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With thanks to

Gail Case
Amy Dunlap

Sandia Orthopaedic Alumni Society (SOAS) provides services that enhance and enrich the educational experience of current residents and fellows in orthopaedics training at UNM. With more than 40 years of alumni to call on, SOAS is a vital and dynamic contributer to the program. We thank them for their generous support of *The University of New Mexico Orthopaedics Research Journal.*

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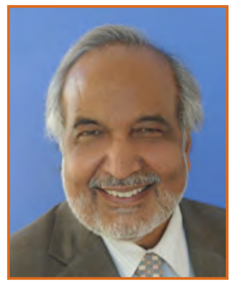

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Clinical Expertise: Orthopaedic Trauma

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Division of Research

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Deana Mercer MD
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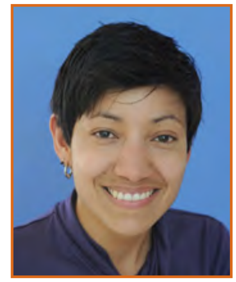

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Letter from the Chair

Robert C. Schenck Jr, MD

I am pleased to present the fifth volume of *The University of New Mexico Orthopaedics Research Journal*. As the premier academic orthopaedic training program in the state, The University of New Mexico (UNM) Department of Orthopaedics & Rehabilitation provides services and information to benefit the people of New Mexico and orthopaedic practitioners who care for them—something we have done with distinction for almost 50 years. Our entire group of residents, fellows, nurse practitioners, physicians, physician assistants, and staff members functions as a supportive community and team, with the same purpose and mission. The popularity of the program extends beyond UNM and into national recognition for resident education.

This journal is quite special, and our research continues to prosper under the leadership of UNM faculty and financial support of the Sandia Orthopaedic Alumni Society (SOAS), allowing us to share state-of-the-art orthopaedic information with our many partners in New Mexico and the Southwest. I am proud to reveal several of our accomplishments during the past year.

As evidenced by this journal, research productivity at our department continues to develop. The total number of publications increased from 12 in 2009 to 77 in 2015. We are very grateful for the leadership provided by Drs. Deana M. Mercer, Christina Salas, and Thomas A. DeCoster, with Dr. Mercer as the director of research. Our appreciation also goes to Dr. Gehron P. Treme, Residency Program Director, for his initiative in helping residents complete requirements of the Accreditation Council for Graduate Medical Education (commonly known as the ACGME). This allows our residents to become experienced in research activities as an equal part of becoming outstanding orthopaedic physicians.

Lastly, my thanks to the many attending physicians, residents, and medical students who create such excellent presentations and publications. The addition of a research incentive program, along with the invaluable dedication from Drs. Mercer and Salas, has fueled scholarly pursuits in the department. This journal was the dream of many, and reaching the fifth volume makes me reflect on the interest and desire of Mary A. Jacintha to create it, who recently moved on to be the executive administrator of UNM Health System. After a national search, we were thrilled to hire our own Gail A. Case as department administrator. Congratulations to them both!

Our faculty continuously grows and reflects the great culture of an orthopaedic family. We are very excited to bring in Dr. Dustin Richter (sports medicine, with a keen interest in research). We are also thrilled to include Sandoval Regional Medical Center (SRMC) in our list of facilities devoted to orthopaedic inpatient care. I would like to thank UNM and SRMC faculties for helping our practice become even more robust. We send our kindest thanks to Dr. Charlotte Orr for her dedication at SRMC and wish her the best of success in her trauma fellowship in Indianapolis, IN. Our appreciation and support similarly extends to Dr. Bryon Hobby as he returns home to begin private practice in Billings, MT. We congratulate Dr. Paul Echols for his appointment to chief medical officer at SRMC.

We hope all the best for our five senior residents as they end this phase of their careers (as "Junior-Junior" faculty at UNM) and begin new ones. Dr. Luke Bulthuis will begin his sports medicine fellowship at Kaiser Permanente Orange County in Irving, CA. At Vanderbilt University in Nashville, TN, Dr. Judd Fitzgerald will perform his sports medicine fellowship. Dr. Michael "Mischa" Hopson will similarly leave for a sports medicine fellowship, at Houston Methodist in Houston, TX. A trauma fellowship will be pursued by Dr. Reilly Kuehn at UC Davis in Sacramento, CA. Finally, Dr. Heather Menzer will complete her sports medicine fellowship at the University of Virginia in Charlottesville, VA. We are so proud of this year's resident class, and I am grateful for the support of their families and friends. These five orthopaedic surgeons are extremely talented and will be missed here in Albuquerque. Luke, Judd, Reilly, Mischa, and Heather, we are most proud of your accomplishments. I, along with the entire department, thank Dr. Treme for his outstanding leadership in the overarching education of UNM orthopaedic residents. I would also like to thank Joni L. Roberts for all of her work and dedication in the process of educating UNM orthopaedic residents.

I am pleased to add that our division of physical therapy, under the direction of Dr. Burke Gurney, has grown into an amazing education jewel for New Mexico. The division now has 10 full-time faculty members (soon to be 11) with expertise in orthopaedics, adult neurology, pediatrics, acute care, geriatrics, and cardiopulmonary physical therapy. These educators (and practitioners!) oversee three cohorts of 30 students who, after successfully completing the 3-year program, obtain a Doctor of Physical Therapy. The physical therapy division will celebrate its 40th anniversary and had a recent accreditation review that highlighted many fantastic achievements.

I want to thank our loyal alumni of SOAS for their enormous dedication and support, which includes hosting three annual events. The Eric Thomas Memorial Golf Tournament is held every September in honor of Dr. Eric A. Thomas (Class of 2004), in which we see alumni from all over the country enjoying Albuquerque's great fall weather at the UNM Championship Golf Course. Additionally, the Joel Lubin Visiting Professorship lecture series occurs every spring to pay respects to Dr. Joel W. Lubin (Class of 2001). This event was recently moderated by Dr. Jonathan Bolton (UNM Department of Psychiatry and Behavioral Sciences), who led invaluable discussions on emotions and positive behaviors in the operating room. And, thirdly, we always look forward to visiting with alumni at the SOAS-sponsored reception during the annual meeting of the American Academy of Orthopaedic Surgeons.

On a more personal note, I would like to thank all the residents, faculty members, staff members, and nursing and mid-level providers for their support and kindness throughout my illness this past October, when my appendix and I decided to part ways. Special thanks to my children and my wife, Patricia, for their compassion and love during my time in the hospital and recovery at home. Thank you all.

Each year, the assistance of alumni becomes more important to the orthopaedics department. SOAS, created exclusively for graduates of our program, has a new lifetime membership available for a pledge of $25,000 to the Sandia Circle ($5000 every year for 5 years). I am a proud funder and lifetime member of SOAS and invite you to join me in becoming one, too. This is an exciting time to participate in the growth and success of our department. In addition to supporting the publication of this journal, you at SOAS support our outstanding resident surgeons. We are grateful to the following alumni and faculty for pledges of $25,000 in helping the SOAS support resident-related activities: Drs. John M. Veitch, Gehron P. Treme, Deana M. Mercer, Kevin M. McGree, Sanagaram S. Shantharam, Joseph K. Newcomer, Brian J. Robinson, Dean W. Smith, John C. Franco, and Jennifer L. Fitzpatrick.

Finally, I want to highlight the outstanding efforts of faculty in caring for our patients. Figure 1 represents our annual clinical productivity from January 2011 through December 2015, in which we performed notably more operative procedures to treat our many patients with joint-related injuries. The additions of SRMC in 2012 and Dustin T. Briggs, MD (who specializes in total joints) resulted in twice as many of these procedures performed since 2011, nearing our annual goal of 1000 total joint procedures. With each passing year, we strive to offer and perform more services to care for the people of New Mexico.

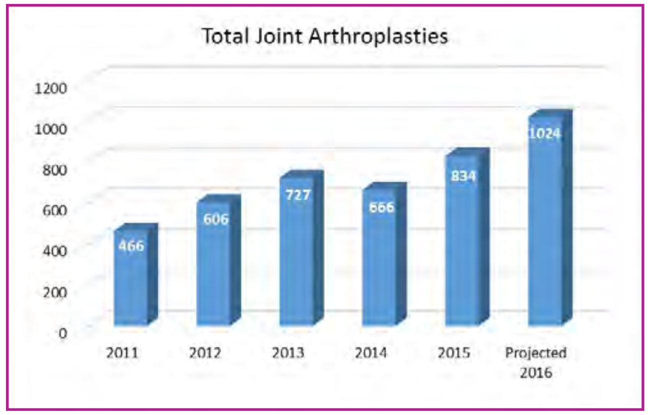


Figure 1. Total numbers of operative procedures performed from January 2011 through December 2015 for treating injuries of the hand and finger, hip, knee, and shoulder. Notably, numbers of projected procedures for 2016 (as of April 2016) indicate continued growth toward our annual performance goal of 1000 total arthroplasties.

It has been another great year at The University of New Mexico Department of Orthopaedics & Rehabilitation. We express our sincerest gratitude to you—the alumni, faculty, and general community—for your continued support.

Thank you.

Robert C. Schenck Jr, MD
Professor and Chair

Letter from the Co-Editors

Deana M. Mercer, MD; Christina Salas, PhD

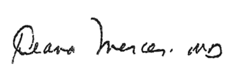
Greetings! We welcome you to the fifth volume of *The University of New Mexico* (UNM) *Orthopaedics Research Journal,* featuring research and educational efforts of faculty, alumni, fellows, residents, and students from the UNM Department of Orthopaedics & Rehabilitation.

We thank all the contributors to this production—Joni Roberts, Managing Editor; Melanie DeLorenzo, Layout Editor; and Sahar Freedman, Copy Editor—whose work and dedication were instrumental in bringing the journal to fruition.

Our publications of 2015 are listed below. Bolded names indicate current or past faculty members, residents, fellows, and graduate students of the department.

