommon injuries. Bilateral simultaneous injury is exceedingly rare. Current literature deals mostly with unilateral proximal hamstring avulsions while there is sparse data on the treatment of bilateral proximal hamstring injuries. We present the case of a patient with simultaneous bilateral proximal origin hamstring tendon avulsions that underwent simultaneous surgical repair and close post-operative management before full return to activity. The decision to undergo simultaneous bilateral repair vs a staged fashion was through a shared decision-making process with the patient. Generally, early repair (<6 weeks) is optimal for unilateral repairs as delay beyond this point has been associated with inferior outcomes. By waiting 4–6 weeks for partial recovery from the first surgery, we believe that the quality of the second repair could be compromised and lead to an inferior outcome. Therefore, the patient was willing to accept a more challenging post-operative course to achieve the best clinical outcome. The post-operative course progressed without significant incident. The patient was able to walk with a stiff legged, antalgic gait at eight weeks with crutch support, driving and walking without support at 12 weeks, and returned to full activity in 10 months.

Introduction

Hamstring muscle injuries are increasingly common sports injuries in recent literature compared to a few decades ago.[5, 6] Reasons as to why we are seeing an increase in incidence are multifactorial, but as a result, hamstring injuries are seen and evaluated by the orthopaedic surgeon more frequently. The majority of hamstring injuries are strains at the myotendinous junction which can be treated non-operatively with excellent outcomes. Proximal hamstring avulsions represent an uncommon but important subset of hamstring injuries comprising 12% of all hamstring injuries.[7, 8] Although the minority of hamstring injuries, complete muscle-tendon avulsions have shown poor outcomes with non-operative treatment protocols designed for hamstring muscle belly strain injuries. In a single retrospective review of complete proximal hamstring avulsions treated non-operatively, 30% of patients were unable to return to the same pre-injury level of sports activity and 47% of patients regretted choosing non-operative treatment.[9, 10] Operative intervention has become the standard for proximal hamstring origin avulsions. Early recognition of the avulsive injury pattern allows for early surgical repair before the avulsed tendon edge has scarred distally or the ischium has been covered with poor quality scar tissue. Both issues can complicate surgical repair and result in poor outcomes.[4, 9, 11]

Following operative intervention, one must balance protection of the repair with the need to initiate range of motion and strengthening rehabilitation. Askling et al. found avoidance of post-operative bracing for total proximal hamstring ruptures can result in favorable outcomes.[12] However, in most cases of proximal origin hamstring avulsions, post-operative bracing using a hinged knee brace or hip brace is typically employed. With knee bracing, the knee can be kept in as much as 90 degrees of flexion for several weeks to prevent tension across the repair site. An alternative is hip bracing to avoid excessive flexion at the hip and similarly decrease stress at the repair site. Bracing and specific rehabilitation protocols have shown the ability to safely return to sports and active lifestyles within 16 weeks as described by Birmingham et al.[13] We present the case of a patient with simultaneous bilateral proximal origin hamstring tendon avulsions undergoing simultaneous bilateral surgical repair as well as post-operative management and rehabilitation. Surgical intervention involved bilateral proximal origin hamstring tendon repair under the same anesthetic as opposed to a staged fashion. Post-operative management involved partial weight bearing in a hip immobilizer on the right side (the side with higher quality tissue and clinically judged more stable repair construct) and non-weight bearing in a hinged knee brace locked in 30 degrees of flexion on the left side (more soft tissue damage and more tenuous repair). Physical therapy continued for approximately 14 weeks. At 20 weeks post-operatively, the patient had minimal pain and was walking normally without braces or crutches. He also had full range of motion in his knees and hips and began to resume normal activities.

Patient History

A healthy, active 48-year-old male presented with bilateral hamstring pain, bruising, and swelling that caused limited range of motion following a non-contact injury while playing recreational flag football. The patient described an awkward fall causing him to hyperextend both of his knees and hyperflex his hips. He felt a subsequent "pop" in both hamstrings followed by extreme pain. He was taken to an emergency department where negative radiographs were obtained. Magnetic resonance imaging (MRI) for both hamstrings was obtained and the patient referred for evaluation and management.

The patient presented two days later in the orthopaedic clinic. On physical exam, the patient was in extreme discomfort. Bilateral palpable defects of the proximal hamstring origin, tenderness in the ischial tuberosities, and diffuse ecchymoses along the posterior thigh which extended into the medial thigh were noted. Review of the MRI revealed bilateral proximal hamstring tendon ruptures with approximately 7.5 cm of distal retraction bilaterally (Figures 1 and 2).

After lengthy discussion, the decision was made to forego conservative treatment and perform bilateral surgical repair of the hamstring tendons under the same anesthetic. Surgical treatment was chosen to prevent the risk of developing late proximal hamstring syndrome associated with non-operative treatments that has been well described in literature.[14] Consideration for staged surgery was given, but the decision for bilateral simultaneous repair was made because staging the repair would result in a three- to six-week delay on one side, allowing for scarring on that side and potentially compromising the repair later on.

Surgical Technique

The patient was placed in the prone position with his arms held in neutral position and all bony prominences well padded. The left side was addressed first. The perineum was sealed off, prepped, and draped in usual sterile fashion. A standard 4-cm full-thickness incision in the gluteal crease was made and carried down to the fascia of the gluteus maximus while also identifying and protecting the posterior femoral cutaneous nerve. The gluteus maximus fascia was sharply incised and the muscle was retracted proximally, exposing the proximal hamstring origin and revealing a pseudo sheath formed of scar tissue. This was incised and a large seroma evacuated. The proximal hamstring tendon was palpated distally and mobilized through combination of blunt and sharp dissection. The common tendon edge was debrided of poor-quality tissue and calcification. The sciatic nerve was identified and gently retracted laterally. The posterior, inferior, and lateral surfaces of the ischium were fully exposed, and all residual scar tissue was cleared. Currettes and small osteotomes were used to gently decorticate the ischium creating a bed of healthy bleeding bone. Four 3.0-mm SutureTak anchors (Arthrex, Naples, FL) were then placed in a diamond configuration to recreate the normal anatomic origin of the common hamstring tendon. Careful attention is made to ensure that the ischium is well exposed proximally and anchors are placed in this "high" position as we have found this significantly improves sitting tolerance later on compared to more distal anchor placement. Sutures are passed in a running tension slide type technique and the common tendon is re-approximated to the ischium with the knee held in flexion. Sutures are tied in a proximal to distal direction while a traction stitch or atraumatic tissue clamp is used to aid in reduction. The knee was taken out of full extension to ensure that the repair was very stable. The wound was irrigated and flushed, and the gluteal fascia closed with a running 0-Vicryl suture. The subcutaneous tissue was closed in typical fashion, the drapes were removed, and similar sterile prep was performed on the contralateral right side.

The right side was approached with identical technique. On this side, the tendon was more easily mobilized and some

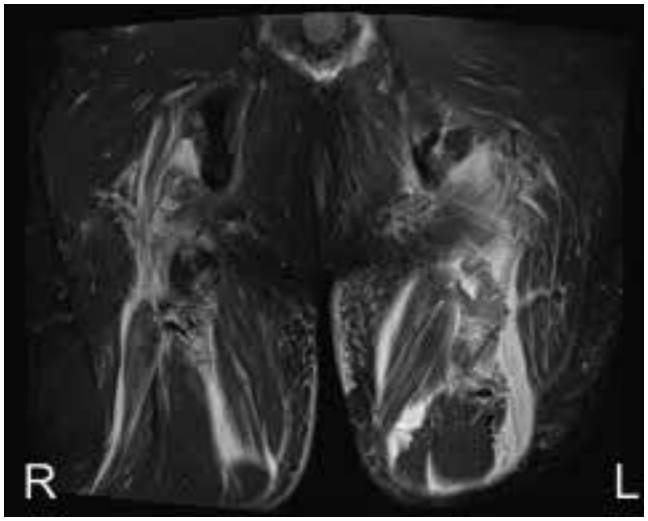

Figure 1. T2 Coronal MRI cut of the pelvis revealing bilateral hamstring tears with about 7.5 cm of retraction for each tear.

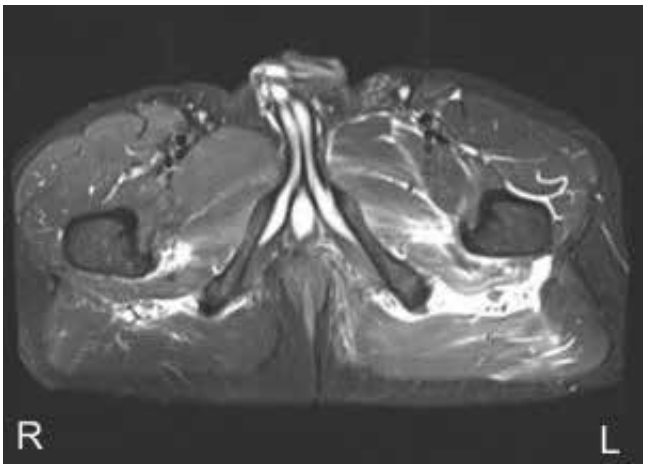

Figure 2. T2 Axial MRI cut of the pelvis revealing bilateral hamstring tears with about 7.5 cm of retraction for each tear and fluid at the ischium.

medial hamstring tissue (common biceps femoris, semitendinosus origin) remained intact (Figure 3). For that reason, only three suture anchors were required for the repair and the stability of repair was deemed to be superior to the other side. This was an important step as we planned for the patient's postoperative rehab and bracing protocol. Both repairs were stable with multiple points of fixation and high-quality tissue, but the right had some intact native tendon origin. Therefore, the plan was to place the right hip in a postoperative hip brace (Breg Phillipon Hip, Carlsbad, CA) blocking hip flexion past 30 degrees, but allowing for partial weight-bearing and transfers. The left knee was placed into a postoperative knee brace (Breg T-Scope, Carlsbad, CA) locked at 60 degrees of flexion. Our rationale was that this would allow the patient to be mobilized in some fashion while still protecting both repairs in slightly different manner. The right repair was protected by preventing high flexion at the hip and the left through prevention of extension at the knee.

Figure 3. Freed right proximal hamstring tendon after removal of calcified tissue surrounding the tendon.

Post-Operative Management

The patient was highly motivated and as such, his post-operative follow-ups progressed without significant incident. At the two-week visit, incisions were well healed, and he was able to extend both knees while supine without discomfort. He had no neurological symptoms, specifically no radicular pain and no numbness or burning in the posterior thigh. The patient continued with home exercise for the first two months. At eight weeks, the patient was able to walk with crutch support and had only a minimally antalgic gait. Formal physical therapy was initiated with a focus on restoring normal gait and hip/core strength. Sitting tolerance was the greatest challenge. For approximately 10 weeks, the patient could not sit for greater than 20-minute intervals due to pain and swelling at the site of his proximal hamstring repairs. Scar desensitization and manual therapy were initiated at 12 weeks and sitting tolerance gradually improved. At the four-month post-operative period, the patient was walking and driving without any assistive devices. Pain only occurred when sitting longer than 90 minutes. At the six-month post-operative period, the patient was able to return to work in medical sales. The patient returned to gym activities including weight lifting, elliptical and light jogging at roughly 10 months from injury. At this point, he has chosen to refrain from any recreation sports although he was cleared to do so by our office.

Discussion/Conclusion

Proximal origin hamstring avulsion injuries are relatively uncommon. The mechanism of injury typically involves rapid elongation of the tendon past its threshold through simultaneous forced high hip flexion and hyperextension of the knee.[12] Consequently, bilateral injury is extremely rare and to our knowledge this study represents the first published case of bilateral traumatic proximal hamstring injury managed surgically.

Unilateral hamstring injury and surgical management is well described. Studies have shown that such injuries can be effectively treated through surgical intervention especially when addressed within six weeks of the injury as described by Askling et al. and Birmingham et al.[12, 13] Birmingham et al. also reported that 108 of 112 athletes had good clinical outcomes and were able to return to play following early surgical intervention to repair proximal origin hamstring injuries. On the other hand, athletes who delayed surgical intervention for up to six months or longer took nine and 13 weeks longer, respectively, to return to play.[13] Our clinical decision making was driven primarily by our understanding of the previous literature which clearly highlights a decline in clinical outcome and function in patients who delay treatment greater than six weeks. For that reason, we believed the best clinical outcome could be achieved in this healthy young patient by simultaneous repair. Importantly, the patient was willing to accept the challenging postoperative course to achieve the best long-term outcome.

Due to the more severe nature of our patient's injury, he will be closely monitored during the mid to long-term post-operative period before a final assessment is made on the

success and effectiveness of his bilateral proximal hamstring tendon repair. Further studies are needed to better define post-operative restrictions and protocols for patients with proximal hamstring repair (unilateral or bilateral). Our typical protocol for unilateral repair does not allow for immediate weight bearing, but our hand was forced in this case and there does not appear to have been any deleterious effects on our patient. A single case should not change protocol, but further investigation could determine the need for protected weight bearing and bracing after proximal hamstring repair. More rapid mobilization of the patient could decrease adverse post-operative events (deep venous thrombosis, persistent weakness, and pain) and improve clinical outcomes.

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Case Report

Complete Traumatic Trifocal Failure of the Extensor Mechanism of the Knee: Surgical Tips and Tricks

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Abstract

This paper discusses the unique case of a rare 3-level extensor mechanism failure in a 28-year-old male, involving a tibial tubercle avulsion fracture, a patellar tendon avulsion off the tibial tubercle fragment, and a severely comminuted patella fracture, and the surgical technique required to repair such an injury. Focus is spent on the unique repair of a tendon injury when both proximal and distal bony attachments are damaged. Trifocal knee extensor mechanism disruption has only been reported in a retrospective review of combat-related injuries in military personnel. It is important to maintain an understanding of knee extensor mechanism anatomy and perform thorough investigation of high-energy knee injuries to ensure adequate treatment of all injuries. Results in this case show that good outcomes after complex extensor mechanism injuries are possible, but limited data exists to elucidate optimum treatment. It is essential for surgeons to have a firm grasp of techniques used to treat each segment of the extensor mechanism so that these may be combined when a patient presents with complex, multifocal injury.

Introduction

Traumatic extensor mechanism injuries are common, especially in those under 40 years of age. Most commonly, when the extensor mechanism fails, the failure occurs at a single location along the chain, with patella fractures being more common than other locations.[1] This paper will discuss in detail the unique case of a three-level extensor mechanism failure and the surgical technique required to repair such an injury. Focus will be spent on the unique repair of a tendon injury when both proximal and distal bony attachments are damaged.

Case Details

A 28-year-old male with body mass index (BMI) of 36 presented to the emergency department after a motor vehicle accident (MVC). He was driving an 18-wheeler truck in the accident, which had the front end of the cab collapse into the cabin. He was initially assessed by the trauma service and was cleared via ATLS standards. His only injury was that sustained to his knee, which was determined to be a Grade II open tibia fracture with associated Grade II open patella fracture upon initial imaging (Fig. 1). Computed topography (CT) scan was acquired that showed a vertical fracture line in the coronal plane of the tibial tubercle and a comminuted patella fracture (Fig. 2). The patient received 2g Ancef in the emergency room for prophylaxis for his open fracture, as well as a tetanus booster. He was then emergently brought to the operating room for irrigation and debridement of his open fracture wounds and ORIF of his patella and tibia. Of note, there was a possible history of remote, pediatric "knee surgery," but this history could not be confirmed by the patient.

Figure 1. Lateral radiograph demonstrating tibial tubercle fracture and comminuted patellar fracture with overlying soft tissue defects.

Figure 2. CT scan delineating the vertical, coronal plane fracture line of the extra-articular tibial tubercle fracture with overlying soft tissue injury. Also demonstrates a large bony defect in the patella, confirming the comminute nature of the fracture.

Figure 3. Picture demonstrating the wounds sustained in the initial injury, with underlying exposed bone of the fracture site.

Surgical Technique

There were two large wounds, one overlying the anterior tibia (with visualized tubercle fracture) as well as one overlying the patella (Fig. 3). Prior to case start, the operative limb was exsanguinated and tourniquet placed at 300 mmHg. The distal-most, transverse wound was extended distally to improve visualization of the underlying fracture. These wounds were initially explored and the patellar tendon was identified and mobilized from the overlying and underlying tissue. Once the tendon was mobilized, it was discovered to have avulsed from its tibial tubercle insertion. The fracture was mobilized and debrided of soft tissue, periosteum and hematoma. After debridement, an initial irrigation of the open wound with 3 L NS by low-pressure gravity tubing was performed. Following that, an anatomic reduction was achieved on the fracture fragment and K-wire placement performed for initial fixation. Following that, two Synthes 3.5-mm cortical lag screws (Synthes Depuy, Warsaw, IN) were placed in the proximal and distal aspect of the fracture fragment with resultant compression at the fracture site. Screw placement was confirmed under fluoroscopy to be in acceptable position (Fig. 4).

Attention was then turned to the patellar fracture. The patellar retinaculum was investigated and determined to be

Figure 4. Intra-operative fluoroscopic images confirming anatomic reduction of the tibial tubercle fragment with 4.0 cannulated bicortical screws, placed in a lag screw fashion.

intact, with a comminuted patella fracture underlying with minimal displacement of fragments. A small retinacular window was made to observe the largest fragments, and a point-to-point bone clamp was placed on the medial and lateral aspect of the patella to compress the fracture fragments. Following compression, a #2 fibre wire was placed in a cerclage, purse string fashion around the patellar retinacular soft tissue and hand tied under tension (Fig. 5). The clamp was removed and good compression across comminuted fragments was found with gross alignment maintained. The patella was then irrigated with 3 L NS solution, and the retinacular window was closed using #0 vicryl suture in an interrupted fashion.

Finally, the patellar tendon insertion avulsion was addressed. Due to the associated tibial tubercle fracture, this presented a unique challenge in acquiring adequate fixation. Two Arthrex 5.5-mm corkscrew anchor sutures (Arthrex, Naples, FL) were placed at the tibial insertion just medial to and through the previously fixed fracture fragment. The anchors were placed in stable, intact bone, bypassing the fracture site (Fig. 6). Attached #2 fibre wire was then stitched

Figure 5. An illustration demonstrating the unique, purse-string technique employed for fixation of the patella fracture with overlying soft tissue deficit.

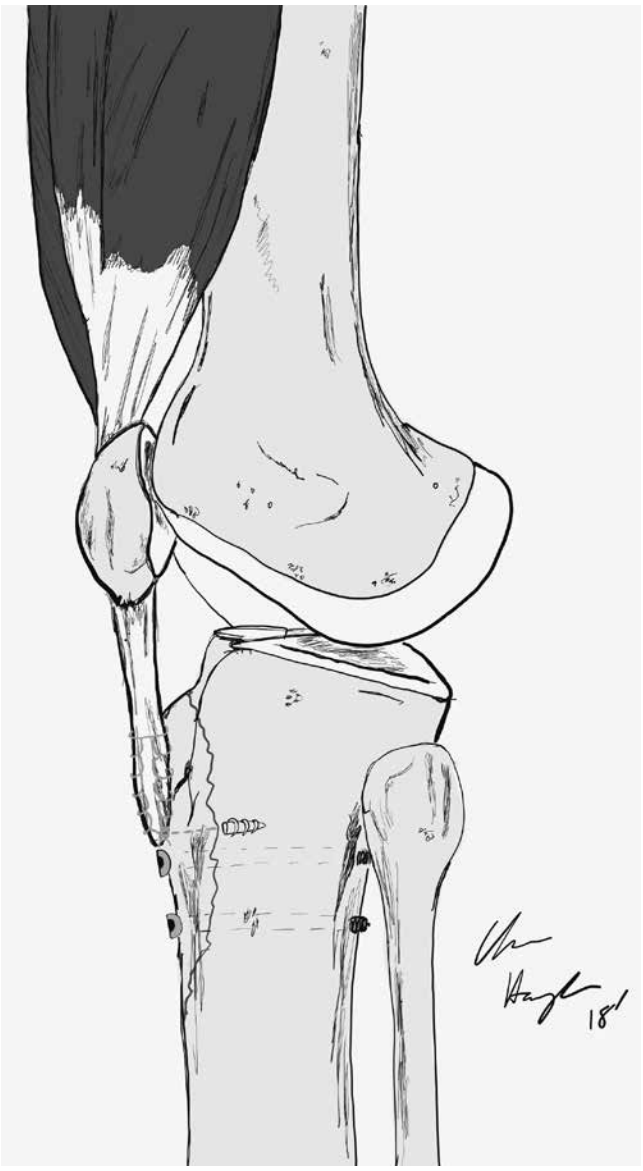

Figure 6. An illustration demonstrating the placement of anchor suture drill holes for fixation of the patellar tendon insertion, bypassing previously fixated fracture site.

through the patellar tendon in a Krakow stitch using a free needle. Two complete distal to proximal, then proximal to distal rows of sutures were performed and tied overtop the tendon. The insertion site was then reinforced with #0 vicryl suture. The entire extensor mechanism repair was tested under 90 degrees of flexion without evidence of gapping at the tibial tubercle fracture site, patellar fracture site or patellar tendon repair site (Fig. 7). At the completion of the case, hemostasis was achieved with electrocautery, tourniquet let down after a total of 99 minutes, and wound closed with interrupted nylon sutures.

Following surgery, the patient remained in the hospital for 24 hours of antibiotic treatment, compartment monitoring and pain control. He was discharged home weight bearing as tolerated in a hinged knee brace locked in extension. First

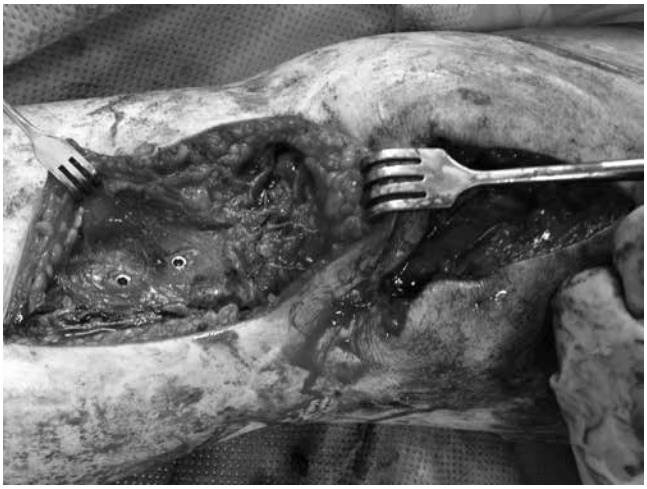

Figure 7. Intra-operative clinical picture showing the completed repair of the tibial tubercle fracture, patellar fracture and patellar tendon avulsion.

follow-up visit two weeks after surgery showed well-healing wounds without evidence of skin necrosis (Fig. 8). His knee brace remained locked in extension with no range of motion. At six weeks, x-ray showed no hardware changes, his knee brace was unlocked to 30 degrees, and he was allowed to begin range of motion exercises and weight-based strength training. At three months, his knee range of motion was 0–120 degrees of flexion with 4/5 quadriceps strength. His brace was discontinued and he was cleared for return to activities as tolerated without restriction. He continued to progress in therapy until final follow-up 11 months out from surgery. At 11 months, his wounds had healed without issue; x-ray showed complete bony union of all fractures, his knee ranged from 0–135 degrees of flexion without extensor lag, and he had returned to full activities with no complaints.

Discussion

We have described a case of trifocal knee extensor mechanism failure including a tibial tubercle avulsion fracture, a patellar tendon avulsion off the tibial tubercle fragment, and a severely comminuted patella fracture. Failure of the knee extensor mechanism in three locations is exceedingly rare with the only identified report in a retrospective review of combat related injuries in military personnel.[1] In that series, complex open extensor mechanism injuries were caused by explosive devices in 15 cases and high energy gunshots in two cases. The current case involved a restrained tractor trailer driver in a high speed motor vehicle collision. The authors proposed a novel classification scheme based on the segment of the extensor mechanism that was injured, soft tissue status, and associated distal femur or proximal tibia fracture requiring fixation. According to this classification, the injury in the current case would be labeled a 345A0, an injury combination that was not present in any of the 17 reviewed cases. The series did include four cases of trifocal extensor mechanism failure and one case of four-level failure.

In adults, patellar tendon avulsions/ruptures are more common in patients with elevated body mass index (BMI), underlying systemic illness, or steroid use.[2] The patient in the current case did have an elevated BMI of 36, but did not clearly possess any other risk factors, although no dedicated workup of systemic illness was performed. Generally, patella avulsion and tendinous failure of the extensor mechanism occur via force applied across a flexed knee, while comminuted or open patella fractures occur via direct trauma.[2] The injury in the current case is most likely related to a combined mechanism evidenced by the tubercle avulsion fracture and the comminuted patella fracture with an overlying open wound. At 10-month follow-up, our patient has minimal pain over the anterior knee, an intact extensor mechanism with five out of five knee extension strength without any extension lag, and knee range of motion of zero to 130. He has returned to work as a truck driver with frequent requirements to lift heavy objects, and has returned to weight training in the gym, reporting focus on squat exercises. The authors consider this patient to have a better than expected outcome given extent of injury. In one previous outcome study, there was a trend for patients with open patella fractures to have more associated injuries, higher pain scores, lower functional outcome scores, and higher incidence of complications, though this data did not reach statistical significance.[3]

In limited case series, patella fractures were open in 7–13% of cases and were treated with antibiotics, incision and debridement, and various forms of fracture fixation with or without internal fixation with or without the use of hardware.[3–5] In the current case, the patient was treated with immediate antibiotics and incision and debridement. The fracture was treated with purse string closure of the overlying periosteum without internal fixation because the highly comminuted fracture had limited fixation options and high risk of infection existed given large open wound. While the

Figure 8. Clinical photograph at first follow-up visit showing well-healing wounds without evidence of skin necrosis, wound breakdown, erythema or drainage.

previously cited series reported infection rates between 0–10.7%,[3–5] there was no evidence of infection in the current case.