- **DeCoster T.** Guest editorial: plating of distal humerus fractures. *Orthop Knowl Online* 2015;13(7). http://orthoportal.aaos.org/oko/article.aspx?article=OKO_TRA064#abstract. Accessed April 18, 2016.
- **DeCoster T.** George E. Omer Jr., MD 1922-2014. J Bone Joint Surg Am 2015;97(8):699.
- **Dickens AJ, Salas C, Rise L**, Murray-Krezan C, Taha MR, **DeCoster TA, Gehlert RJ**. Titanium mesh as a low-profile alternative for tension-band augmentation in patella fracture fixation: a biomechanical study. *Injury* 2015;46(6):1001-6.
- Dragomir-Daescu D, **Salas C**, Uthamaraj S, Rossman T. Quantitative computed tomography-based finite element analysis predictions of femoral strength and stiffness depend on computed tomography settings. *J Biomech* 2015;48(1):153-61.
- **Evans S, Brantley J**, Brady C, **Salas C, Mercer D**. Structures at risk during volar percutaneous fixation of scaphoid fractures: a cadaver study. *Iowa Orthop J* 2015;35:119-23.
- **Fitzgerald J**, Saluan P, **Richter DL, Huff N, Schenck RC**. Anterior cruciate ligament reconstruction using a flexible reamer system: technique and pitfalls. *Orthop J Sports Med* 2015;3(7):2325967115592875.
- **Godfrey J**, McGraw J, **Kallur A, Silva S, Szalay E**. A modification to the McHale procedure reduces operative time and blood loss [Epub ahead of print Sep 11, 2015]. *J Pediatr Orthop* 2015.
- Indelli PF, Graceffa A, Baldini A, **Payne B**, Pipino G, Marcucci M. Relationship between tibial baseplate design and rotational alignment landmarks in primary total knee arthroplasty. *Arthritis* 2015;2015:189294.
- Kimsal J, **Mercer D, Schenck R, DeCoster T, Bozorgnia S, Fitzpatrick J**, Mlady G, Lerma J, Khraishi T. Finite element analysis of plate-screw systems used in medial opening wedge proximal tibial osteotomies. *Int J Biomed Eng Technol* 2015;19(2):154-68.
- **Menzer H, Gill GK, Paterson A**. Thoracic spine sports-related injuries. *Curr Sports Med Rep* 2015;14(1):34-40.
- **Menzer H, Treme G, Wascher D**. Surgical treatment of medial instability of the knee. *Sports Med Arthrosc* 2015;23(2):77-84.
- **Mercer DM, Baldwin ED, Moneim MS**. Posterior interosseous nerve laceration following elbow arthroscopy. *J Hand Surg Am* 2015;40(3):624-6.
- Miskimins R, **Decker M, Hobby B**, Howdieshell T, Lu S, West SD. Complications of pelvic ring fixation in patients requiring laparotomy. *J Surg Res* 2015;199(1):244-8.
- **Mulawka B**, Jacobson AR, Schroder LK, Cole PA. Triple and quadruple disruptions of the superior shoulder suspensory complex. *J Orthop Trauma* 2015;29(6):264-70.
- Ortega G, McLaren AC, **DeCoster TA**. Infections after fractures [e-book]. In: Hsu WK, McLaren AC, Springer BD, eds. Let's Discuss Surgical Site Infections. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2015:chap 8. http://www3.aaos.org/product/productpage.cfm?code=05434E. Accessed April 29, 2016.

We invite you to explore this selection of recent department publications and hope that they inspire thought, discussion, and future research ideas and contributions.



Deana M. Mercer, MD
Associate Professor

Christina Salas, PhD
Assistant Professor

Letter from the Chief of the Division of Physical Therapy

Burke Gurney, PT, PhD, OCS

There is much to talk about in The University of New Mexico Division of Physical Therapy. First off, the program was issued a 10-year unconditional accreditation by the Commission on Accreditation in Physical Therapy Education (CAPTE). Only about 1 in 10 programs is issued unconditional accreditation. Otherwise, CAPTE sends a yearly progress report that amounts to a list of conditions, which must be improved upon to confirm accreditation status. We were very pleased to meet all of the requirements of CAPTE and achieve unconditional status for a lengthy term.

The graduating class of 2015 just finished the National Physical Therapy Exam, and 25 of 26 students passed. That brings our 5-year accumulative-passage rate to 98.5%! The program continues to exceed national-average scores in both initial and overall pass rates.

We are currently performing national searches for our last two faculty positions, which we hope to have filled by the end of the year. One opening will replace James “Bones” Dexter’s vacancy (of course, he could never be replaced!) and another will be a new role, that of an engineer. This new faculty member (assuming the 11th full-time position) will help with the more technical aspects of our Motion Analysis Laboratory. The hire is part of the move to take our research on motion and gait analysis to the next level. Speaking of which, the program had a banner year for research productivity, viewable in detail at our webpage (http://orthopaedics.unm.edu/pt/faculty.html). Finally, Fred Carey, PT, PhD, was recently promoted to Associate Professor in the Clinical Track! We now have five of our faculty members in senior status, an all-time high.

The Physical Therapy Program has launched its Faculty-Directed Student Instructional Pro Bono Clinic. The clinic is open twice a month on Wednesday evenings for two hours, with four patients (underinsured or uninsured) seen each time. Two first-year students are paired with a second-year student and faculty member to evaluate conditions and provide home-based programs to treat these individuals.

We will move our classrooms into new digs by the end of next year. Construction on the third phase of the Domenici Building complex will begin shortly, in which we will have two dedicated classrooms. The rooms will be 20% larger than those existing, and we are looking into increasing our enrollment capacity accordingly. As a result of this construction, part of the west building of the Domenici Center will revert to its original design, that of a 3000-square-foot fitness center. This is worth mentioning because the physical therapy division will have a presence in the facility.

In the fitness center, our goal is to set aside 2 hours each Friday afternoon for exercise assessments of employees. A semi-private area will be set off from the main gym, in which two students and a faculty member will team up to help employees of the Health Sciences Center customize their exercise programs based on respective desires (and needs).

We are hoping to procure a free-standing clinic that functions as both a faculty and pro bono clinic. Right now, most faculty members are involved in clinical pursuits throughout the Albuquerque area, and we would like to consolidate our services. Additionally, this new space would help increase patient capacity of the pro bono clinic, thereby allowing us to treat patients on a weekly basis. Other ideas in the mix include PhD and collaborative residency programs with The University of New Mexico Hospital.

Ultimately, The University of New Mexico Division of Physical Therapy is proud of the many accomplishments—both present and in looking toward the future—of our students and faculty members. We found and will continue to find ways to better serve the communities of our students, profession, and state.

Burke Gurney, PT, PhD, OCS

Burke Gurney, PT, PhD, OCS
Professor and Chief

Letter from the Residency Director

Gehron P. Treme, MD

I would like to be the first to congratulate our graduating class of 2016 on successfully completing 5 years of orthopaedic training here at The University of New Mexico. Drs. Luke W. Bulthuis, Judd R. Fitzgerald, Michael J. “Mischa” Hopson, Heather M. Menzer, and Reilly R. Kuehn have faced the many challenges of residency with resiliency. During the journey from wide-eyed intern to seasoned chief resident, each displayed characteristics of toughness, humor, and an intellectual curiosity. These five graduates have the promise of a fulfilling career waiting to be taken on in the same way.

Every year, as we interview prospective residents, we look for individuals that fit into our group. We hope to train young surgeons with diverse interests and personalities, who share the common goals of learning our craft, learning to learn, and learning to do this with an eye on enjoying the moment as often as possible. This year, we have the pleasure of welcoming another outstanding class of incoming residents. Drs. Amber Price (Creighton University), Jory Wasserburger (University of Washington), Jordan Polander (Louisiana State University in Shreveport), Matthew Wharton (University of Arizona), and Scott Plaster (University of Oklahoma) will begin their training with us this summer, and we all look forward to witnessing their growth as physicians of our team during the next 5 years.

It is always such a pleasure to witness the maturation of talented physicians, and I am grateful for what I have learned from the members of our graduating class. It is an honor to call them graduates, colleagues, and peers. Congratulations to you all for a job very well done.

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Treatment of Tears of the Superior Labrum Anterior and Posterior: A Review

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Abstract

Tears to the superior labrum anterior and posterior (SLAP) are common injuries of the shoulder, and patients with these types of lesions are treated regularly by both general and sports-specialized orthopaedic surgeons. The causes, diagnosis, and effective treatment of these wounds have been examined extensively in the past several decades, owing partially to the development of arthroscopic techniques. Because clinical understanding has thus undergone frequent and notable changes, no standard method exists for current treatment. To help identify effective techniques for treating isolated SLAP tears, I reviewed the anatomy of the labrum and associated range of motion and stability of the complex, including pertinent locations such as the glenohumeral joint and long head of the biceps tendon; common mechanisms of injury (ie, inline, peel back, compression, and traction forces); past and current classification systems; results of physical examinations and imaging tests in diagnosing the injury; and nonoperative, operative, and current treatment methods (eg, tenodesis, debridement, and use of mattress sutures or knotless anchors). Although knowledge of the causes and long-term results of treating SLAP tears are limited, conservative techniques can be considered first to successfully treat the tear, with careful progression to operative treatment.

Introduction

Shoulder pain resulting from lesions of the superior labrum anterior and posterior (SLAP) presents a challenging problem for surgeons. A study in 1985 by Andrews et al[1] first described detachment of the superior labrum in a group of baseball pitchers. Five years later, the abbreviated term of "SLAP" tear was used.[2] As arthroscopic techniques develop, associated lesions have been noted more frequently. Currently, patients with isolated SLAP tears are seen often by both general and sports-specialty orthopaedic surgeons.