Although examples of trifocal extensor mechanism failure are lacking in non-military series, there are a number of reports of bifocal failure. Kang et al. summarized these reports and presented a case of bifocal knee extensor mechanism disruption in an 84-year-old male after a motorcycle accident resulting in an open avulsion fracture of the inferior patellar pole and avulsion fracture of the tibial tubercle.[6] In this case, the patellar avulsion was repaired with three non-absorbable number 2.0 Ethibond sutures using vertical wiring technique,[7] and the tibial tubercle avulsion was repaired with a 4.0 cannulated screw. The authors also proposed a classification system for double disruptions of the knee extensor mechanism. The injury presented in the current case resembles a type 1 injury under this classification system-avulsion fracture of tibial tubercle with patellar ligament avulsion off the tibial tubercle — with an ipsilateral comminuted patella fracture. In the literature review presented by Kang et al., 14 reported cases of type 1 injuries were identified, all in patients 18 years or younger, further illustrating the rarity of the case presented here in a 28-year-old patient.[6]

Though reports of such injuries are limited in adult literature, several repair techniques have been described in pediatric cases of combined tibial tubercle and patella tendon avulsion injuries. Common to most of these reported techniques is open reduction and internal fixation of the tubercle fragment with screw fixation, but K-wire and staple fixation have also been described.[6] Multiple techniques to repair the patella tendon injury have been described including staple fixation of the patellar tendon to the tibia distal to the tubercle fracture,[8] suture fixation of the patellar tendon through transverse transosseous tunnels in the tibia distal to the tubercle fragment,[9] and suture repair of the patella tendon to the tibial periosteum distal to the tubercle fracture.[10] Regardless of method used, the repair of the avulsed tendon is commonly performed with fixation distal to the reduced tibial tubercle fragment, as it was in this case.

Conclusion

Although the injury described in this case does appear to be extremely rare, it is important to maintain a complete understanding of knee extensor mechanism anatomy and perform thorough investigation of high-energy knee injuries to ensure adequate treatment and improved outcomes in injuries that could be otherwise devastating to future function. The case and technique reviewed in this case demonstrate that acceptable outcomes after complex extensor mechanism injuries are possible, but limited data exists to elucidate optimum treatment. It is essential for surgeons who may encounter similar injuries to have firm grasp of techniques used to treat injury to each segment of the extensor mechanism so that they may be combined accordingly when a patient presents with complex, multifocal injury.

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Case Report

Megaprosthesis Modular Junctional Failure: A Case Report and Surgical Technique

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Introduction

Megaprostheses are utilized in orthopedic surgery for complex cases, including failed joint arthroplasty with severe bone loss, comminuted or unreconstructable fractures, and limb sparing tumor reconstruction.[1] Implant modularity in these cases allows for customization of component sizing and position, which in turn leads to improved kinematics and fixation.[2] Unfortunately, the junctions in modular designs are areas of stress concentration and possible failure.[3] Micromotion at modular junctions can cause fretting, a commonly reported type of wear between metallic surfaces that can compromise implant integrity.[4–6] Repetitive cyclic motion experienced during normal movement of the knee joint places modular implants utilized in total knee arthroplasty (TKA) at risk of structural failure.[4] Benefits of modularity must be carefully weighed against the downside of possible junctional failure.

There have been numerous case reports in the literature describing modular junction failure in joint arthroplasty. Failure of modular femoral stems at the stem-prosthesis junction have been described in multiple cases, typically involving fracture of the femoral stem in individuals over the age of 50.[5, 7, 8] To our knowledge, no cases address fracture of the femoral component at the stem-condyle junction.[5, 7, 9] We present the case of a 27-year-old woman with a fractured femoral component at the stem-condylar junction, with a well-fixed proximal tibial replacement and intact femoral cement mantle. Following removal of the broken prosthesis, we utilized a cement-into-cement technique to insert a new femoral stem and femoral component.

Case Description

The patient is a 27-year-old otherwise healthy female who underwent right knee limb sparing proximal tibial osteosarcoma resection and endoprosthetic reconstruction 13 years ago. She completed both pre- and postoperative chemotherapy and was followed six years postoperatively without any significant symptoms or concern for disease recurrence. She went on to lead an active lifestyle and became a laborer, loading boxes and walking significant distances without difficulty.

She presented to our office 13 years after her index operation with recurrence of knee pain. Her knee pain started two months prior to presentation, at work. She described a pop in her knee, as well as a sensation of weakness and instability. Subsequently, she was evaluated at an outside hospital, and found to have no evidence of extensor mechanism disruption, infection, or oncologic disease recurrence. During this time, she was only able to bear weight with a knee immobilizer. She came for a second opinion.

On presentation, her knee range of motion was 0–110 degrees. She had minimal varus-valgus laxity and no extensor lag. Her imaging now showed a fractured femoral component at the stem-condylar junction, with a well-fixed proximal tibial replacement and intact femoral cement mantle. Laboratory workup at our institution showed ESR 11 and CRP 1.5.

Surgical Technique

A preoperative adductor canal block and a spinal anesthetic were performed. Dual antibiotic prophylaxis was administered in the form of weight-dosed vancomycin and cefazolin. A thigh tourniquet was applied and inflated to 250 mmHg from skin incision until curing of cement for a total of 91 minutes.

Her prior midline incision was utilized and the previous subvastus approach was developed. Care was taken to minimally disrupt the gastrocnemius flap distally. A synovectomy was performed and the medial and lateral gutters were cleared of scar. A limited medial release was performed. The hinge mechanism was unlinked and the polyethylene insert removed. At this point, the condylar portion of the femoral component was easily removed without bone loss. We confirmed that the component had fractured at the stem-condylar junction. Trephines were utilized to slightly open the distal portion of the cement mantle around the stem by 2–3 mm, to engage the periphery of the stem. A hemostat was utilized to unthread the remaining broken portion of the body from the stem. Once removed, a small trial tibial baseplate was threaded onto the exposed stem threads and used to disimpact the stem from the cement mantle. This was confirmed to be a 14x80 mm stem extension.

The cement mantle left *in situ* was grossly intact, which was expected based on preoperative imaging. There was some osteolysis distally but the condyles were supportive and intact. Based on this, the decision was made to cement a

new prosthesis into her existing intact cement mantle using a cement-into-cement technique. Based on the prior stem that was removed, a 10x80 mm stem was selected to allow for adequate cement fill around the stem. A new construct was assembled using a size small femoral component, and inserted to confirm adequate seating. The components were removed. Osteolytic membrane was debrided and the bony surfaces were cleaned and dried. Antibiotic cement was prepared and using a cement gun, the canal was back-filled and pressurized. The metaphyseal bone and backside of the prosthesis was also coated. At this point, the implant was inserted, taking care to maintain appropriate femoral rotation. Excess cement was removed. Once the cement was fully hardened, we retrialed her polyethylene insert and found that she had adequate flexion and extension as well as patellar tracking. A final 13-mm polyethylene insert was placed with a rotating platform according to manufacturer's recommendations.

The tourniquet was deflated, hemostasis was achieved and a routine wound closure was performed.

Discussion

Megaprostheses provide orthopaedic surgeons the ability to bridge large bone defects. They are used in complex total knee arthroplasty (TKA) cases to restore function and improve quality of life.[10] Overall, the mean survival rate of megaprostheses in lower-limb reconstruction is about 13.2 years, with overall survival to breakage rates of 95% and 85% at 10 and 20 years, respectively.[11, 12] Despite their usefulness in orthopedic surgery, megaprostheses are associated with high failure rates ranging from 17–33% at five years, 33–52% at 10 years and up to 73% at 15 years.[13] Henderson et al. observed structural failures, classified by loss of structural integrity, in about 17% of megaprosthesis failures.[14]

Design improvements have led to decreasing failure rates for modular implants, but have not eliminated the problem. Modular junctions are areas of stress concentration, making them common sites of failure. Fretting and corrosion at modular junctions are documented causes of structural failure, gradually reducing mechanical integrity and releasing metal debris that may negatively affect tissue quality.[4, 6, 13, 14] A study conducted by Arnholt et al. observed mild-to-severe fretting and corrosion damage in up to 93% of knee implants requiring revision surgery, indicating the impact this type of damage can potentially place on knee arthroplasty.[6]

Rotating-hinge implants allow a small rotational degree of freedom that achieves constraint and stability, while also dispersing stresses that may contribute to implant fretting at modular junctions and aseptic loosening at bone-implant interfaces.[15] Fifteen-year survivorship rates for these implants range from 76% to 98.3%.[15, 16] Modular intramedullary stems can be utilized in rotating-hinge implants to aid in implant fixation, stress dispersion, and load-sharing with the associated bone.[17] The original implant utilized in our patient's primary reconstruction was the Global Modular Reconstruction System (Stryker Inc., Rutherford, NJ, USA), with a modular rotating hinge shown to have an extremely low rate of structural failure.[18, 19]

The literature surrounding knee megaprostheses provide several reports of structural failures at the stem-condylar junction. A study conducted by Agarwal et al. investigating megaprosthesis knee implants reported 22/28 breakages occurring at the stem collar junction.[20] Five breakages of a highly constrained Total Condylar III prosthesis (DePuy Johnson & Johnson, Warsaw, IN) were also reported by Lim et al., describing fracture at the stem-condyle junction.[5] Baral et al. reported a case of fatigue fracture of the femoral adapter bolt and taper adapter of a rotating knee prosthesis.[9] Fracture of a modular femoral stem in a cemented, varus-valgus constrained revised TKA has also been reported by Nikolopoulous et al.[7] The only other case describing breakage of the femoral component in the GMRS prosthesis has been reported by Koch et al., describing a fractured lateral condyle. Although these studies and case reports describe structural failures with similarities to our patient's case, to our knowledge, fracture of the femoral component at the stem-condyle junction has not been previously described.

The structural failure observed in our patient involved a fractured femoral component at the stem-condyle junction, with a well fixed proximal tibial replacement and intact femoral stem and cement mantle. There were several factors predicting failure in our case. Generally, complex reconstruction of the proximal tibia is associated with higher complication and mechanical failure rates as compared to other anatomical locations, such as the distal femur.[13, 21] In addition, the primary reconstruction occurred in adolescence, a period of high physical activity. The patient subse-

Figure 1. Anteroposterior **(A)** radiograph of implant taken prior to revision surgery indicating no apparent fracture. Lateral **(B)** radiograph shows fracture of the femoral component and distal femoral osteolysis.

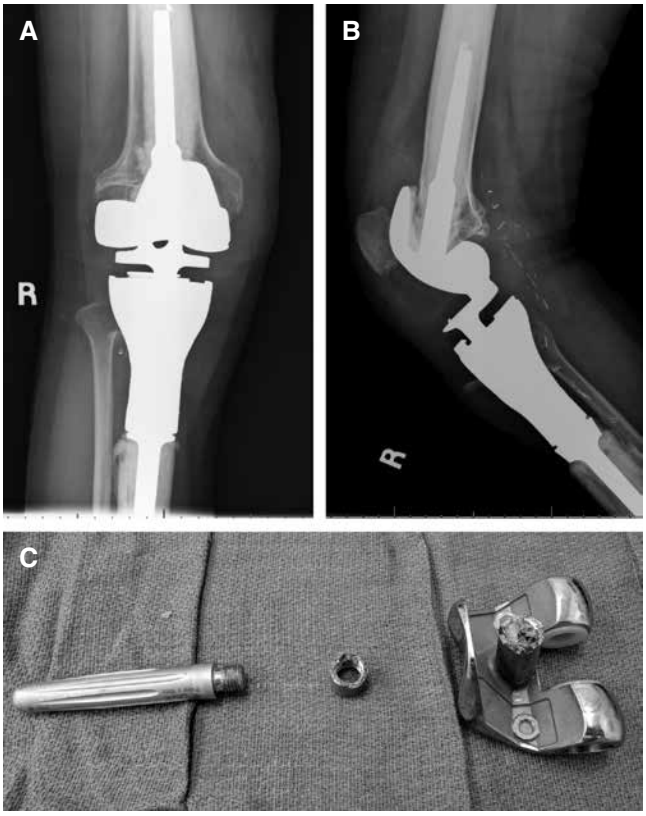

Figure 2. Postoperative radiograph showing anteroposterior **(A)** and lateral **(B)** aspects demonstrating revised hinged TKA. Photograph **(C)** of explant showing intact femoral stem with proximal fracture of femoral component at the stem-condylar junction.

quently worked as a laborer and presumably placed high demand on her implant. Younger patients typically achieve better clinical outcomes following TKA, but experience lower survivorship compared to patients above the age of 50.[22] The femoral component experiences axial compression, flexion-extension and varus-valgus stresses. The condyles of the femoral component transmit forces through the femoral stem and host bone, and the stem is most likely to experience stress concentration at the stem-condyle junction and proximal tip of the stem.[5, 7, 23] In addition, osteolysis induced by wear debris of metal and polyethylene components is a common issue in TKA.[4, 24] The resulting bone degradation may decrease the surface area over which the femoral component can transmit forces to the femur, leading to even greater stresses on the femoral stem. Min et al. concluded that aseptic loosening of the femoral component would increase stresses through the stem-condyle junction, and osteolysis can contribute to aseptic loosening.[23] Although the patient attained good use of her implant prior to fracture, her age, lifestyle and anatomical site of reconstruction placed her at greater risk of implant failure and subsequent revision.[13, 21, 25]

The elected method of revision poses several advantages. The removal of a well-cemented stem from the intramedullary canal during TKA revision has been described as the most difficult step during revision surgery and can severely damage cancellous bone surrounding the stem.[20, 26] The cement-into-cement technique is well-described in revision total hip arthroplasty to minimize the risk of bone loss, cortical perforation and fracture, and surgical time and complexity.[27] Although there is less information surrounding this technique in revision TKA, the same advantages theoretically apply to our patient. In addition, surgery time was shortened, reducing risks of infection and morbidity. Revision knee arthroplasty is associated with an up to four times greater risk of infection that primary procedures due to increased operative time and poor vascularity of tissues and bone as a result of multiple procedures.[26] Overall, this treatment approach conserves her existing bone and cement, leaving more options for future reconstruction should another complication arise.