Because studies in the past several decades have extensively examined SLAP tears, clinical understanding has undergone frequent changes. Clavert[3] discussed a wide range of possible pathological features associated with the tears, including the locations of six sextants in the glenoid. I reviewed SLAP tears that occurred in the first sextant to focus on a specific area of the injury, at 60° of the glenoid labrum centered about the insertion of the long head of the biceps tendon (LHBT) on the glenoid labrum. To help shed light on effective treatment, I outlined the notable anatomical locations of the superior labrum and LHBT complex; possible mechanisms of SLAP injuries; classification systems; and standard methods of diagnosing the wound. Additionally, I examined past and recent studies to evaluate any change in techniques used for successfully treating tears to the SLAP.

Anatomy of the Labrum

The labrum, which lines and reinforces the ball and socket joints of the shoulder, consists of a fibrocartilage attached to the glenoid. It is circular, curved like a dish, and triangular shaped in a cross-sectional area.[4] As such, labral anatomy can be described by three parts: the superficial, articular, and peripheral sides.[4] The first part is the "surface," which directly contacts the humeral head; the second contains attachments to the glenoid and a free-standing edge between the humeral head and the glenoid; and the last attaches to the joint capsule.

Range of Motion and Stability of Shoulder

Dynamic stabilization is essential in allowing control of the shoulder because bony contacts apply minimal strain and provide a wide range of motion to the glenohumeral joint. The humeral head articulates on the glenoid cavity, with three to four times more articular surface than the glenoid.[5] During the normal range of motion of the glenohumeral joint, only 25% to 30% of the humeral head contacts with the glenoid.[6] These ligaments of the glenohumeral joint and capsule provide dynamic stability within the shoulder, which relax on motion and tighten in response to unstable positions of the shoulder.[7] Additionally, the muscle of the rotator cuff generates the compressive force that holds the humeral head within the glenohumeral joint. This restrictive force shields the joint from direct pressure when active motion occurs.[8-9]

Additionally, the labrum plays an enormous role in stabilizing the shoulder. A small area of the humeral head touches the joint of the glenoid, and compression of the humeral head to this small area occurs through a series of dynamically working cross-linked cables. The labrum helps impart the forces from the humeral head to the glenoid and stabilizing structures.[10] In this way, the labrum acts as a gasket.

Glenohumeral Joint

The labrum has three major roles in the anatomy of the glenohumeral joint. First, it serves as an attachment point for stabilizing structures and thereby acts as a force conduit, spreading tension from the glenohumeral displacement to the capsule and ligaments that prevent displacement.[10] Second, the labrum provides a larger, concave surface upon which the humeral head can articulate. Subsequently, the contact area to the humeral head is increased by 2mm in the anterior-to-posterior direction and 4.5 mm in the superior-to-inferior direction.[3] Third, the uniform surface and synovial fluid provides a negative viscoelastic pressure between the humeral head and glenoid, imparting additional stability.[11]

Long Head of the Biceps Tendon

The role of the LHBT is diverse and only partially understood. The complex typically inserts partially on the superior labrum and supraglenoid tubercle, a firm bony attachment, and the structure prevents multidirectional displacement of the humeral head.[12,13] Furthermore, the function of the long head can prevent humeral head translation when viscoelastic forces of the joint have been diminished.[14] Additionally, the role of the long head may be connected to the deceleration phase of throwing mechanics, as Andrews et al[1] originally noted.

The superior portion of the labrum about the attachment of the LHBT displays a notable amount of anatomic variance. In particular, the action between the superior labrum and biceps muscle-tendon unit has been examined. A study by Clavert et al[15] identified three types of labral variants to the glenoid (type 1, flat or adherent; type 2, rounded with a recess before attachment; and type 3, meniscal or mobile) in 100 patients treated with shoulder arthroscopy. In patients older than 30 years, the authors noted an increased number of types 2 and 3 labrums compared to patients younger than 30 years, suggesting a normal change in anatomy with aging. Furthermore, Williams et al[16] found 12% and 1.5% of superior labrums with sublabral foramen and Buford complex (normal variant to anatomy), respectively.

Mechanisms and Classification of Injury

The lesion that Andrews et al[1] initially discussed was observed in overhead-throwing athletes, mostly baseball pitchers. The wound was suggested to be caused by a wear-and-tear process, involving an inline pull on the labrum created by the biceps tendon during deceleration of the throwing motion. In the study,[1] the biceps-muscle belly was electrostimulated during arthroscopy for treating SLAP tears, and the contraction of the biceps displaced the labrum. Results of later studies have indicated that the causes of the lesion are more complex than one simple mechanism, with multiple classifications.

Inline and Peel-Back Mechanisms of Injury

Burkhart and Morgan[17] discussed the tear as a repetitive process of trauma owing to traction applied at the LHBT insertion, which can be observed during deceleration or late-cocking phases of throwing. Subsequently, two proposed mechanisms of injury gained acceptance, relating to repeated stress applied to the superior labrum gained acceptance: “inline” for noting the eccentric contraction of the biceps in line with the tendon (ie, deceleration phase); and “peel back” for describing the twisting and traction forces on the labrum created by the biceps, with the shoulder in maximum flexion, abduction, and external rotations (ie, late-cocking phase).

In a rather interesting study performed by Shepard et al,[18] the exposed biceps tendon of eight matched pairs of cadaveric shoulders were tested for maximum strength before tearing or rupturing when loaded with peel-back and inline mechanisms of force. Because the tendons in the peel-back group withstood significantly more force, the attachment of the LHBT may be more robust, with a force vector of equivalent value to the inline mechanism. Additionally, Pradhan et al[19] noted greater strain placed on the posterior labral attachment in a cadaveric study, with the arm positioned in the late-cocking phase.

The peel-back and inline mechanisms are possibly related to the appearance of lesions because, in terms of use-related tears, the shoulders of overhead-throwing athletes experience both types of stress during sports-related activity. However, one mechanism may not be more likely than the other to cause SLAP tears. Current thought is that both patterns contribute to the wound’s appearance.[20] Continual stress at the superior-labral and LHBT insertions could lead to displacement of a microlesion. Further studies on displacement of pre-existing lesions by using both mechanisms may help reveal the role of each movement in causing SLAP tears.

Compression and Traction Forces

Acute lesions can also occur at the superior labrum. Snyder et al[2] noted injury to the glenohumeral joint resulting from a single instance of compression, often a fall onto outstretched hands, with the shoulder adducted and in slight flexion. On the other hand, Morgan et al[21] reported acute lesions related to a single traction-based injury. Although similar in location to compression-based wounds, traction-type lesions are treated operatively more often.

Classification

SLAP tears were originally classified into types I through IV. Type I tears involve fraying of the superior labrum; type II, tearing of the superior labrum, with the LHBT attached to the torn portion of labrum; type III, tearing of the labrum from its attachments and the LHBT attachments; and type IV, tearing of the superior labrum to the LHBT, with the tendon-to-glenoid anchor intact. In a study by Maffet et al,[22] fifty-five percent of tears were type II, and types III and IV wounds accounted for 8%. Difficulty in categorizing the tears may be reflected in the fact that 38% of the observed wounds were considered non-classifiable.

Classification of SLAP tears has been expanded to types V though VII,[3] which consider pathological features extending to other areas of shoulder stability. Type V tears involve instability; type VI, biceps detachment; and type VII, middle and inferior tears of the glenohumeral ligament (implying instability). These categories encompass additional causes of SLAP tears to the original five classifications.

Diagnosis

Results of physical examinations are commonly obtained yet unreliable in diagnosing SLAP tears, and most tests involve a simple stimulation of the biceps attachment. For example, Synder et al[2] noted the presence of shoulder pain with SLAP tears in patients who, while in the overhead position, snapped their fingers. However, despite suspicious findings of physical examinations, arthroscopic or direct visualization remains the gold standard for diagnosing SLAP tears.

Physical Examinations

Many studies have examined the reliability of provocative maneuvers used to identify SLAP tears.[23-25] A well-known maneuver, the O'Brien test,[25] was originally dubbed the "active compression test" and requires the shoulder to be in a position of flexion to 90°, maximum internal rotation, and adduction of 15°. Pain in resisted extension, with relief when the patient resists in external rotation, indicates positive test results for the injury.

In a review of all findings of physical examinations of patients with SLAP tears, Cook et al[23] noted that results of the Biceps Load II test were effective indicators of SLAP tears, with a 1.7 positive likelihood ratio and 0.39 negative likelihood ratio for the wound. In this test, the patient and forearm are in a supine position, with the shoulder in 120° of abduction and maximum external rotation. Positive results for a SLAP tear are indicated by re-creation of pain with resisted elbow flexion. Ultimately, some retrospective reviews have found no definitive findings of physical examinations, whereas other research has highlighted a handful.[23]

Imaging Procedures

Results of imaging procedures have indicated reliable rates of accurately diagnosing SLAP tears. High-resolution magnetic resonance imaging (MRI) is not readily available or practiced, yet one study noted that findings from a computed tomography arthrogram proved to be 94% to 98% sensitive and 73% to 88% specific in noting SLAP tears.[26] In the same study, results of an MRI arthrogram were similar, with 91% to 98% specificity and 82% to 89% sensitivity. Although these data are not uniform, an older study[27] reported similar MRI findings of 98% and 89% sensitivity and specificity, respectively, in 104 patients.

Treatment

Operative and nonoperative treatment methods for SLAP tears exist. When operative treatment is recommended, the decision is usually guided by two possible procedures: repair of the tear from the SLAP to glenoid, and tenotomy or tenodesis of the LHBT. These methods may be performed in tandem and are not mutually exclusive. Typically, nonoperative procedures are preferred and performed before the suggestion of surgical treatment.

Nonoperative

Nonoperative treatment of SLAP wounds has focused on the mechanisms proposed to cause the tear. Tension in the LHBT caused by peel-back motions, inline movements, and other mechanisms can result in stress along the superior labrum. For instance, internal impingement owing to tightening of the posterior capsule may place additional pressure on this superior labrum-biceps complex. Often, this outcome has been seen in overhead-throwing athlete-patients who have possibly reduced internal rotation of the shoulder and display signs of hypermobile external rotation in the later cocking phase of throwing. As such, therapy treatment has included stabilizing the scapula and performing stretches to relieve tension in the posterior capsule.[28] Additional stress placed on the biceps-labral complex may be caused by stabilizing the scapula in high external rotation and deceleration. Subsequently, techniques used in therapy have emphasized proper throwing mechanics, strengthening of the rotator cuff, and scapular stabilization.

Operative

Several decades ago, operative treatment of superior labral tears focused more on repairing the SLAP lesion-to-glenoid tear rather than releasing the LHBT. These repairs were typically unsuccessful in treating overhead-throwing patient-athletes. Furthermore, performing biceps tenodesis may not reliably result in a full return to high-level competitive sports for athletes.

A case series by Denard et al[29] reported the difference in outcomes between 22 SLAP repairs and 15 tenodesis procedures of the LHBT. About 77% and 100% of patients in the former and latter groups, respectively, reported satisfaction with the treatment outcomes. One study[30] in Korea examined 34 patients with type II isolated SLAP tears, in which 90% reported satisfactory results after undergoing treatment. However, results of the University of California-Los Angeles Shoulder Scale test were lower in overhead-throwing athletes, indicating poorer treatment outcomes. In a case series of 25 overhand-throwing athletes in France, Boileau et al[31] noted that 40% of patients who underwent repair (n = 10) were satisfied with treatment. Return to pre-injury level of play was noted in 20% and 87% of patient-athletes treated with direct repairs and LHBT tenodesis, respectively.

Current Methods

A variety of treatment algorithms have been proposed, although no definitive standard exists. Results from a comprehensive literature review and professional recommendation suggest that clinical expertise is essential in deciding treatment of SLAP tears.[32] The author recommended tenodesis and debridement for treating type IV and degenerative or type I tears, respectively. For type II tears, repair of the labrum was only suggested for treating patients with acute trauma-related injuries, suspicious findings of physical examination, SLAP tears or paralabral cysts shown in an MRI arthrogram, and absence of injury to the biceps.

Furthermore, the effectiveness of techniques used to repair the superior labrum has been debated.[33] In a cadaveric study, DiRaimondo et al[34] showed that mattress sutures used for repairing superior labral tears could withstand more force than simple stitches or absorbable tacks. Similarly, Yoo et al[35] found that a horizontal mattress stitch had greater resistance to pullout forces than one or two simple stitches. Domb et al[36] also performed a cadaveric study, in which mean force until rupture or tear of the tendon was greater with use of two sutures, particularly horizontal mattress stitches.

The use of knotless anchors in repairing SLAP tears has also been examined. Yang et al[37] prospectively noted the outcomes of 46 patients treated with repair using knotless anchors, in which improved range of motion of the shoulder was noted postoperatively (in comparison to using traditional anchors). Another study[38] reported that a knotless repair possibly resulted in a meniscoid-shape appearance of the tear in the superior labrum.

Conclusion

SLAP tears are common injuries, frequently seen by general and sports-specialized orthopaedic surgeons. Abnormal appearances of labral tears may be a normal variant of the injury, sequel of aging, result of repetitive instances of microtrauma, or caused by an acute injury. Findings of physical examinations, although unreliable, can be helpful in deciding the next type of preoperative evaluation (ie, MRI) to confirm the diagnosis of a SLAP tear.

Treatment should be performed conservatively, with use of nonoperative methods and careful progression to surgical intervention. Operative procedures can be considered for patients with acute trauma-related tears of the labrum, tears with resultant instability of the shoulder, or tears involving chondral damage. Furthermore, patients with a paralabral cyst should be treated with decompression of the cyst, and labral repair may be considered. Biceps tenodesis or tenotomy and debridement of the superior labrum can be recommended for treating patients who underwent unsuccessful nonoperative treatment for chronic tears of the SLAP. Type II SLAP tears, in which the biceps tendon remains attached to a glenoid-detached labrum, can be treated when no obvious presence of injury to the biceps is noted. If performing a repair procedure, surgeons should consider use of more than one suture and horizontal mattress stitch.

Knowledge of the mechanisms behind and standard treatment for SLAP tears are limited. Additionally, long-term sequela of tenotomy and tenodesis for treating the LHBT remains uncertain. Clinical understanding of the injury may continue to increase as further studies are published on diagnosing and treating SLAP tears.

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Conflict of Interest

The author reports no conflict of interest.

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Ruptures of the Quadriceps and Patellar Tendons of the Extensor Mechanism: A Review

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Abstract

Damage to the quadriceps and patellar tendons of the extensor mechanism can be devastating and often life-changing injuries that require prompt diagnosis and treatment. A sound understanding of anatomy, biomechanics, and degenerative changes of both tendons and the extensor mechanism of the knee can help guide surgical repair and postoperative rehabilitation of patients. Immediate primary repair has often resulted in improved postoperative results compared with delayed reconstruction, and the avoidance of gap formation by use of careful techniques and augmentation has been critical for successful treatment. Additionally, patients with extensor mechanism injuries frequently have medical comorbidities or notable tendon degeneration; subsequently, careful consideration of systemic diseases and appropriate medical treatment has been vital to success of operative treatment. I reviewed the anatomy of quadriceps and patellar tendons; biomechanics of the extensor mechanism and tendons; mechanisms of injury; clinical and biomechanical studies on use of surgical techniques for treatment; and postoperative rehabilitation protocols and possible complications. Early diagnosis, awareness of comorbidities, prompt surgical treatment using a careful approach, and a thorough postoperative rehabilitation program may allow patients to return to previous levels of activity, with promising long-term results.

Introduction

Injuries of the extensor mechanism occur relatively infrequently but often require timely diagnosis and treatment. Ruptures of the quadriceps tendon are more common than the patellar tendon in patients aged 40 years and older who have notable medical comorbidities, whereas healthier patients aged 40 years or younger typically have patellar tendon ruptures. Extensor mechanism injuries are much more common in men than women, with a reported ratio of 8:1. This may be explained by the reported earlier onset of osteoporosis in women, which weakens the patella bone. Subsequently, tensile overload of the extensor mechanism has resulted in transverse patella fractures rather than tendon ruptures. Furthermore, systemic diseases have been strongly correlated to bilateral, spontaneous, and low-energy rupture.[1,2]

An understanding of the anatomy of quadriceps and patellar tendons can considerably help a surgeon in caring for patients with these complex injuries. To help investigate successful methods of treatment, I reviewed notable anatomical locations of the patellar and quadriceps tendons; biomechanics of the extensor mechanism; mechanisms of injury and other possible causes of tendon rupture; methods used to help appropriately diagnose the injury during clinical evaluation; various operative techniques; process of rehabilitation; and possible postoperative complications.

Tendon Anatomy

Tendons are relatively avascular and rely on intrinsic and extrinsic systems for nutritional and healing support. The level of function of the extrinsic and intrinsic systems decreases with age, presence of systemic disease, and mechanical loading of force, resulting in a weakened tendon with decreased regeneration and healing potential.[3]

Quadriceps Tendon Anatomy

The quadriceps tendon is a coalescence of the tendinous portion of quadriceps muscles that form three to four distinct layers, ranging from most anteriorly located to deepest within the tissue: rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius, respectively.

In 2008, Yepes et al[4] published an anatomical study with a proposed subdivision of the quadriceps tendon into three zones based on vascular supply and resultant common sites of rupture. By distance from the superior pole of the patella, zone 1 was at 0 to 1 cm; zone 2, 1 to 2 cm; and zone 3, greater than 2 cm. The most common site of rupture was zone 2 (41%), followed by zone 1 (37%) and zone 3 (12%). The high amount of zone 1 ruptures may have been explained by subperiosteal bone resorption caused by systemic diseases, which had weakened the site of attachment between tendon and bone.

Patellar Tendon Anatomy

The patellar tendon consists of 90% and less than 10% of types 1 and 3 collagens, respectively. Elastin, proteoglycan, and glycoproteins compose the remaining dry weight. Water makes up between 60% and 70% of the wet weight of the tendon, and collagen composes from 70% to 80% of the dry weight. The proximal width of the tendon approximates the width of the patella, which narrows and thickens as it extends distally. The average length of the patellar tendon spans 50 mm (SD, 5 mm).

The infrapatellar fat pad provides the main blood supply of the patellar tendon, which occurs by anastomoses from the genicular and recurrent tibial arteries through the patellar retinaculum. Similar to the distal attachment of the quadriceps tendon, the proximal and distal attachments of the patellar tendon are relatively avascular and prone to rupture.[1]

Biomechanics of the Extensor Mechanism

The function of the extensor mechanism allows for standing, bipedal ambulation, rising from a chair, and performing stairs. The force necessary to extend the knee against gravity to accomplish these tasks is called torque. In comparison with bringing the knee from a fully flexed position to less than 15° of extension, twice as much torque is needed to extend the knee to the final 15° of terminal extension.

The patella provides the constant torque and mechanical advantage needed by two separate mechanisms: linking and displacement. The linking mechanism generates torque from the quadriceps muscle to the tibia, whereas displacement helps generate the extra torque needed to reach full extension. As the knee extends, the patella slides out of the groove and onto the anterior cortex of the femur, which displaces the patella from the knee axis of rotation and generates 605 N of torque to gain the last 15° of full extension. This mechanical advantage indicates an important relationship between the patella and femur during arthroplasty and reconstruction of the extensor mechanism.[5]

The relative force applied to each tendon depends on the degree of knee flexion and ability of the patella to tilt in the sagittal plane in relationship to the trochlear groove. The greatest force undertaken by the extensor mechanism occur with the knee at 60° of flexion. At 30° or greater than 90° of flexion, the quadriceps-tendon force is 30% less or greater than the patella-tendon force, respectively.[2]

Mechanism of Injury

The most common mechanism of injury of quadriceps and patellar tendons has been forceful quadriceps contraction (ie, sudden force of the patient’s body weight, with the knee in a flexed position).[1] Eccentric loading of the extensor mechanism often occurs when the foot and knee are planted and slightly bent, respectively, such as in an attempt to regain balance for avoiding a fall. This time-dependent, sudden strain with the knee in the position of greatest force (60° of flexion) causes tensile overload of the extensor mechanism, resulting in failure to extend the knee. Because the patella is considered to be the weak link of the structure, this mechanism commonly results in a transverse patella fracture in patients with intact quadriceps and patellar tendons. If damage occurs at the tendons, the cause of extensor mechanism failure becomes tendon rupture and avulsion.