Although the treatment approach allowed us to restore reasonable function to our patient, there are also potential disadvantages to this treatment approach. The treatment approach involved the use of a 10x80 mm stem in place of a 14x80 mm stem. Stem fracture has been shown to be more common in smaller diameter stems because they are subjected to higher stress levels, making the new implant more likely to fail by this mechanism.[12] There was also notable osteolysis in the distal femur, and there is the likelihood that polyethylene wear will contribute to further osteolysis progression. The most significant increase in stress at the stem junction occurs in the presence of large condylar defects. Therefore, patients with femoral defects or compromised bone quality are particularly vulnerable to modular implant failure.[4] In addition, the lack of literature describing clinical outcomes of the cement-into-cement technique in revision TKA remains a limitation on our treatment approach. Although the patient has reportedly adopted a more sedentary lifestyle, her young age and level of physical activity predict higher strains on her prosthesis and she remains at a relatively higher risk of implant failure.[13, 22]

Conclusion

Our case presents a unique fracture of the femoral component, with the utilization of a cement-into-cement revision technique to restore function to our patient. This conservative approach may be employed in patients experiencing similar mechanisms of structural failure, while preserving valuable bone stock and maintaining reconstructive options for the future.

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Case Report

Acute Proximal Tibiofibular Joint Dislocation and Surgical Repair Through Suture Post Technique: A Case Report

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Abstract

Acute isolated proximal tibiofibular dislocation is a rare injury. The most common injury mechanism typically results from non-contact athletic injuries or high-energy trauma. With the knee hyper-flexed, the ankle is inverted and plantar flexed imparting tremendous stress across the proximal tibiofibular joint.[1–3] The injury may also be seen with multi-ligament knee injuries. Current trends are shifting towards early surgical management as unfavorable outcomes and residual instability have been seen with conservative management.[1, 4]

We present the unique case of a proximal tibiofibular dislocation resulting from a high-energy shear mechanism that effectively dissociated the proximal tibiofibular joint and de-gloved the proximal fibular head. In our case, posterolateral corner repair and peroneal nerve neurolysis were performed in conjunction with proximal tibiofibular joint open reduction and internal fixation. A secondary procedure was performed to remove hardware and recess the gastrocnemius to achieve optimal ankle range of motion. The patient's post-operative follow-up progressed without incident. At 9.5 months following the original injury and surgery, the patient had full ankle and knee range of motion, no neurological or sensory deficits and returned to her prior level of function.

Introduction

The proximal tibiofibular joint is an inherently stable arthrodial synovial joint.[2, 5] The articulation of proximal fibula and the posterolateral surface of the tibia is encompassed by joint capsule and the anterior and posterior tibiofibular ligaments providing significant stability. The joint is further stabilized by the surrounding soft tissue attachments, namely the fibular or lateral collateral ligament and the distal biceps femoris tendon.[2] Functions of the proximal tibiofibular joint include transmission of axial loads during weight bearing and the dissipation of torsional loads at the ankle and with lateral tibial bending moments.[6] Stability of the joint is greatest with the knee in extension, which accounts for the majority of injuries affecting the flexed knee.[6]

The posterolateral corner and lateral structures are closely associated with the proximal tiobiofibular joint and are frequently injured accounting for 16% of all knee ligament injuries. As the anatomy and biomechanics of the posterolateral corner have been more completely described, the recognition of such injuries has improved. In turn, surgical indications are more clearly defined and outcomes have steadily improved with a focus on anatomic reconstruction.[7] With associated injury to the proximal tiobiofibular joint, the normal anatomy of the posterolateral corner should be reviewed. In normal anatomic relationship, the fibular collateral ligament insertion lies distal and anterolateral to the tip of the fibular head and the long head of the biceps inserts on the posterolateral aspect of the fibular head both aiding in knee stability.[3, 7]

Proximal tibiofibular dislocations are uncommon. Described mechanisms are during sports-related competition or high-energy trauma, often associated with other ligamentous injury of the knee.[1, 4] In the athletic setting, injury typically occurs when the knee is hyper-flexed and the ankle inverted and plantar flexed.[1–3] Isolated proximal tibiofibular dislocation is rarely reported. More commonly, proximal tibiofibular dislocation is a component of a multi-ligament knee injury. If the proximal tibiofibular joint is left unaddressed, the long-term stability of the knee and patient outcome may be compromised.[1, 4] Jabara et al. reported a 9% incidence of dislocated or dislocateable proximal tibiofibular joint in their multi-ligament knee injury population. In their cohort, stabilization was performed before proceeding with lateral collateral ligament or posterolateral corner repair/reconstruction as the majority of techniques involve bone tunnels through or direct suturing to the fibular head.[1]

Early reduction is necessary to provide a stable platform for reconstruction techniques and also prevent late instability and/or progressive cartilage damage to the tibiofibular joint itself.[1, 3] Treatment of proximal tibiofibular joint dislocation has been well described with multiple surgical techniques including closed reduction, open reduction and internal fixation, ligamentous repair and/or reconstruction, arthrodesis and fibular head resection.[2] We present a case of a complete disruption of the proximal tibiofibular joint and the anterior and posterior ligaments as well as complete stripping of the proximal insertions of the biceps femoris,

capsule and lateral collateral ligament. As anatomic reconstruction of knee ligaments has been reported as achieving improved biomechanical and clinical outcomes, the decision was made to proceed with surgical stabilization and anatomic repair of surrounding structures to avoid chronic lateral knee pain and instability.[3]

Patient History

A 35-year-old female was transferred from an outside hospital following a pedestrian-struck motor vehicle accident. The patient was stepping off a curb when she was struck by a car at a low speed resulting in her right leg being pinned between the vehicle and a wall for approximately one minute. The patient had immediate complaints of knee pain and swelling. She was transferred from an outside emergency department to a level 1 trauma center after radiographic examination revealed dislocation of the proximal tibiofibular joint (Figure 1). She presented to our facility with obvious swelling and ecchymosis about the knee and leg; however, lower extremity compartments were soft and compressible. An initial closed reduction was attempted in the emergency room but was unsuccessful. The proximal tibiofibular joint was noted to be freely mobile and grossly unstable. The patient was admitted for monitoring and underwent MRI of the right knee during her stay. MRI demonstrated obvious lateral injury, specifically complete disruption of ligamentous attachments at the proximal tibiofibular articulation including the biceps femoris attachment, lateral displacement of the proximal fibula, and avulsion of the conjoined tendon from the proximal fibula without fracture (Figure 2). Also noted was stripping of lateral patellar retinaculum from femoral attachment and Morel Levalle lesion posteriorly and laterally.

The patient was monitored to ensure she did not develop compartment syndrome. Four days post-injury, she had decreased swelling. Her compartments remained soft and compressible and she was deemed appropriate for surgery.

Figure 2. Coronal T1 and T2 views of a plain MRI of the right knee revealing disruptions of ligamentous attachments at the proximal tibiofibular articulation.

Surgical Technique (Posterolateral Reconstruction and Peroneal Nerve Neurolysis)

Examination under anesthesia revealed obvious lateral instability and hypermobility of the fibular head all consistent with complete dislocation of proximal tibiofibular joint and posterolateral corner injury. The patient had 5-mm asymmetric opening to varus stress in extension, 1.2-cm opening to varus stress at 30 degrees of flexion.

The patient was positioned supine and a tourniquet was applied high up on the thigh. A lateral hockey stick incision was made posterior to the femoral origin of the lateral collateral ligament extending just distal to the proximal tibiofibular articulation. A large hematoma consistent with the Morel-Levalle lesion was evacuated and the area was irrigated and flushed with antibiotic solution. The level of injury was identified below the hematoma with obvious avulsion and retraction of the biceps femoris and complete stripping of the proximal tibiofibular joint with capsule detached and displaced laterally. The fibular head was easily translated independent of the tibia. The peroneal nerve was next identified at the fibular head and neurolysed proximally and distally into the lateral anterior compartment of the leg. The

Figure 1. AP radiographs of the right knee and tibia-fibular revealing dislocation of the proximal tibiofibular joint. Degree of dissociation best appreciated on the oblique knee radiograph.

detached biceps femoris was mobilized and cleaned of scar and torn tissue debris, leaving a small stump of tendon. The tendon was reinforced with four #2 fiberwire sutures in an interlocking Krakow fashion. The lateral collateral ligament was dissected from surrounding scar tissue, isolated and augmented with two augmented with #2 fiberwire sutures as well. Once all structures were identified and prepared, the proximal fibular head was rasped to promote healing as these structures would be repaired to the surface as opposed to conventional tunnels. The fibular head was reduced using percutaneous reduction forceps and the knee was taken through full range of motion to ensure no excessive movement at the proximal tibiofibular joint. A guide wire was placed across the proximal tibiofibular joint and floursocopy was used to confirm accurate placement. A single 6.5 mm partially threaded screw with a washer was placed to maintain reduction of the joint. The foot was held in dorsiflexion at the time of screw placement to ensure normal ankle range of motion postoperatively. The screw and washer were then utilized as a suture post to attach the soft tissues structures. The lateral collateral ligament followed by the biceps femoris sutures were tied around the post and the knee was again taken through full range of motion. The biceps femoris was reinforced with a running 0 vicryl suture and the remainder of the hematoma in the area was evacuated. The peroneal nerve was again evaluated and the nerve was confirmed to be completely mobile and resting free of hardware irritation. The incision was closed in routine fashion and the patient was placed in a post-operative knee brace locked at 20 degrees of flexion.

Post-Operative Management

Following the procedure, the patient remained overnight in the hospital for monitoring and pain control. She was discharged the following day with instructions to remain non-weight bearing with brace and crutches. The patient was seen for evaluation in the office two weeks following surgery and had complaints of deep calf pain as well as some numbness and tingling in the distribution of the superficial peroneal nerve. She was only able to flex the knee 20–25 degrees and had moderate difficultly and pain with ankle dorsiflexion. A venous duplex doppler was obtained to confirm no evidence of deep venous thrombosis. The patient was started on a continuous passive motion unit for the knee to prevent stiffness. She remained non-weight bearing for four weeks at which point she was placed in a CAM walking boot to progress due to her limited ankle motion and pain. She continued to experience ankle stiffness as she progressed in physical therapy and ambulated with crutches. Three months following her procedure, the patient had achieved full range of motion of the knee, the proximal tibiofibular joint remained reduced on serial radiographic examination, but she continued to experience significant ankle stiffness particularly with dorsiflexion (Figure 3). In order to improve her ankle motion and prevent further stiffness, a decision was made to undergo removal of the screw and washer at the tibiofibular joint and perform a Strayer gastrocnemius lengthening procedure concomitantly.

Figure 3. Two-month post-operative AP lateral radiographs of the right knee revealing that the proximal tibiofibular joint had remained reduced following posterolateral reconstruction.

Surgical Technique (Removal of Hardware and Strayer Gastrocnemius Lengthening)

Approximately 19 weeks following the index procedure, the patient underwent removal of hardware and Strayer gastrocnemius fractional lengthening. The patient was placed supine and a 4-cm incision was made under direct visualization and fluoroscopic guidance to dissect to the level of the hardware through significant scar tissue. It was confirmed that the previous LCL and hamstring repair were stable so the screw and washer were removed. The knee was taken through full range of motion with no issue. Under fluoroscopy, the foot was fully dorsiflexed and externally rotated to stress the tibiofibular joint demonstrating no increased motion. The ankle was reevaluated and still stiff. A 3-cm incision was made over the confluence of the medial and lateral gastrocnemius to the level of the Achilles tendon. The sural nerve was identified and mobilized and the fascia was identified and released. The foot was dorsiflexed and a 1-cm gap was noted in the fascia. Routine closure was performed and the patient was discharged that day in a CAM boot with instructions to weight bear as tolerated on the right lower extremity.

Post-Operative Management

Post-operative follow up progressed without incident. The patient attended structured physical therapy to regain full range of motion in her knee and ankle. At 9.5 months following the original injury and surgery, she had full ankle and knee range of motion, no neurological or sensory deficits and returned to her prior activities without incident.

Discussion/Conclusion

Several surgical techniques have been described to repair and/or reconstruct the capsuloligamentous tibiofibular joint and surrounding structures following reduction of the joint. Most focus on restoring the fibular collateral ligament with techniques through trans-fibular head bony tunnels with supplemental allograft or autograft tissue, such as with the split biceps femoris tendon reconstruction.[1, 9] In our case, the mechanism of injury was unique and essentially cleanly degloved all the structures attached to the fibular head. During surgical repair, the biceps femoris tendon and fibular collateral ligament could be easily identified and mobilized and the fibular head was intact. Therefore, primary repair with reinforcement of injured structures was performed. The single screw served a dual function to reduce the proximal tibiofibular joint while also providing a suture-post fixation point for anatomic repair of soft tissue structures. This technique allowed for satisfactory reduction of the tibiofemoral joint through full knee range of motion, restoration of the lateral complexes including stability to varus stress at zero and 30 degrees of knee flexion, and full knee range of motion.