In younger patients, the mechanism of injury has often been direct trauma, either blunt (ie, football helmet to the knee) or penetrating (ie, laceration from edges of ski blades). The three typical patterns of extensor mechanism injury, ranging from most common to least, are avulsion with or without bone fragments from the poles of the patella; midsubstance rupture; and distal avulsion from the tibia tubercle.[1]

Systemic Diseases and Degenerative Changes

Possible factors that affect tendon health have been grouped into two general categories: systemic diseases and degenerative changes. Systemic diseases include chronic renal failure; uremia; diabetes; chronic inflammation and synovitis of rheumatoid arthritis; hyperparathyroidism; and connective-tissue disorders. Degenerative changes result from microscopic injury to the tendon owing to repetitive force applied in the most severe “plastic phase” of tendon deformation (≤ 10% strain).[1]

A study published in 2011 by Wani et al[6] detailed the importance of simultaneous medical treatment in patients with long-term hemodialysis of chronic kidney disease and tendon ruptures. Concerning degenerative changes, Kannus and Józsa[7] evaluated 891 biopsy specimens with spontaneously ruptured tendons (of which 53 were patellar tendons) and noted that 97% had degenerative characteristics, mainly hypoxic tendinopathy, mucoid degeneration, tendolipomatosis, and calcifying tendinopathy. To note, multiple studies have reported on “jumper’s knee,” or quadriceps-patella tendinitis, which results from repetitive overloading of force on the extensor mechanism.[8-10] The injury has been shown to be a significant risk factor for ruptures of the patellar tendon.[10]

Clinical Evaluation

After initial injury of quadriceps and patellar tendons, patients present with the inability to actively extend the knee or maintain extension against gravity. Findings of radiographs may be essential in confirming diagnosis of extensor mechanism injuries and should be obtained before other imaging procedures are performed.

Physical Examination

Missed diagnosis of injury to the quadriceps and patellar tendons is relatively common and has been reported in 10% to 15% of patients without and 30% of patients with concomitant injuries.[1,11] Signs of limited active extension of the knee have been confused with an intact sartorius muscle.[11] An intact patellar retinaculum may allow for the limited active extension, in which considerable weakness and extensor lag exist compared with the uninjured leg when patients maintain extension against gravity. Use of knee aspiration and intra-articular anesthetic injection may improve the sensitivity of the examination to health of tendons. The presence of suprapatellar gap and palpable depression has been an indicator for possible disease of quadriceps tendons with ruptures. Furthermore, hemarthrosis can prevent the palpation of a gap and aspiration of the knee joint. Additionally, flexion at the hip to shorten the length of the rectus femoris (crosses hip joint) and increase the gap length may improve the sensitivity of the examination.

Imaging Procedures

Radiographs should be critically evaluated for the presence of patella alta and possible bone fragments that may be attached to the tendon after avulsion-type injuries. Patella alta or baja can be identified by the relationship of the patella to the Blumensaat line on a lateral radiograph, showing the knee flexed to 30°. Additionally, several standardized measurements can be used to assess patella position.

Ultrasonography has been a relatively cost-effective and timely imaging procedure, with acceptable specificity for ruptures of the quadriceps and patellar tendons. Disadvantages have included operator- and reader-dependent natures of the modality. Results of magnetic resonance imaging (MRI) are useful in diagnosing chronic injuries and partial ruptures and determining location of the disruption. The major disadvantages of MRI procedures are the cost and limited availability at some centers.

Treatment

Immediate primary repair within 72 hours after initial injury is the standard for successful operative treatment of quadriceps and patellar tendon injuries. Surgical treatment after 72 hours can result in difficulty with apposition of tendon edges and increase tension on suture lines. Notably, nonoperative treatment is associated with limited results in patients with incomplete rupture and should be reserved for patients with low levels of activity, who may not successfully undergo operative procedures. Findings of MRI help justify the use of nonoperative techniques because most views of the extensor mechanism should be intact. Nonoperative treatment typically consists of immobilization for 6 weeks, followed by limited activities involving high range of motion of the knee.

Operative Procedures

Several well-accepted techniques used during primary repair have helped minimize gap formation, including use of Krackow stitches,[12-14] suture anchors,[15,16] and augmentation to reduce tension placed on the suture.[17]

Although the gold standard of primary repair for treating extensor mechanism injuries has involved use of Krackow stitches, a biomechanical study by McKeon et al[13] reported no difference in maximum strength compared with use of a whipstitch, in which results were attributed to suture rupture rather than suture pull out. Petri et al[15] compared results of using theoretically improved suture anchors for repairing quadriceps and patellar tendon ruptures in patients, in which significantly high levels of maximum strength before failure that resulted in decreased gap formation were noted.[16] In 2011, Massoud[17] found promising results with use of augmented suture cerclage, with no cases of re-rupture or radiographic evidence of patella alta, patella baja, and patella-femoral degenerative changes in the tendons.

Postoperative Rehabilitation and Long-Term Outcomes

In rehabilitation of patients with injuries of the quadriceps and patellar tendons who were treated with operative repair, use of strict immobilization in a cylinder cast or knee immobilizer has been favored, particularly for treating quadriceps tendon ruptures in patients with systemic diseases. The other method of rehabilitation has involved early controlled motion, in which controlled tensile force promotes increased collagen production of the tendons, improved tendon architecture, and decreased scar formation. No consensus exists on the most effective method of postoperative rehabilitation because studies on either protocol have reported similar results.[18-21]

In general, the long-term results of immediate primary surgical repair for treating acute ruptures of quadriceps and patellar tendons have been promising. In 2014, Boudissa et al[18] reported a series of 50 acute quadriceps tendon ruptures, with a mean follow-up of 6 years, in which 97% of patients had regained full extension of the knee and mean flexion of 125°. No significant difference in level of function was noted when the results were compared with those of studies on early range of motion methods. Concerning patients with chronic ruptures and systemic diseases, Malta et al[19] reported that results of treatment were significantly worse with acute ruptures in healthy patients, although biochemical alterations of the tendon structure and delayed time to operative treatment may have affected findings. Finally, patients with patellar tendon ruptures tend to be young and healthy, and subsequent long-term results of postoperative treatment have been promising.[20,21]

Complications

Loss of range of motion of the knee and particularly active terminal extension (extensor lag) have been common postoperative complications after treating extensor mechanism injuries. Many techniques and modifications to rehabilitation protocols have been used to avoid postoperative extensor lags. The combination of tensioning the repair in full extension of the knee and protected methods of controlled motion has improved results by decreasing the degree of extensor lag while achieving acceptable knee flexion. Atrophy and weakness of the quadriceps muscle have been recognized as considerable postoperative complications. In 1981, Siwek and Rao[22] reported quadriceps atrophy of 2 to 4 cm at final follow-up but did not find clinical significance because the level of weakness still allowed for adequate strength of normal knee function.

Furthermore, because most patients with extensor mechanism injuries have comorbidities and low levels of activity, wound complications and postoperative infections occur more frequently than noted with other operative procedures for treating knee injuries.[23] The subcutaneous positioning of wires and large caliber sutures may contribute to this high rate of wound complications and infections, which can be minimized with avoidance of placing sutures in line with the incision, careful placement of knots, and tension-free closures of the wound. Patella baja, resultant loss of motion, and potential for patellofemoral degeneration should be carefully considered at the time of operative procedure because careful anatomical restoration of patella position and biomechanics can reduce complications. Finally, re-rupturing of tendons has required revision surgery, which has been reported in between 1% and 8% of cases.[10,20,23]

Conclusion

A general knowledge of quadriceps and patellar tendon structure, anatomy, and biomechanics may greatly improve the ability to diagnose, surgically treat, and appropriately direct postoperative rehabilitation of extensor mechanism injuries. Special attention to comorbidities of patients is critical to successful treatment. Additionally, many operative procedures and techniques warrant consideration (ie, type of suture, type and number of throws, and pre-loading methods). Use of augmentation methods and base-level rehabilitation plans should be employed for treating individual patients, which vary depending on patient characteristics and type and degree of injury. Time to operative procedure after initial injury is crucial, with the universally accepted notion that chronic injuries worsen quickly and considerably. A timely diagnosis and immediate yet careful primary repair, followed by a thoroughly directed physical therapy program, may result in a reliable return to previous levels of daily activities, work, and sports of patients.

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Causes, Evaluation, and Treatment of Instability of the Patellofemoral Joint of the Knee: A Review

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Abstract

Instability of the patellofemoral (PF) joint of the knee is typically caused by chronic atraumatic injuries and inciting traumatic events. Anatomically, bony and soft-tissue structures surrounding the PF joint and extensor mechanism contribute to overall stability of the area, which results in efficient kinematic function at the PF articulation. Furthermore, physiological, genetic, anatomical, and demographical factors may affect the development and progression of PF joint instability. Treatment techniques have varied owing to individual factors that may have influence on pathological features of the injury. Nonoperative treatment has predominantly focused on strengthening of the quadriceps and vastus medialis by coordinated, closed chain exercises; if unsuccessful, surgical treatment can be a viable option for chronic dislocation and instability of the PF joint. I reviewed anatomy of the patella and notable bony and soft-tissue constructs; radiographic evaluation and findings suspicious of PF joint instability; and common operative and nonoperative methods for treatment. Despite improved understanding of possible causes and outcomes of treating PF joint instability, further clinical studies are necessary to evaluate the long-term clinical impact of treatment.