Our case does highlight the need to remain attentive to the impact of proximal tibiofibular joint fixation on distal ankle mechanics. Our patient was able to achieve full range of motion under anesthesia but had significant discomfort with active ankle dorsiflexion similar to patients with an over constrained distal syndesmosis. This was addressed early through hardware removal and gastrocnemius recession and therefore, did not compromise patient function.

Short-term results in our patient support the findings of Ogden and Robinson et al. in that stabilizing the proximal tibiofibular joint through K-wire or screw fixation will allow for direct repair of the fibular head, early reduction, and avoidance of cartilage damage at the tibiofibular joint along with chronic dislocations or instability.[3, 8] The suture-post fixation technique has provided a promising short-term outcome for the patient in this case effectively reducing the proximal tibiofibular joint and allowing for anatomic repair of adjacent soft tissue structures. However, studies on a larger population of patients with a focus on the long-term outcomes from the procedure are needed in order to determine the technique's clinical relevance and true effectiveness in treating proximal tibiofibular dislocations and associated multi-ligament injuries. Every multi-ligamentous injury is unique and may require a combination of techniques. We believe our approach represents an effective technique in acute soft tissue stripping injuries associated with complete proximal tibiofibular joint dislocation.

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Case Report

Tibiofibular Joint Synostosis After Tibial Intramedullary Nailing: Conservative Management of the Novel Finding

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Abstract

We report the case of a 28-year-old male semi-professional basketball player who presented with left knee pain post intramedullary nailing (IMN) of non-healing proximal tibial stress fractures. Review of films approximately one year later showed no loosening or misplacement of hardware, but revealed synostosis of the tibiofibular joint (TFJ). A literature review bares few similar cases and none in which TFJ synostosis occurred post tibial nailing without the presence of excessively protruding screws. The patient was managed conservatively with retention of hardware and physical therapy. The patient's pain improved without invasive intervention, and he returned to his previous semi-professional athletic activities. Although an unusual complication with limited data, we recommend conservative management.

Introduction

TFJ synostosis, as a complication of trauma or surgery, is an exceptionally rare complication with few reports available in the literature.[3, 4, 7, 8] This interosseous bone growth is thought to occur from soft tissue damage, hemorrhage, or subperiosteal dissection.[7] As far as we know, this is the second case reported of TFJ synostosis post tibial nailing. It is the first reported case of TFJ synostosis post tibial nailing without excessively protruding hardware. Here, we offer our review of the literature with a presentation of the patient's case.

Case Report

A 28-year-old male semi-professional basketball player presented to our orthopaedic practice with complaint of pain proximal and lateral to the left knee joint approximately one year after left tibial intramedullary nailing. There was some concern that the lateral pain could be caused by complications involving the proximal interlocking screw, though the pain was not localized directly over its location. The tibial nail was placed one year prior to presentation at an outside hospital for treatment of tibial stress fracture. Upon presenting to our practice one year after the surgery, we ordered a CT scan to rule out hardware complications including screw breakage or prominent position. The CT showed that the initial drilling may have penetrated through the tibia and into the fibula. However, it also demonstrated that the hardware is properly positioned with no protruding or loosening screws. It displayed no acute fracture consistent with the patient's reported level of pain (Figure 1). Instead, the CT scan revealed proximal tibiofibular synostosis immediately distal to the TFJ joint (Figure 1). We posited that the hardware likely had little to no impact on the patient's pain, given location of reported symptoms. Following a literature review and a discussion with our patient, we decided to proceed with conservative management including physical therapy. The patient declined a steroid injection. We left the hardware in place and performed no resection of the bony formation. The patient's knee pain resolved with these conservative measures and he was able to return to playing semiprofessional basketball. He does report intermittent, mild pain on the medial side of the knee while playing basketball, but this does not limit his participation.

Discussion

Upon presenting with post-operative knee pain near the site of tibial proximal interlocking screws, there was a high suspicion of hardware complications. IMN hardware issues are very common and the source of many patients' post-operative pain,[2, 5] especially with protrusion of interlocking screws beyond 5 mm.[10] Hardware removal after tibial IMN often leads to symptomatic relief.[2, 5] The CT scan in the current case failed to show evidence of broken or loose hardware that would clearly indicate surgical hardware removal. Instead, the CT did show a synostosis that did not specifically correlate with his localized pain.

After no published case matched our patient's pathology, we consulted several similar cases to make the best fitting assessment. The most similar case involved a 14-year-old female who developed asymptomatic TFJ synostosis secondary to tibial nailing; the new bone developed around the screw protruding well into the interosseous space. The patient had the screw removed at 48 weeks, and she remained asymptomatic at five years. Surgical excision was ruled out as long as the patient remained asymptomatic.[7] In a second similar case, a 62-year-old female developed asymptomatic TFJ synostosis post osteotomy when a screw, later removed, penetrated well into the interosseous membrane.[3] While both cases bear similarities to the current case, CT scan confirmed

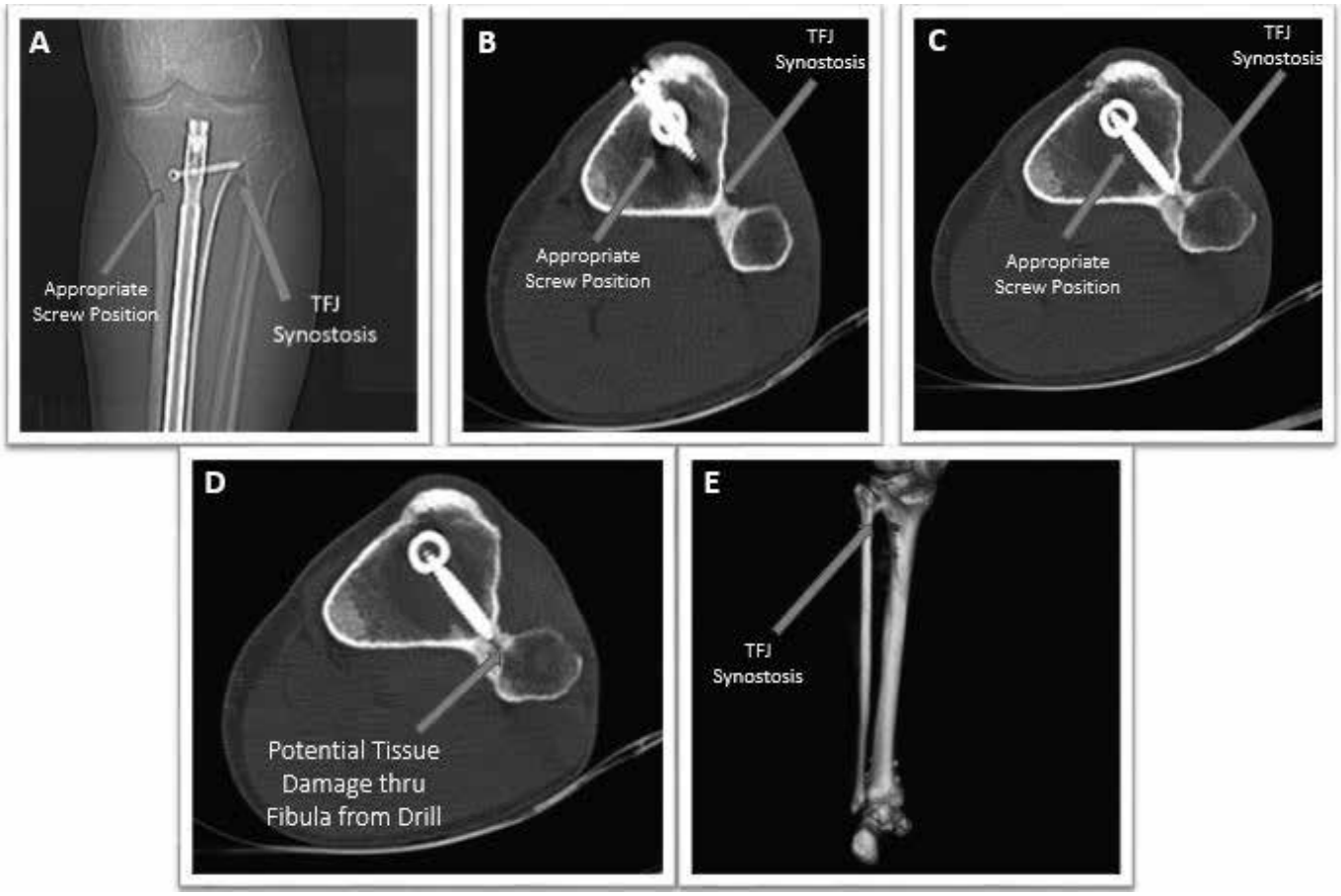

Figure 1. Proximal Tibiofibular Joint Synostosis: A. AP x-ray of the left proximal tibia show tibial nail in acceptable position with visible TFJ synostosis. **B.** Axial CT scan showing appropriate position of hardware and TFJ synostosis. **C.** Axial CT scan showing appropriate position of interlocking screw without excessive prominence. **D.** CT scan demonstrating potential soft tissue damage from drilling through the TFJ space into the fibula. **E.** 3D reconstruction showing TFJ synostosis.

appropriate placement of hardware prompting the decision to continue with nonoperative management.

Six other TFJ synostosis cases, none of which matched the surgical etiology of the current case, were identified lacking syndromes or deformities in the literature over the last 19 years. The identified cases were all asymptomatic and effectively managed with conservative treatment.[4, 9] The asymptomatic nature of these patients casts doubt on the synostosis as the source of our patient's pain, suggesting the synostosis acted as a red herring. The possibility remains that the presence of the implant or the synostosis caused the pain in the patient. However, knee pain after tibial IMN is a well-known complication with poorly delineated etiology and it is impossible to attribute the knee pain in the current case to any one factor.[6, 8] Alternate low probability causes of pain in this case include metal allergies leading to nonspecific deep generalized pain and metal corrosion not seen on imaging.[1]

After evaluating the asymptomatic nature of the most similar synostosis cases, considering surgical tissue damage as a proposed source of knee pain, and reviewing the patient's lower extremity imaging, we surmised that patient's pain was most likely unaffected by the synostosis or the final position of the screw. These considerations along with a patient discussion led us to a conservative approach. With these measures, the patient returned to semi-professional basketball 13 months post-surgery with tolerable discomforts.

Conclusion

TFJ synostosis is an extremely rare finding post IMN nailing. This is the second TFJ synostosis case reported post tibial IMN, with the other case involving prominent screw placement. It is the only reported case in which TFJ synostosis occurred post tibial nailing without excessive protrusion of the screw into the interosseous space. In patients where the IMN screws are not protruding or loosening, we recommend conservative treatment pending additional data related to both this rare form of synostosis and hardware removal.

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Senior Abstract

Opioid Prescribing Patterns in Shoulder Surgery Before and After Implementation of a Statewide Registry

Peter Eyvazzadeh, MD

Senior Bio Questionnaire

- Full Name: Peter Matthew Eyvazzadeh
- Hometown: Bethlehem, PA
- Undergraduate University: Bucknell University
- Undergraduate Degrees: Spanish (BA), Biology (BS)
- Medical School: Penn State Hershey College of Medicine
- Fellowship: MedStar Union Memorial Hospital, Sports Medicine
- Significant Other: Jane Wieler
- Hobbies: Tennis, squash, running, skiing
- Interesting Fact: I have never been able to touch my toes while keeping my legs straight

Introduction

Opioid use has become a national epidemic in terms of its impact on both mortality and medical costs. The purpose of this study was to examine the effect of a statewide prescription drug monitoring program (PDMP) on opioid prescribing patterns within the context of elective shoulder surgery at an urban academic medical center.

Methods

A total of 425 patients aged 18 years or older who had undergone shoulder arthroscopy, arthroscopic rotator cuff repair, arthroscopic labral repair, and shoulder arthroplasty between January 1, 2015 and July 31, 2017 were included in the study. Data was collected on patient age, medical comorbidities, post-operative complications, insurance type, prior opioid exposure, the amount and type of pain medication prescribed within six months post-operatively, and the prescriber. Statistical tests including Student t-tests, Wilcoxon-Mann-Whitney, Chi-Square, Fisher's Exact, Kruskal-Wallis, as well as two-way and multivariable ANOVA were performed to compare variables between patients before and in the first six months after statewide registry implementation.

Results

There was a total of 215 patients in the group prior to implementation of the statewide registry, and there were 181 patients in the group after initiation of the registry. There was no significant difference in opioid prescription rates before and after implementation of the PDMP in this study. Through statistical analyses, this study demonstrated a number of factors that correlated with greater amounts of opioid prescriptions as measured in morphine equivalents. Specifically, the presence of a greater number of medical comorbidities, specific post-operative complications, Medicaid as the insurance provider, and the prescriber type were associated with higher numbers of total morphine equivalents prescribed.

Discussion and Conclusion

Implementation of a statewide registry did not statistically change the amount of opioid prescriptions filled after shoulder surgery in this study. In this study, other factors were identified as having more influence on the quantity and duration of opioid treatment. Future studies may examine this phenomenon at a broader level across the orthopaedic field, and how the associated factors demonstrated in our study, among others, impact physician prescribing.

Senior Abstract

Senior Bio Questionnaire

- Full Name: Justin Michael Kistler
- Hometown: Horsham, PA
- Undergraduate University: University of Pittsburgh
- Undergraduate Degree: Chemistry
- Medical School: Temple University School of Medicine
- Fellowship: The Rothman Institute, Hand/Upper Extremity
- Significant Other: Megan Kistler
- Children: Nathan
- Hobbies: Golf, baseball, home-brewing, Philly restaurant scene
- Interesting Fact: I hopped over a restricted area at Ellis Island to meet Yogi Berra and get his autograph when I was in high school

MRSA Incidence and Antibiotic Trends in Urban Hand Infections: A Ten-Year Longitudinal Study

Justin Kistler, MD

Background

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been the most reported pathogen in hand infections at urban medical centers throughout the country. Antibiotic sensitivity profiles are continually evolving, but trends are not well known. The purposes of this study were to examine the epidemiology and determine the drug resistance trends for MRSA infections of the hand and to provide recommendations for empiric antibiotic treatment based on sensitivity profiles.

Methods

A 10-year longitudinal and consecutive, retrospective chart review was performed on all culture-positive hand infections encountered at a single urban medical center from 2005 to 2014. The proportions of all organisms were calculated for each year and collectively. MRSA infections were additionally sub-analyzed for antibiotic sensitivity.

Results

A total of 815 culture-positive hand infections were identified. Overall, MRSA grew on culture in 46% of cases, with the highest annual incidence peaking in 2007 at 65%. However, during the 10-year study period, there was a decrease in overall MRSA prevalence reaching a nadir of 27% in 2014. While there was a drop in MRSA infection incidence over the 10-year study period, there was a steady increase in polymicrobial infections during that same 10 years, starting at 7% in 2005 and eventually peaking at 39% in 2014. Relative to antibiotic sensitivity, MRSA hand infections were universally resistant to penicillin, oxacillin, and ampicillin. Clindamycin resistance increased steadily during the course of the study, starting at a nadir of 4% in 2008 but growing to 31% by 2014. Similarly, levofloxacin resistance also consistently increased throughout the study reaching its peak at 56% in 2014.

Conclusion

The annual incidence of MRSA in hand infections has declined overall, but with an alternative increase in the number of polymicrobial infections. In addition, MRSA resistance to clindamycin and levofloxacin has consistently increased over the past 10 years. These findings present a new challenge in treating hand infections. Empiric antibiotic therapy for hand infections should not only avoid penicillin and its synthetic alternatives, but based on this study's findings, should also consider avoiding clindamycin and levofloxacin for empiric treatment.

Senior Abstract

Senior Bio Questionnaire

- Full Name: Courtney Quinn
- Hometown: Potomac, MD
- Undergraduate University: University of Southern California
- Undergraduate Degree: Business Administration (BS)
- Medical School: Georgetown University School of Medicine
- Fellowship: University of Virginia, Sports Medicine
- Significant Other: Michael Narvaez
- Hobbies: Traveling, exploring new cuisines, becoming an entry-level wine snob, extreme hummus consumption, overseeing the slow death of any and all houseplants
- Interesting Fact: I can recite almost any line from Chappelle's Show

Incidence of Infection in Civilian Gunshot Arthrotomies: Does Formal Joint Washout Make a Difference?

Courtney Quinn, MD

Objectives

To determine if the incidence of joint infection is lower in patients with civilian gunshot arthrotomies treated with surgical irrigation and debridement (I&D) as compared to patients treated with antibiotics alone.

Design: Retrospective review.

Setting: Single urban level-1 trauma center.

Patients/Participants: All patients with gunshot arthrotomies of shoulder, hip, and/or knee treated between January 2008 and December 2016.

Intervention: Review of arthrotomy treatment methods with antibiotics and surgical I&D versus antibiotics alone.

Main Outcome Measurements: The presence or absence of septic arthritis.

Results

Ninety-four gunshot arthrotomies in 93 patients met the final criteria. Of those joints, 82.98% (78/94) were treated with antibiotics and formal I&D, with or without fracture fixation, 14.89% (14/94) of joints were treated with antibiotics alone, and 2.13% (2/94) were treated with antibiotics and fracture stabilization without I&D. There was no incidence of infection in any cases regardless of treatment at any point in follow-up (0/94; $p > 0.05$).

Conclusions

The incidence of infection is low in traumatic arthrotomies of the hip, shoulder, and knee due to civilian gun missiles when patients are treated with IV antibiotics with or without formal I&D. In cases in which there are no mechanical indications for surgical debridement (retained intra-articular missiles or bony debris), it may be safe to treat patients with IV antibiotics alone to prevent infection.

Senior Abstract

Senior Bio Questionnaire

- Full Name: Megan Erin Reilly
- Hometown: Longwood, FL
- Undergraduate University: University of Florida
- Undergraduate Degrees: Zoology (BS), Anthropology (BA)
- Medical School: Georgetown University School of Medicine
- Fellowship: Hospital for Special Surgery, Foot and Ankle
- Significant Other: Taylor Lewis (husband)
- Children: Fur babies, Libby, Miles, and Sweet Pea!
- Hobbies: Running, piano, travel
- Interesting Fact: Took the stamina I built up during residency to run six marathons during my five years with Temple Orthopaedics

Plantar Plate Reconstruction for Stage IV Plantar Plate Tear Using Flexor Tendon Tenodesis

Megan Reilly, MD

Background

Outcomes of the surgical treatment of dislocated lesser toes have improved significantly over the past few years due to the development of techniques to repair plantar plate tears through a dorsal incision. However, treatment of Stage 4 tears with no reparable plantar plate can be challenging. The current treatment involves flexor to extensor tendon transfer, requiring multiple incisions and additional surgical time. An alternative approach is presented, using the same modern techniques of plantar plate repair, but reconstructing the plantar plate using a flexor tendon tenodesis to the plantar base of the proximal phalanx.

Methods

Four fresh frozen cadaver foot and ankle specimens were used to determine the stability of this new technique. A simulated Lachman's test was performed on the 2nd, 3rd, and 4th metatarsophalangeal joints utilizing a force measurement instrument with displacement control on specimens with an intact plantar plate, an excised plantar plate, and following a flexor tenodesis reconstruction.

Results

The intact plantar plate force was 9.0 + 2.6 kN for 2 mm displacement, and following excision of the plantar plate, the force reduced to 1.3 + 0.4 kN. The flexor tenodesis reconstruction improved the force to 6.0 + 1.9 kN.

Conclusion

Plantar plate reconstruction with a flexor tenodesis to the proximal phalanx resulted in stability equal to 53% of the intact plantar plate, for the shear displacements between 2 to 6 mm. This procedure may be an alternative treatment option in patients with Stage 4 irreparable plantar plate tears.

Special Event

Resident Research Day

April 14, 2018

On April 14, 2018, the Temple University Department of Orthopaedic Surgery held its annual Resident Research Day. This event allows current Temple orthopaedic surgery residents to showcase their ongoing and published research endeavors. Kurt R. Weiss, MD, Assistant Professor of Orthopaedic Surgery and Director of the Musculoskeletal Laboratory at the University of Pittsburgh, was a moderator at the journal club held on April 13th. He presented an insightful lecture on osteosarcoma and was also a guest judge for the research day event.

James Bennett, MD (PGY-5) won first place for his paper "Reoperation in Patients with Cerebral Palsy After Spinal Fusion: Incidence, Reasons, and Impact on HRQoL." Although patients with cerebral palsy have been found to have high rates of reoperation after undergoing spinal fusion, it has not been quantified. Dr. Bennett's study sought to establish a rate and reasons for reoperation in this patient population. The study revealed a rate of reoperation of 13.9%. He also concluded that infection, proximal junctional kyphosis, and instrumentation prominence/loosening were the most common reasons for reoperation.

Katharine Harper, MD (PGY-5) took second place for her work entitled "Hospital Discharge Instructions for Orthopaedic Trauma Patients — An Opportunity for Improved Care." Dr. Harper's study showed that patients who received enhanced instructions with illustrations demonstrated improved understanding and retention of postoperative instructions.

Third place went to John Jennings, MD (PGY-5) for his work entitled "Orthopaedic Surgical Attire Influences Patient Perceptions in an Urban, Inpatient Setting." Dr. Jennings had previously established that outpatient orthopaedic patients generally prefer their surgeon to wear a white coat or scrubs. In his current study, he concluded that in the inpatient setting, patients consistently preferred their surgeon to wear a white coat and formal attire followed by white coat over scrubs and scrubs alone respectively.

Dayna Phillips, MD

Special Event

10th Annual Philadelphia Orthopaedic Trauma Symposium

June 8–9, 2018

On June 8th and 9th of 2018, the 10th annual Philadelphia Orthopaedic Trauma Symposium was held at Temple University's Medical Education and Research Building. Leading this course, the event's co-chairmen included Drs. Saqib Rehman, Asif Ilyas and Rakesh Mashru in addition to more than two dozen orthopaedic surgeons from Philadelphia and the metropolitan area. Participation from residents, students, nurses, physician assistants, and athletic trainers was essential to the success of this event.

Rich discussion spanned diverse topics including the treatment of challenging fractures, approaches to resident education and the complexities of the growing opioid epidemic in the United States. Dr. Asif Ilyas, Vice President of the Pennsylvania Orthopaedic Society and Professor of Orthopaedic Surgery at Jefferson University, delivered a thought-provoking lecture highlighting the gravity of the opioid epidemic and the role of the orthopaedic surgeon in combatting this crisis. Dr. Ilyas revealed stark statistics including that 80% of heroin abusers cite the initial use of prescription opioids prior to the use of heroin. He later reflected on the status of the opioid epidemic within our community, prescribing practices and evidence-based prescribing strategies aimed at reducing opioid consumption.

This year's symposium provoked stimulating conversations covering various approaches to care of the orthopaedic trauma patient. Expert educators reviewed challenging cases including multi-ligamentous knee injuries and dislocations, complex elbow and distal radius fractures as well as a rigorous debate on the use of hemi-arthroplasty versus total hip arthroplasty in the treatment of geriatric hip fractures. In total, the diversity and expertise amongst the faculty revealed continued controversy but also demonstrated creative and multi-faceted approaches to the treatment of these complex patients. As a junior orthopaedic surgeon in training, a glimpse into this thought process is invaluable.

Dana Cruz, MD

Special Event

Ponderosa Bowl 2018

Sunday, December 2nd, marked the 8th annual Ponderosa Bowl in the friendly confines of Dr. Thoder's backyard. For the past few years, the weather has been quite favorable for the annual battle on the gridiron. However, the lucky streak of weather came to a very messy end this year. While the temperatures were mild, heavy rains in the days leading up to the game made for a slippery and muddy track, making this year's game one of the more memorable in recent years.

There were again some alumni appearances as well as attending participation. This year, the Cherry Team was comprised of Brad Wiekrykas (PGY-1), Josh Luginbuhl (PGY-2), Alex Johnson (PGY-3), Will Smith (Class of 2018), Nate Bodin (Class of 2012), and Min Lu (attending from the Adult Reconstruction division). The White Team was comprised of Heather Flynn (PGY-1), Jeff Wera (PGY-4), Colin "Mac" Vroome (PGY-4), Justin Kistler (PGY-5), Mark Solarz (Class of 2016 and attending from the Hand/Upper Extremity division), and Milo Sewards (Residency Program director).

The field conditions made for some interesting play early on that only deteriorated as the game progressed. Divots created by the footing of Alex Johnson created obstacles that rivaled those of a Tough Mudder competition. The defenses of each respective team struggled to cover the quickness of Josh Luginbuhl and Mac Vroome. The game was fairly called by Dr. Thoder and I hear the NFL could benefit from his officiating prowess. In the end, the Cherry Team came out on top behind an MVP performance from Josh Luginbuhl.

Once the participants were hosed off at the conclusion of the game, all were granted entry into the basement of the Ponderosa for food, beers, cigars, and of course NFL football on all three television screens. Next year, perhaps, we will hope for some snow rather than mud. This is always a highlight event of the academic year.