Introduction

Instability of the patellofemoral (PF) joint is classically described as the result of chronic atraumatic injuries (eg, anatomical anomalies and ligamentous laxity) or inciting traumatic events. The incidence of a primary dislocation has been reported as 5.8 per 100,000 patients, with a disproportionate occurrence in patients aged 10 to 17 years (incidence, 29 per 100,000). Additionally, women have often been noted with a higher overall incidence of the injury.[1] Recurrent instability has been noted in 17% and 50% of patients with a first-time dislocation and history of subluxation, respectively, which suggests that either may be a strong predictor for future injury.[1]

Most dislocations occur during sports-related activity, commonly after impact that drives the patella out of the trochlear groove, or after an indirect lateral force vector that contracts the quadriceps muscle and thereby the knee experiences a simultaneous valgus stress. After an acute dislocation of the PF joint, time is needed to restore strength and functional range of motion to the knee. In patients with an acute patellar dislocation, significant delay has been reported for return to functional range of motion, quadriceps strength, and sports-related activities.[2]

However, no standard method exists for treatment owing to individual patient characteristics and pathological features of the injury. To help examine long-term effects of treatment, I reviewed the anatomy of the patella and notable bony and soft-tissue structures; radiographic indicators for PF joint instability; and operative and nonoperative methods of treatment.

Anatomy

The triangular-shaped patella is the largest sesamoid bone in the human body and represents a key component of the extensor mechanism. It is an essential element in the biomechanical kinematics that define the extensor mechanism.

Bony Structures

Bony constraints contribute to PF joint stability. The patella is approximately 12 cm^2 in surface area and comprises the medial and lateral facets, which are separated by a vertical ridge. These articulating facets make up the retropatellar surface, which articulates directly with the trochlear groove of the femur.

In a biomechanical study, Goodfellow et al[3] demonstrated that the contact area and zone of articulation changes throughout the arc of motion of the knee joint. As the knee extends from 20° to 90° of flexion, the articulating zone of the patella moves from inferior to superior locations, respectively. Greater than 90° of flexion results in the disengagement of the patella from the trochlear groove, and the area of articulation moves to the peripheral borders of the medial and lateral facets. This articulation is affected by factors such as patella alta, in which the patella does not engage with the trochlear groove until the knee has reached greater degrees of knee flexion. The resulting motion affects the stability and joint-reaction forces at the PF articulation.[4,5]

Soft-Tissue Structures

Soft-tissue structures help ensure efficient kinematic function at the PF articulation. Laterally, three distinct layers of the lateral retinaculum are composed of the lateral restraining structures. Superficially, this layer is confluent with the iliotibial band, with attachments to the quadriceps and patellar tendons. Deep within this layer, the intermediate layer is composed of the lateral PF band, followed by the deepest layer, which is confluent with the joint capsule itself.

The major lateral restraining structures on the medial side of the knee include the medial retinaculum and medial patellar stabilizers. These stabilizers, located in layer two of the three-layer confluence on the medial side of the knee, consist of three medial ligaments.[6] The most notable of which, the medial PF ligament (MPFL), measures about 40 to 50 mm in length. The widest portion remains at the patellar insertion, narrowing to a width of 10 to 20 mm at its attachment to the femur. Additionally, the MPFL fibers have been shown to mesh with those of the vastus medialis obliquus, essentially dynamyzing an otherwise static structure to help guide the patella into the trochlear groove during knee flexion.[7]

In biomechanical and cadaveric studies, the mean tensile strength of the MPFL has been reported at 208 N.[8] Panagiotopoulos et al[7] evaluated 25 fresh-frozen cadaveric specimens and noted that, in the static stabilizers, the MPFL contributed about 53% of the retraining force to lateral patellar subluxation from 0° to 30° of knee flexion, which suggested that the MPFL provides the most substantial static PF joint stabilization.

Radiographic Evaluation

As outlined by Dejour et al,[9] four well-described radiographic factors help categorize and define the potential causes of PF joint instability. Characteristics of trochlear dysplasia, patella alta, and the distance from the tibial tubercle to trochlear groove (TT–TG) may be essential in defining treatment and pathological features of PF joint instability.

Trochlear Dysplasia

Sulcus angle is measured from the highest point of the medial and lateral femoral condyles to the lowest point of the trochlear groove. The average sulcus angle in all patient populations is 138°, with angles greater than 145° indicating trochlear dysplasia. In a study on patient characteristics associated with acute lateral patellar dislocation, Atkin et al[2] found that 28% of symptomatic patients with a primary patellofemoral dislocation exhibited an abnormal sulcus angle greater than 150°. Another method used for identifying trochlear dysplasia involves use of four distinct morphological types, described by Dejour and Le Coultre.[10] Each type allows for general characterization of four distinct anatomic variants that appear to recur frequently when assessing and describing PF joint instability. Although these morphological variants have not shown consistent inter- and intraobserver reproducibility,[11] anatomical variability between individuals may predispose certain patients to an increased risk for PF joint instability.

The identification of trochlear dysplasia is important from risk and natural-history standpoints because of the subsequent effect on PF biomechanics. In their cadaveric study, Van Haver et al[12] simulated the four types of dysplasia in four cadaveric knees and found a significant impact and effect on PF kinematics, contact area, contact pressure, and stability. The results of this study validated predisposing factors that may influence the incidence and progression and contribute to the overall causes of PF joint instability.

Patella Alta

Patella height has been an important radiographic factor in evaluating PF joint instability. Patella alta has frequently been associated with abnormal PF kinematics, increased PF pain and instability, high PF stress, and decreased contact area.[13] Patella height is commonly described by four main indices: the Caton-Deschamps, Blackburne-Peel, Insall-Salvati, and Labelle-Laurin. Studies on each measurement have validated the use of each; however, Caton-Deschamps and Blackburne-Peel indices have been generally regarded as the most reliable and reproducible.[14-16]

Distance from the Tibial Tubercle to Trochlear Groove

Finally, the TT–TG distance has been another radiographic variable that helps describe the characteristics, causes, and treatment of PF instability.[17] Balcarek et al[18] reported that TT–TG distance can be viewed as an independent variable, contributing directly to instability. In general, the mean distance noted in adult populations is about 9 mm (range, 9.4 to 13.6 mm). In their research on TT–TG distance associated with PF joint instability, Caton and Dejour[19] reported 12.7 mm and 19.8 mm in the control and instability groups, respectively. Their results illustrated the cause and effect of TT-TG distance on PF joint instability and the independent contribution of TT–TG distance to the continuum of pathological instability. The threshold for TT–TG distance has been commonly regarded as 20 mm, in which values greater than 20° contribute notably to PF instability. Greater distances may indicate the need for operative treatment.

Treatment

Treatment of PF joint instability has depended on individual patient characteristics that contribute to pathological features of the injury. Several factors and options exist within both operative and nonoperative categories. Nonoperative techniques have been commonly used for treatment after the initial injury.

In a prospective randomized trial[20] and retrospective review,[21] the results of nonoperative and operative methods were compared in treating acute primary patellar dislocations. Both studies found no significant difference in subjective outcomes, recurrent instability, and function or activity scores between the two groups, which reinforced the initial use of nonoperative techniques.

Nonoperative Treatment

Nonoperative treatment has focused on quadriceps and vastus medialis strengthening by coordinated, closed chain exercises. Additionally, the use of bracing has been advocated as an initial modality to help stabilize and prevent recurrent dislocation. Shellock et al[22,23] reported (in two separate studies) on the relative benefits of realignment bracing, with 73% and 76% of patients noted with improvement and correction of lateral subluxation, respectively. However, Muhle et al[24] found no difference with and without bracing in re-establishing lateral patellar tilt angle and displacement using an active motion, kinematic magnetic resonance imaging scanner. Subsequently, uncertainty may exist in using bracing as a standard procedure, with some potential benefit in certain clinical settings such as relatively low risks and contraindications.

Operative Treatment

Surgical procedures have involved treating factors that play a central role in the recurrence of dislocations. The three most commonly addressed components include 1) the trochlear groove, 2) the tibial tubercle and its relationship to the alignment of the PF joint in the axial and sagittal planes, and 3) the restraint associated with the medial soft-tissue structures. Often, it has been helpful to address these components in concert to adequately treat PF joint instability.

Surgical indications for trochleoplasty include patellar instability in trochlear dysplasia, with a sulcus angle greater than 145°, and distinct radiographic patterns. Two main methods involve lateral elevation trochleoplasty and deepening trochleoplasty. In the short term, use of both techniques has shown promising postoperative results.[25,26] In studies on long-term results, however, the findings have been less favorable. One[27] study reported osteoarthritis in 33 of the 34 patients treated with sulcus-deepening trochleoplasties after mean 15-years follow-up. In a similar study, von Knoch et al[28] found that 30% of the patients (n = 38) had patellofemoral degenerative changes in various stages after mean follow-up of 8.3 years. Although use of trochleoplasty may help treat PF joint instability with trochlear dysplasia, alterations in the contact area and pressure about the PF joint may occur, which can result in the onset of arthritis and cartilage damage.