Justin Kistler, MD

Special Event

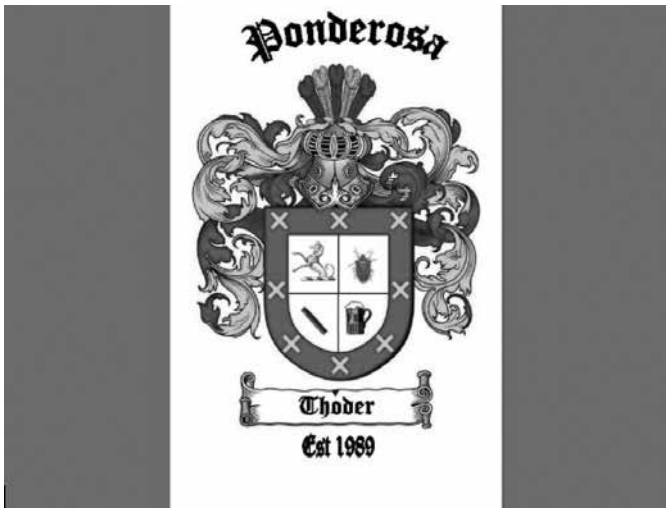
How to Be a Gentleman and Gentle Lady Social

November 10, 2018

The annual Temple Orthopaedics "How to Be a Gentleman and Gentle Lady" social event was held on November 10, 2018. It continues to be sponsored by Dr. Thoder at the Ponderosa. Each year, Temple residents and attendings join together for a night of fun and laughter while learning a multitude of skill sets outside of orthopaedics. Activities included fundamental cigar knowledge, how to tie a bow tie, and appropriate dress for different events. For those interested in learning only a few skills, there was amazing food to keep them preoccupied. Although multiple skills were taught that night, the most important skill was how to avoid being placed in the corner of shame by Dr. Thoder.

As with every year, the event was an overall great success. We thank Dr. Thoder for having the event at the Ponderosa as well as the many faculty members who were in attendance. Their support and dedication to educating residents on not only orthopaedics but also life outside of the specialty is greatly appreciated by every single one of us residents.

Dayna Phillips, MD



Departmental News

Faculty

Temple University Department of Orthopaedic Surgery and Sports Medicine

Chairman

Eric J. Kropf, MD

Professors

Joseph Thoder, MD, *The John W. Lachman Professor*
William DeLong, MD
Pekka Mooar, MD
Ray Moyer, MD
Saqib Rehman, MD, *Vice Chairman*
Joseph Torg, MD

Associate Professors

Eric Gokcen, MD
Christopher Haydel, MD
Cory Keller, DO
J. Milo Sewards, MD

Assistant Professors

Hesham Abdelfattah, MD
Leslie Barnes, MD
Matthew Lorei, MD
Min Lu, MD
Michelle Noreski, DO
Theresa Pazionis, MD
Zeeshan Sardar, MD
Vishal Saxena, MD
Ryan Schreiter, DO
Julie Shaner, MD
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
Michael Gratch, MD
John Horneff, MD
Victor Hsu, MD
Moody Kwok, MD
Guy Lee, MD
Thomas Peff, MD
Rachel Shakked, MD
T. Robert Takei, MD
Jeffrey Vakil, 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

Min Lu, MD

Pekka Mooar, MD

Julie Shaner, 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 August of 2018, we welcomed Julie Shaner to our staff. Julie recently completed her Adult Reconstruction Fellowship at the Brigham and Women's Harvard Combined program and is a graduate of the Jefferson Orthopaedic residency.

We are pleased to announce that we have finished our electronic comprehensive care plan (Pathway) for perioperative joint replacement patients. 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 followup. The Pathway has been well received by providers, patients and nurses. It was tightly constructed with very few edits or problems since going live in October 2018 and 100% compliance since December. We believe the Pathway will streamline the preop and postop processes and eliminate errors and omissions for the joint replacement patient. Ultimately, we hope it not only improves the patient experience, but builds on our success at reducing length of stay, reducing the need for SNF admission and reducing readmission. This will be critical as we transition away from a multi-day inpatient stay following joint replacement surgery. This will also help us as we move toward a 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.

Research Activity

Publications

Lu M, Phillips D. Total Hip Arthroplasty for Post-traumatic Conditions. *J Am Acad Orthop Surg.* 2018 Oct 4. PMID 30289797.

Shaner JL, et al. Intraoperative Ketamine During Total Knee Arthroplasty: A Prospective Randomized Controlled Trial. Accepted for publication in *J Arthoplasty.*

Ferrera HK, Jones TE, Schudrowitz NJ, Collins JE, Lichstein PM, Shaner JL, Fitz W. Perioperative Dietary Restriction of Carbohydrates in the Management of Blood Glucose Levels in Patients Undergoing Total Knee Replacement. *J Arthroplasty.* 2019 Jan 29. PMID 30797646.

Ponzio DY, Syed UAM, Purcell K, Cooper AM, Maltenfort M, Shaner J, Chen AF. Low Prevalence of Hip and Knee Arthritis in Active Marathon Runners. *J Bone Joint Surg Am.* 2018 Jan 17;100(2):131–137.

Chang EY, Tadros A, Mooar PA, et al. ACR Appropriateness Criteria — Chronic Ankle Pain. *Journal of the American College of Radiology,* Volume 15, Issue 5, Supplement, May 2018, pages S26–S38.

Fox M, Chang EY, Amni B, Mooar PA, et al. ACR Appropriateness Criteria — Chronic Knee Pain. *Journal of the American College of Radiology,* Volume 14, Issue 11, Supplement, November 2018, pages S302–S312.

Presentations

Shaner JL, et al. Intraoperative Ketamine During Total Knee Arthroplasty: A Prospective Randomized Controlled Trial. *Podium Presentation at American Association for Hip and Knee Surgeons 2018.*

Book Chapters

Trabecular metal augments. *The Adult Hip: Masters Case Series and Techniques,* edited by Eleftherios Tsiridis, MD. Springer; 1st edition 2018.

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 podiatry students is performed with both didactic and clinical education.

Residency education is of primary importance in the division, and to improve the experience, cadaver dissections were performed with the residents to learn various surgical techniques and understand the anatomy better. Several presentations and teaching sessions over the course of the year included Lisfranc injuries, diabetic foot, adult-acquired flatfoot deformity, Global Health Orthopaedics, among others.

The Division continues to organize international orthopaedic experiences for the department residents. Dayna Phillips, MD, PGY-4, was able to join Dr. Gokcen in a return trip to Kenya, providing educational opportunities and surgical assistance. Eric Kropf, MD, our department chair, was able to join us as well and provide his expertise in sports medicine. Dr. Gokcen also visited Addis Ababa, Ethiopia on a scout trip as a potential second site for our department short-term medical mission trips.

Research is progressing well and several foot and ankle research projects were presented at the annual July 2018 AOFAS meeting in Boston. Papers included "Plantar Plate Reconstruction for Stage IV Plantar Plate Tear Using Flexor Tendon Tenodesis" and "Evaluating the Subtalar Joint in Tibiotalocalcaneal Nailing," both presented by Megan Reilly, MD, PGY-5. Further research projects are ongoing, including studying driving after foot surgery, cost analysis of ankle fracture surgery, effect of EMR on patient safety, and others.

Several podium presentation opportunities have been completed by the division, both locally and nationally. At the 2018 AOFAS Humanitarian Symposium in Boston, foot and ankle surgery in Kenya was presented. Dr. Gokcen was a speaker at the 10th Annual Pediatric Global Health Conference at the Children's Hospital of Philadelphia, discussing orthopaedic surgery training in the developing world.

The division founded the Philadelphia Orthopaedic Foot Club in 2017, and it has successfully continued meeting. The meetings provide networking opportunities for the foot and ankle orthopedists in the Philadelphia area in order to provide the best care possible to our patients.

In summary, the Division of Foot and Ankle Surgery continues to grow, providing excellent care for our patients in an academic teaching environment.

Division Report

Division of Hand Surgery

Joseph Thoder, MD
Division Chief

Hesham Abdelfattah, MD

Mark Solarz, MD

General

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 remain dedicated to resident and 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.

For nearly 30 years, Temple Orthopaedics has graduated a significant number of 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, graduating resident Justin Kistler will be doing his hand fellowship at the Rothman Institute, where his fellowship director will be Asif Ilyas (Cass of 2006).

In closing, we would like to say thank you to Dr. Bruce Vanett who completed his 14-year tenure at Temple this past summer. Dr. Vanett has been an exemplary educator to both medical students and residents since starting at Temple in 2003. Throughout his tenure, he was a willing and active participant in the department in general, and specifically in the Division of Hand Surgery. We wish him well in his future endeavors and know he will continue to carry on the Temple way.

Division Report

Division of Orthopaedic Trauma

Saqib Rehman, MD, MBA
Division Chief

Christopher Haydel, 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 well over 100 participants gathered for two days of CME lecture, case discussion, technique labs, 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 Trial

The Division of Orthopaedic Trauma, as Principal and Sub-Investigators, have been involved in the following clinical trial: Regional vs. General Anesthesia for Promoting Independence after Hip Fracture Surgery (REGAIN).

Scientific Publications in Peer Reviewed Journals

1. Lachman J, Elkrief, J, Pipitone P, Haydel C. Comparison of Surgical Site Infections in Ankle Fracture Surgery with and without Post-Operative Antibiotics. *Foot and Ankle Int. 2018 Jul 1.* PMID: 30035617.
2. Harper KD, Quinn C, Eccles J, Ramsey F, Rehman S. Administration of Intravenous Antibiotics in Patients with Open Fractures Is Dependent on Emergency Room Triaging. *PLoS One.* 2018 Aug 14;13(8):e0202013. PMID: 30106964.

Scientific Podium and Poster Presentations

1. Reynolds J, Weikrykas B, Ramsey F, Haydel C, Gonzalez, M. Physician Burnout and Associated Factors: Orthopaedics vs Anesthesia. Poster presentation. *Philadelphia Orthopaedic Trauma Symposium,* Philadelphia, PA, June 2018.
2. Jennings J, Kakalecik J, Pinninti A, Haydel C. Orthopaedic Surgical Attire Influences Patient Perceptions in an Urban, Inpatient Setting. Podium presentation. *Philadelphia Orthopaedic Trauma Symposium,* Philadelphia, PA, June 2018.
3. Pinninti A, Gonzalez M, Rubin R, Ramsey F, Haydel C. The Echocardiogram: A Scapegoat for Surgical Delay for Hip Fracture Patients. Poster presentation. *Philadelphia Orthopaedic Trauma Symposium,* Philadelphia, PA, June, 2018.
4. Reynolds J, Weikrykas B, Ramsey F, Haydel C, Gonzalez, M. Physician Burnout and Associated Factors: Orthopaedics vs Anesthesia. Poster presentation. *American Orthopaedic Association Annual Meeting,* Boston, MA, June 2018.
5. Pinninti A, Gonzalez M, Rubin R, Ramsey F, Haydel C. The Echocardiogram: A Scapegoat for Surgical Delay for Hip Fracture Patients. Podium presentation. *Orthopaedic Trauma Association Annual Meeting,* Orlando,

FL, October 2018.

6. Pinninti A, Gonzalez M, Rubin R, Ramsey F, Haydel C. The Echocardiogram: A Scapegoat for Surgical Delay for Hip Fracture Patients. Podium presentation. *American Society of Anesthesiology Annual Meeting,* San Francisco, CA, October 2018.
7. Reynolds J, Weikrykas B, Ramsey F, Haydel C, Gonzalez, M. Physician Burnout and Associated Factors: Orthopaedic Surgery vs Anesthesiology. Poster presentation. *American Society of Anesthesiology Annual Meeting,* San Francisco, CA, October 2018.
8. Jennings J, Quinn C, Rehman S. Orthopaedic Surgery Resident Financial Literacy: An Assessment of Knowledge in Debt, Investment, and Retirement Savings. *Pennsylvania Orthopaedic Society Spring Scientific Meeting,* Charleston, SC, April 2018. Award Winner, first prize, resident research presentation.
9. Quinn C, McKinney R. Incidence of Infection in Civilian Gunshot Arthrotomies: Does Formal Joint Washout Make a Difference? *American Academy of Orthopaedic Surgery Annual Meeting*, New Orleans, LA, March 2018.
10. Harper K, Wera J, Jordan H, Kakalecik J, Ramsey F, Rehman S. Are We Informing Our Patients Properly About Their Care? A Prospective Study on Patient Education Following Traumatic Orthopaedic Injury. *Academy of Orthopaedic Surgery Annual Meeting,* New Orleans, LA, March 2018.
11. Banerjee S, Ly JA, Ramsey FV, Rehman S. Factors Impacting Access the Surgical Care of Distal Radius Fractures. *Pennsylvania Orthopaedic Society (POS) 2018 Spring Meeting,* Charleston, SC, April 26–27, 2018.
12. Harper K, Wera J, Jordan H, Kakalecik J, Ramsey F, Rehman S. Are We Informing Our Patients Properly About Their Care? A Prospective Study on Patient Education Following Traumatic Orthopaedic Injury. *Annual Meeting of the American Orthopaedic Association,* Boston, MA, June 2018.

Educational Presentations

1. Instructor: Casting Workshop for the Orthopaedic Interest Group. William Maul Measey Institute for Clinical Simulation and Patient Safety, April 2018 (Haydel).
2. Symposium Faculty: Symposium: The Opioid Addiction Crisis in Pennsylvania. *Pennsylvania Orthoapedic Society,* May 2018 (Haydel).
3. Course Faculty: Lecturer and Table Instructor. AO Trauma Course — Basic Principles of Fracture Management for Residents, Madison, WI, May 2018 (Haydel).
4. Instructor: Splinting Workshop for Emergency Medicine Interns. *William Maul Measey Institute for Clinical Simulation and Patient Safety,* August 2018 (Haydel).
5. Course Faculty: AO Trauma Course — Basic Principles of Fracture Management for Residents, Baltimore, MD, May 2018.
6. Lecture: Online Education in Orthopaedic Surgery. *Grand Rounds at LSU Orthopaedic Surgery Residency Program,* New Orleans, LA, Jan. 26, 2018 (Rehman).
7. Lecture: Malreduction and Malrotation with Proximal Femur Fractures. *LSU Orthopaedic Surgery Residency Program,* New Orleans, LA, Jan. 26, 2018 (Rehman).
8. Lecture: Fractures of the Proximal Femur: ICL#388. *Annual Meeting of the American Academy of Orthopaedic Surgery,* New Orleans, LA, March 8, 2018 (Rehman).
9. Lecture: Extreme Nailing: Tips and Tricks from the Experts. *Annual Meeting of the American Academy of Orthopaedic Surgery,* New Orleans, LA, March 9, 2018 (Rehman).
10. Moderator: Difficult Tibial Nailing Cases. *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 8, 2018 (Rehman).
11. Moderator: Lower Extremity Trauma Debates. *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 9, 2018 (Rehman).
12. Panelist: Knee Dislocations. *10th Annual Philadelphia Orthopaedic Trauma Symposium,* June 9, 2018 (Rehman).
13. Lectures: Orthopaedic Trauma Board Review Lectures. *The 5th Qatar Orthopaedic Review Course,* Doha, Qatar, Sept. 5–6, 2018 (Rehman).
14. Lecture: Tips for Taking the Board Exams. *The 5th Qatar Orthopaedic Review Course,* Doha, Qatar, Sept. 6, 2018 (Rehman).

Division Report

Division of Sports Medicine and Shoulder Surgery

Eric J. Kropf, MD
Director of Sports Medicine

Leslie Barnes, MD

Cory Keller, DO
Medical Director, TU Athletics

Ray Moyer, MD

Michelle Noreski, DO

Vishal Saxena, DO

Ryan Schreiter, DO

J. Milo Sewards, MD
Residency Program Director

Joseph Torg, MD
Professor Emeritus

Clinical Care

The Division of Sports Medicine and Shoulder Surgery is a comprehensive, multidisciplinary group committed to providing the highest level of care to active and athletic patients of all ages. The sports medicine team continues to restructure and expand to meet the needs of our patients and learners. The division is currently comprised of four surgeons, four non-surgical providers and one professor emeritus. The team continues to perform advanced and cutting-edge arthroscopic and minimally invasive surgery of the shoulder, elbow, hip and knee. In turn, our non-surgical providers routinely perform in-office ultrasound-guided procedures and offers stem cell and biologic therapies for acute sports-related injuries and early arthritis in active young patients. The sports medicine team works in a fully integrated fashion to develop individualized patient-focused treatment plans to maximize outcomes and meet patient-specific goals. The sports team sees over 25,000 patient visits a year and performs 1300+ procedures annually. A key area of recent growth has been through continued development of our Shoulder Reconstruction/Arthroplasty program led by Dr. Leslie Barnes. Dr. Vishal Saxena joined the team this year and is already underway developing a practice focused on complex knee and shoulder arthroscopy and cartilage restoration. In key events, Dr. Cory Keller was promoted to the rank of associate professor. Dr. J. Milo Sewards recently returned from a year of naval deployment in Iraq. We collectively welcome him home and thank him for his service.

Education

This diverse group of providers has much to offer to our students and residents. Currently, our providers teach in the classroom, clinics, training rooms, athletic sidelines and operating rooms. We have dedicated time with Temple University medical students, physician assistant students, and Kinesiology undergraduate and graduate athletic training students. While orthopaedic residents remain our primary focus, the sports division also works with internal medicine, family medicine and PM&R residents as well as area primary care sports medicine fellows.

The "Temple Sports Medicine Journal Club" meets on a bimonthly basis with a target audience of regional physical therapists, athletic trainers and sports medicine physicians and trainees.

The sports medicine faculty continues to teach at national courses and meetings including annual meetings of the American Academy of Orthopaedic Surgeons (AAOS), Arthroscopy Association of North America (AANA), the American Medical Society for Sports Medicine (AMSSM) and the American Orthopaedic Society for Sports Medicine (AOSSM).

Service/Outreach Programs

The Division of Sports Medicine provides comprehensive medical coverage for Temple University's 600 varsity athletes. Our physicians can be seen in training rooms or on the sidelines of football, basketball and soccer games on a regu-

lar basis. We continue to deploy athletic trainers throughout the Philadelphia public and catholic leagues serving as team physicians to St. Joseph's Preparatory, Father Judge High School, Archbishop Wood HS, and LaSalle College Preparatory. Members of the team have also developed affiliate relationships with Arcadia University Athletics and Drexel University's primary care sports medicine program.

Scientific Publications (Peer Reviewed)

1. Fink Barnes LA, Lombardi J, Gardner TR, Strauch RJ, Rosenwasser MP. Comparison of Exposure in the Kaplan Versus the Kocher Approach in the Treatment of Radial Head Fractures. *Hand.* January 2018.
2. Shukla DR, Rubenstein WJ, Barnes LA, Klion MJ, Gladstone JN, Kim JM, Cleeman E, Forsh DA, Parsons BO. The Influence of Incision Type on Patient Satisfaction After Plate Fixation of Clavicle Fractures. *Orthop J Sports Med.* 2017 Jun 22;5(6):2325967117712235.
3. Quinn CA, Ly JA, Narvaez MV, Kropf EJ. Management of Recurrent Posterior Shoulder Instability in a Young Contact Athlete Using a Posterior Bone Block Technique with Distal Tibia Osteochondral Allograft. *Techniques in Shoulder & Elbow Surgery*. 2017 June;18(2):57–61.
4. Greenhill DA, Abdelfattah H, Torg JS, Sewards JM. Atypical Presentation of Parsonage-Turner Syndrome Confounded by Surgical Rotator Cuff Injury. *BMJ Case Reports – Online First.* Doi:10.1136/bcr-2017-220532.
5. Amoako, AO, Nassim, A, Keller, C. Body Mass Index as a Predictor of Injuries in Athletics. *Current Sports Medicine Reports.* July/August 2017.

Scientific Presentations (Podium, Poster, Invited Lecture)

1. Kropf EJ. Femoroacetabular Impingement; Surgical Indications and Treatment Options. *PA Ortho Society Spring Meeting,* Charleston, SC, April 27, 2018.
2. Kropf EJ. Combined Hip and Core Muscle Injury. *PA Ortho Society Spring Meeting,* Charleston, SC, April 28, 2018.
3. Kropf EJ. Femoroacetabular Impingement and Core Muscle Injuries; Management of Non-Arthritic Hip Pain. *UPMC St. Margaret's Hospital,* Pittsburgh, PA, May 19, 2018.
4. Kropf, EJ Hip Pathology Assessment for Athletic Trainers. *PA Athletic Trainers Society Student Symposium,* Philadelphia, PA, March 24, 2018.
5. Keller CJ. Medical Assessment of Lumbar Pain. *Arcadia University Interdisciplinary Case-Based Approach to Medical Screening for the Physical Therapist,* March 2018.
6. Keller CJ. Medical Assessment of Lumbar Pain. *Arcadia University Interdisciplinary Case-Based Approach to Medical Screening for the Physical Therapist,* March 2018.
7. Kropf EJ. Knee Dislocations: Panel Discussion. Presenter and Moderator at the *Philadelphia Orthopaedic Trauma Symposium,* Philadelphia, PA, June 9, 2018.
8. Keller CJ. Orthopedic Cases. *LKSOM Family Medicine Review Course,* March 2018.
9. Keller CJ. Assessment of Shoulder Pain. *LKSOM Family Medicine Review Course*, October 2017/March 2018.
10. Barnes LA, et al. Shoulder Instability — Bankart and Remplissage vs. Open Stabilization; Arthritis — Is RTSA Actually a More Reliable Long-term Solution than Anatomic TSA? Panels at the *2018 Biennial NYOH Alumni Meeting,* New York, NY, May 2018.
11. Noreski MA. Pelvic Pain in Athletes. *AOASM Conference,* Philadelphia PA, January 2018.
12. Keller, CJ. Throwing Injuries. *Mid-Atlantic Regional Chapter of the American College of Sports Medicine,* November 2018.
13. Sewards JM. Combat Orthopaedic Surgery: Lessons Learned. Presented at *Grand Rounds, Department of Orthopaedic Surgery,* Cooper Hospital, Camden, NJ, July 2018.

Book Chapter

Wera J, Kropf EJ. Latarjet Procedure. In Fu FH. *Masters Techniques in Sports Medicine,* 2nd Ed., 2018.

Clinical Trial (Ongoing)

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. (Aesculap) Phase III (Sewards, Mooar, Kropf).

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2018–2019

Peter Eyvazzadeh, MD

Hometown: Bethlehem, PA

Undergraduate: Bucknell University

Medical School: Penn State University College of Medicine

Fellowship: Sports medicine at Union Memorial Hospital

Justin Kistler, MD

Hometown: Horsham, PA

Undergraduate: University of Pittsburgh

Medical School: Temple University School of Medicine

Fellowship: Hand/upper extremity at the Rothman Institute

Courtney Quinn, MD

Hometown: Potomac, MD

Undergraduate: University of Southern California

Medical School: Georgetown University School of Medicine

Fellowship: Sports medicine at University of Virginia

Megan Reilly, MD

Hometown: Longwood, FL

Undergraduate: University of Florida

Medical School: Georgetown University School of Medicine

Fellowship: Foot and ankle at Hospital for Special Surgery

Robert Ames, MD

Hometown: Dallas, TX

Undergraduate: Rutgers University

Medical School: Temple University School of Medicine

Interest: Spine

Dayna Phillips, MD

Hometown: Rosenhayn, NJ

Undergraduate: University of the Sciences

Medical School: Rutgers – New Jersey Medical School

Interest: Pediatrics

Colin "Mac" Vroome, MD

Hometown: Havertown, PA

Undergraduate: Villanova University

Medical School: Jefferson Medical College

Interests: Hand/upper extremity

Jeffrey Wera, MD

Hometown: Villa Hills, KY

Undergraduate: The College of William & Mary

Medical School: University of Louisville School of Medicine

Interests: Hand/upper extremity

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2018–2019 *(cont.)*

Dana Cruz, MD

Hometown: New York, NY

Undergraduate: University of Southern California

Medical School: Albert Einstein College of Medicine

Interests: Hand/upper extremity

Alexander Johnson, MD

Hometown: East Norriton, PA

Undergraduate: Randolph-Macon College

Medical School: Drexel University College of Medicine

Interest: Undecided

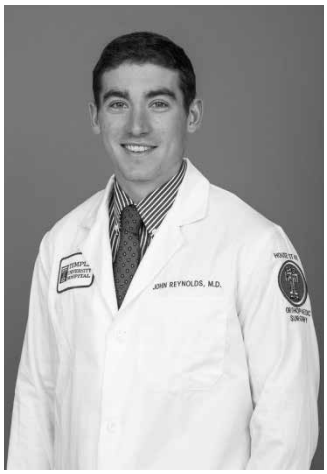
Nimit Lad, MD

Hometown: Winona, MN

Undergraduate: Duke University

Medical School: Duke University School of Medicine

Interest: Sports medicine



Jack Reynolds, MD

Hometown: Malvern, PA

Undergraduate: Villanova University

Medical School: Jefferson Medical College

Interest: Undecided

Colin Ackerman, MD

Hometown: Allentown, PA

Undergraduate: Pennsylvania State University

Medical School: Jefferson Medical College

Interests: Hand, adult reconstruction, sports

Joshua Luginbuhl, MD

Hometown: Denver, PA

Undergraduate: Muhlenberg College

Medical School: Drexel University College of Medicine

Interests: Hand, foot and ankle

Akul Patel, MD

Hometown: Ampthill, England

Undergraduate: Duke University

Medical School: University of North Carolina

Interests: Hand, spine

Andrew Porter, MD

Hometown: Chester, NH

Undergraduate: Boston University

Medical School: Temple University School of Medicine

Interest: Adult reconstruction

Temple University Hospital
Department of Orthopaedic Surgery and Sports Medicine
House Staff 2018–2019 *(cont.)*

Jared Colon, MD

Hometown: Colorado Springs, CO

Undergraduate: University of Colorado

Medical School: Temple University School of Medicine

Interest: Undecided

Heather Flynn, MD

Hometown: Sea Girt, NJ

Undergraduate: Georgetown University

Medical School: Georgetown University School of Medicine

Interest: Undecided

Rajkishen Narayanan, MD

Hometown: Stony Point, NY

Undergraduate: New York University

Medical School: New York University School of Medicine

Interest: Undecided

Bradley Wiekrykas, MD

Hometown: Reading, PA

Undergraduate: Pennsylvania State University

Medical School: Temple University School 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, **Nimit Lad** (Class of 2021) was selected by chief residents Katharine Harper, William Smith, John Jennings, and James Bennett (Class of 2018).

Previous Winners:
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

Nimit Lad, MD

The Dr. Eremus Teaching Award 2018

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. Bruce Vanett as the 2018 award recipient. Dr. Vanett played a pivotal role in resident as well as student education throughout his 14-year tenure at Temple. Although he has completed his time as a faculty member at Temple, he will always be remembered as an exemplary educator.

Dayna Phillips, 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 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.**

Notes

Notes

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