In the presence of increased tibial tubercle offset, patella alta, and altered relationship between the quadriceps and patellar tendons (ie, Q-angle), PF joint stability may be achieved by using distal realignment to simultaneously mitigate the impact of each condition. Possible osteotomies include the Elmslie-Trillat (direct medial translation), Fulkerson (anteriomedial translation), Hauser (posteriomedial translation), and Maquet (direct anterior translation). Use of the Elmslie-Trillat technique has generally been reported with successful results.[28] However, similar to data on patients who underwent trochleoplasty, long-term studies have questioned the sustainability of function.[30-32] In a study with 39 patients, Nakagawa et al[33] noted promising return to function of 91% and 64% at 3.5 and 10 years, respectively, with eventual decline in function and worsening of PF pain and degeneration. Originally described for treating PF pain with articular degeneration to help offload the joint and redistribute contact forces, the Fulkerson osteotomy has since been adopted as a successful distal realignment procedure, in which long-term results have indicated improved function.[34]

Techniques used to treat medial-sided soft-tissue structures include direct repair, imbrication, and reconstruction. In particular, results of MPFL reconstruction have been promising. Long-term follow-up studies on the technique have reported improved functional scores without any subsequent re-dislocation[35] and effective patellar tracking, reduced PF joint pain, and improved apprehension in most patients.[36] Interestingly, use of MPFL reconstruction has been shown to improve PF joint stability despite the presence of other contributing components (ie, trochlear dysplasia or increased TT–TG distance).[37] Additionally, Steiner et al[38] found improve postoperative recurrent dislocation and subluxation rates in patients (n = 34) with untreated trochlear dysplasia.

Although no current consensus exists on type, positioning, and tensioning of potential reconstruction graft,[39] use of MPFL reconstruction has resulted in improved patient outcomes, decreased recurrence of PF joint instability, and possible treatment of other factors associated with PF joint instability.

Conclusion

PF joint instability can have a notable impact on functionality and quality of life of patients. Many factors and anatomical variants contribute to its chronicity and overall impact. Published research has increased substantially in the last several years, resulting in considerable improvements to general knowledge and treatment of the condition. Because PF joint instability results from interrelated factors and conditions, it should not be thought of or treated in isolation to other injuries.

Soft-tissue structures, bony elements, anatomical variants, and demographical factors should be considered when evaluating and treating PF joint instability. In acute conditions, use of nonoperative methods such as physical therapy, quadriceps strengthening, and bracing can improve rehabilitation of patients. However, as acute dislocations transition into chronic and recurrent instability, surgical treatment may become more effective.

The success of certain procedures in treating factors that influence the causes of PF joint instability has become more evident. Distal realignment and MPFL reconstructions can have profound impact on long-term, functional outcomes of the treatment and can re-establish PF kinematics. Our general understanding of PF joint instability and the impact various individualized factors on incidence and prevalence continues to expand, and treatment of PF instability will continue to improve with further clinical research.

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Periprosthetic Fractures of the Femur after Total Hip Arthroplasty and Hemiarthroplasty: A Review

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Abstract

Periprosthetic fractures of the femur after total hip arthroplasty (THA) and hemiarthroplasty represent relatively uncommon but challenging complications. The incidence of these types of fractures has been rising, owing to an increasing number of hip arthroplasties performed, aging population, and prevalent use of uncemented stems, which may have unsuccessful long-term results compared with use of cemented stems. Method of treatment has been generally based on the Vancouver classification system that describes radiographic characteristics of fractures and stability of the femoral stems in respect to placement in the bone. In particular, the presence of loose stems has often indicated the need for revision THA; on the other hand, fractures located around and distal to well-fixed stems typically have been treated with open reduction and internal fixation (ORIF). The failure to preoperatively identify loose stems may result in unsuccessful treatment with ORIF. I reviewed clinical evaluation, mortality rates, and treatment of patients with Vancouver types A, B1, B2, B3, and C periprosthetic femur fractures. Appropriate treatment of these challenging injuries requires high-level surgical technique, ranging from use of biologically-friendly methods to performing complex revision THA.

Introduction

After total hip arthroplasty (THA) and hemiarthroplasty, periprosthetic fractures of the femur may occur and represent a challenging problem for patients and surgeons. Most periprosthetic femur fractures result from a fall while in sitting or standing positions, with less than 10% of fractures occurring after a high-energy trauma.[1] Risk factors for periprosthetic femur fractures in patients include female sex, osteoporosis, older age, inflammatory arthropathies, and bone deformity.[2] Notably, loosening of previous stems used in THA has recently emerged as a considerable risk factor for these fractures.[3,4]

The prevalence of periprosthetic femur fractures has been rising, possibly owing to the aging population and increasing number of THA performed each year.[5] Fractures occurring intraoperatively during primary THA range from 0.1% to 1% and 0.3% to 5.4% with use of cemented and uncemented stems, respectively. On the other hand, fractures after revision THA occur more frequently, ranging between 3.6% and 20.9%.[6] In particular, although relatively low, the incidence rate of periprosthetic fractures identified years after primary THA (0.1%–7.8%) has been reported as increasing.[6,7] Proposed explanations for this include increased longevity of the population, high level of activity at older ages, and use of uncemented stems during the initial procedure.[6] To help identify effective techniques in treating periprosthetic femur fractures after revision THA and hemiarthroplasty, I reviewed common clinical evaluation, current mortality rates, and operative and nonoperative methods for treatment based on classification of the fracture.

Clinical Evaluation

Use of medical records of the patient can help in selecting the appropriate technique and type of implant used. In diagnosing periprosthetic femur fractures after THA and hemiarthroplasty, the pertinent aspects of patient medical history include functionality level before injury, pre-existing pain, systemic signs of infection, presence of comorbidities, and mechanism of injury. In particular, any indication of pre-existing aseptic loosening around the stem (eg, expressed pain in the anterior thigh during ambulation) is important to note. Furthermore, fevers, chills, draining of the sinus tract, prolonged time required for healing of the wound after the primary procedure, and the need for antibiotic treatment during the initial perioperative period suggests that systemic signs of infection are predisposing factors for the fracture, which can affect future technique of treatment.

Physical examination typically includes a detailed neurovascular and skin evaluation in diagnosing the injury. Identification of scars can help determine the previous technique used during the index procedure. Additionally, findings of the physical examination can be helpful in assessing risk factors of periprosthetic factors, including comorbidities and general health status of the patient.

Results of laboratory analysis should also be obtained during preoperative evaluation of the patient. Despite the described incidence of infection in 11.6% of periprosthetic femur fractures, authors have discouraged the workup routines involving erythrocyte sedimentation rate, C-reactive protein, and white blood cells in patients without clinical findings suspicious of infections.[8]

Routine imaging procedures should include anteroposterior (AP) views of the pelvis and AP and lateral views of the affected femur. Radiographs should be evaluated for fracture characteristics, stem loosening, polyethylene wear of stem, and available bone stock on both the femoral and acetabular sides of the injury. In general, cross sectional advanced imaging may not be necessary during standard workup of periprosthetic femur fractures.

Mortality Rates

Mortality and morbidity rates associated with periprosthetic femur fractures are more similar to those of patients with general hip fractures than those of patients who underwent revision THA. Reported mortality rates relating to periprosthetic hip fractures range from 7% and 18% at 1 year after initial injury,[7] which is greater than noted in patients who underwent primary THA. The New Zealand Registry described 7.3% and 0.9% rates of mortality of patients at 6 months after revision THA for treating periprosthetic femur fractures and aseptic loosening around the stem, respectively.[9] In particular, a high perioperative risk of mortality has been found in patients with periprosthetic femur fractures after undergoing hemiarthroplasty. In a recent study of 79 patients with periprosthetic femur fractures after hemiarthroplasty treated using a standard algorithm, mortality was reported in 11%, 23%, 34%, and 49% of patients at 4 weeks, 3 months, 1 year, and 2 years postoperatively, respectively.[10] These data indicate that careful perioperative management of comorbidities may be essential in treating patients with periprosthetic femur fractures identified after hemiarthroplasty.

Classification and Treatment

Based on findings from imaging procedures, periprosthetic fractures can be categorized using the Vancouver classification system[11] that describes anatomical location of fracture, stability of used stems, and available bone stock. The successfulness of treatment can depend on appropriate classification of the fracture, particularly into types A_G, A_L, B1, B2, B3, and C.

Vancouver Type A Fractures

Vancouver type A fractures are anatomically located in the greater trochanter (Vancouver type A_G) or lesser trochanter (Vancouver type A_L) around a well-fixed femoral stem. In a case series of 24 type A_G fractures treated nonoperatively without weight-bearing restrictions or bracing, the authors reported resolution of pain in most patients, with a nonunion rate of about 50% yet minimal functional impairment.[12] The opposing pulls of the abductors and vastus lateralis of the thigh may prevent further displacement of fractures.

Additionally, the presence of osteolysis should be determined in treating Vancouver type A_G fractures. In a case series of 17 type A_G fractures treated nonoperatively and associated with osteolysis resulting from polyethylene wear of the stem, about 37% of stems remained intact at mean 3-year follow-up, despite healing of the bone in nearly all cases.[13] Although nonoperative methods have been advocated for treating most Vancouver type A_G fractures, the presence of osteolysis may indicate the need for a revision procedure. Other suggested operative indications for revision procedures include intraoperative fractures and largely displaced fractures, suggesting discontinuity of the soft-tissue sleeve located between the abductors and vastus lateralis.[7] Generally, operative methods involve claw plate fixation.

On the other hand, most type A_L fractures are avulsion based, which can be treated nonoperatively. However, it is essential to differentiate between small avulsion fractures of the lesser trochanter caused by contraction of the iliopsoas and avulsion fractures involving notable portions of the medial cortex of the femur. The latter usually become evident by postoperative week 6 and can be more appropriately classified as Vancouver type B2 fractures because of subsequent instability of the stem.[14]

Vancouver Types B1 and C Fractures

Vancouver types B1 and C fractures account for about 40% of periprosthetic femur fractures.[15] Type B1 fractures occur around well-fixed femoral stems, whereas type C fractures occur at the distal end of the femoral stem. Operative treatment of both types with osteosynthesis has been standard; however, numerous authors in Europe have recommended revision THA instead.[15-17] Nonoperative treatment of types B1 and C fractures using traction and bracing methods has resulted in high rates of malunion, symptomatic stem loosening, and postoperative complications of immobility such as deep vein thrombosis and ulcers. Currently, most authors recommend operative treatment of patients who can survive the stress associated with undergoing surgical procedures.[18]

The modern technique used during osteosynthesis is essentially a modification of the technique described in 1978 by Ogden and Rendall.[19] This study described fixation of a lateral plate around the proximal and distal ends of the stem, using cables and bicortical screws, respectively. After many studies reported unsuccessful treatment using a single lateral plate, some authors began to investigate treatment with adjuvant fixation of pins using allograft struts. In a series of 40 types B1 and C fractures treated operatively using cortical onlay allograft struts or allograft struts with a lateral plate, union of the fractured bone was reported in 39 fractures, with greater than 10° malunion noted in four.[20]

A more recently published study described types B1 and C fractures (n = 50) treated with open reduction and internal fixation (ORIF) using biologically friendly techniques such as lateral plates without allograft. Union was reported of all fractures in patients who presented at final follow-up, with less than 5% of malalignment in all cases.[21] Furthermore, a systematic review on 37 papers and 682 fractures compared the postoperative results between ORIF and plate fixation with and without use of allograft struts, respectively. Resulting rates of union were similar between the groups, but the use of allograft struts was associated with higher infection rates and longer time to union than with plate fixation.[5] Subsequently, the currently accepted technique used in osteosynthesis has involved biologically friendly treatment of the fracture, without routine use of allograft struts.[22]

Studies have investigated methods to improve the biomechanical stability of implants used in the original Ogden method for treating Vancouver types B1 and C fractures. The vulnerable area of the fixation technique may be related to the proximal end of the screw. Results of finite element analysis indicated that adding unicortical locking screws to supplement fixation of cables proximally improved the rigidity of the construct, whereas applying cable fixation to bicortical screws distally did not significantly improve the stability of the construct.[23] Bicortical screws placed around the proximal end of the stem have shown optimal fixation, but use of unicortical locking screws were helpful in improving axial stiffness to cable constructs for proximal fixation.[24] Particularly in treating Vancouver type C fractures, level of stress concentration may predispose patients to future periprosthetic fractures after the initial fixation procedure. Proximal fixation should optimally overlap the stem when using a lateral plate to fix Vancouver type C fractures, and stress concentration can be increased maximally, with close proximal fixation to the tip of the stem until overlap occurs.[25]

Although osteosynthesis remains the standard procedure for treating periprosthetic fractures around well-fixed stems in the United States, numerous European authors have advocated for revision THA in this scenario. In a study on 52 patients with periprosthetic femur fractures, the mortality rates at postoperative month 6 were lower in the revision THA group than the ORIF group, including a subgroup analysis of B1 fractures.[16] In a retrospective analysis on 1049 periprosthetic femur fractures and risk factors, use of a well-fixed stem with ORIF rather than revision THA was associated with failure.[15] In contrast, results of multiple case series on ORIF for treating periprosthetic fractures around well-fixed stems have shown high union rates with minimal complications.[20,21] Despite suggested improved results with revision arthroplasty, osteosynthesis remains the standard treatment of periprosthetic femur fractures around well-fixed stems.

Vancouver Types B2 and B3 Fractures

Vancouver type B2 fractures involve loose femoral stems and account for 53% of periprosthetic femur fractures, whereas Vancouver type B3 fractures occur around loose femoral stems with inadequate bone stock and account for 4% of periprosthetic femur fractures.[15] In properly classifying and treating Vancouver types B2 and B3 fractures, identification of stem loosening is essential. In a study on types B2 and B3 fractures treated with use of modular fluted, tapered stems, a total of 98% of fractures healed and 98% of femoral stems were well fixed at follow-up, with instability of stems as the main postoperative complication.[26] Findings of other studies have similarly indicated successful treatment of types B2 and B3 fractures using modular distally fixed stems.[27,28]

Vancouver type B3 fractures with severe bone loss can be treated using allograft prosthetic composite (APC) or proximal femoral replacement (PFR). Published survivorship of APC varies between 70% and 90% at 2 to 15 years postoperatively.[29] Commonly reported complications with APC include infection, allograft resorption, trochanteric escape, and junctional nonunion. In general, APC is performed on young active patients, whereas PFR is indicated for treating patients aged 70 and older. Results of a study on 48 patients with non-neoplastic conditions (ie, type B3 fractures) treated with PFR indicated a 73% survivorship at 5 years postoperatively, with a 30% complication rate and the most common complication being stem instability.[30] Both APC and PFR require high levels of technical skill owing to long operating times, high amount of blood loss, and surgical-related stress experienced by the patient.[29]

Conclusion

Periprosthetic femur fractures after THA and hemiarthroplasty are common challenges for modern-day orthopaedic surgeons. Successful treatment requires careful assessment and management of medical comorbidities owing to high rates of morbidity and mortality in patients with pre-existing conditions. Most of these fractures occur around a loose stem (Vancouver type B2 classification), which can be appropriately treated with revision THA using long, uncemented, porous-coated stems for diaphyseal fixation. Vancouver types B1 and C fractures can be treated using biologically friendly techniques with ORIF, focusing on optimizing proximal fixation using a mixture of cables, bicortical screws, and unicortical locking screws. In general, Vancouver type A fractures may be effectively treated nonoperatively. Surgeons should consider patient comorbidities, fracture type, and level of technical skill required in performing successful procedures for treating periprosthetic fractures of the femur.

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Conflict of Interest

The author reports no conflict of interest.

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Treatment of Injuries and Conditions of the Distal Clavicle: A Review

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Abstract

Several trauma-related injuries and degenerative conditions affect the distal end of the clavicle. Fractures of the distal clavicle and separations of the acromioclavicular (AC) joint are common, resulting from direct impact onto the shoulder region. Osteolysis and osteoarthritis of degenerative processes of the AC joint are caused by repetitive activity and overuse of the shoulder. To help identify options for treating the distal end of the clavicle, this review highlighted notable anatomical locations and biomechanics; findings of physical examinations; classification systems of injuries; and standard operative and nonoperative methods used for treatment. Although distal clavicle fractures, AC joint separations, osteolysis, and AC joint osteoarthritis can be treated nonoperatively, severe injuries may be successfully treated using operative techniques.

Introduction

Injuries to the distal clavicle and acromioclavicular (AC) joint are common, ranging from fractures to degenerative conditions. Fractures of the distal clavicle account for 10% to 30% of all clavicle fractures seen in patients.[1] Radiographs showing nonunion of the bone have been reported in 10% to 44% of patients with the injury. The severity of the fracture, combined with physical activity of the patient and risk of symptomatic nonunions, has resulted in indications for operative treatment of certain fracture patterns. Furthermore, AC joint separations occur in 40% to 50% of athletic-related shoulder injuries.[2] Indications for treatment are often based on findings of clinical evaluation of the patient and radiographic classification of the injury.

Osteolysis of the distal clavicle most commonly occurs in young male weight lifters and has been typically caused by repetitive stresses to the subchondral bone.[3] This results in microfractures to the subchondral bone, degenerative changes in articular cartilage, chronic inflammation, and fibrosis of the AC joint.[4] Similarly, primary osteoarthritis of the AC joint results from the application of high amounts of force to a small area. Patients often experience pain during activity in overhead positions and cross-body adduction, with tenderness to palpation of the shoulder. Treatment of these overuse-related and degenerative conditions has been generally nonoperative, although distal clavicle resection may be considered for treating chronic symptoms that do not improve with use of conservative methods.[4] The current paper reviewed the anatomy and subsequent biomechanics of the AC joint; important clinical and radiographic findings; classifications of injuries; and treatment options of several conditions that affect the distal clavicle and AC joint.

Anatomy and Biomechanics

The clavicle connects the upper extremy to the appendicular skeleton. The distal end of the clavicle is stabilized by the coracoclavicular (CC) ligaments and AC joint capsule and ligaments. To help reinforce the AC capsule in stabilizing horizontal motion of the joint, the CC ligament attaches to the distal end of the clavicle and medial aspect of the acromion.[5] The trapezoid and conoid ligaments of the CC prevent superior displacement of the clavicle in relation to the acromion. Both ligaments originate at the base of coracoid process of the scapula and insert on the undersurface of the distal clavicle. The trapezoid and conoid attach at 2 and 4 cm from the AC joint, respectively.[6] Typical distance between the coracoid process and undersurface of clavicle is between 1.1 and 1.3 cm.[7]

Physical Examinations and Imaging Procedures

Acute injuries affecting the distal clavicle often result from a direct impact to the shoulder region. Subsequently, patients typically present with symptoms of pain in the anterior and lateral parts of the shoulder.

Physical examination should include visualization of the shoulder region and palpation of the clavicle. During these tests, patients often shows signs of swelling, ecchymosis, and pain during active and passive motions of the shoulder. Additionally, inspection can identify "skin tenting" in displaced fractures or AC joint separations, which suggests soft-tissue attenuation and impending risk of open fracture. Re-creation of pain after a cross-body adduction test suggests changes in pathological features of the distal clavicle. This test is performed by elevating the arm to 90°, holding the elbow, and adducting the arm across the body.[4]

Radiographic evaluation is recommended if findings of physical examinations are suggestive of an injury. Use of a Zanca view of the clavicle, in which the x-ray beam is directed between 10° to 15° of cephalic tilt, can be a helpful diagnostic tool in addition to standard anteroposterior and axillary-lateral radiographs. In this view, any intraarticular involvement of the AC joint can be effectively identified. Radiographs of both shoulders are also helpful in comparing patterns, location, and displacement of acute injuries to the distal clavicle.[1,4]

Fractures

Fratures of the distal clavicle are often categorized using the Neer[8] classification system, which describes anatomical location of the fracture and resultant stability of the clavicle. Depending on the type, the fracture may be treated nonoperatievly. However, because of the high rate of nonunion in distal clavicle fractures, operative treatment is often considered.

Neer Classification

The Neer system categorized distal clavicle fractures into types I through V. Type I fractures occur lateral to the CC ligament, with the AC joint intact. The intact CC ligament and deltotrapezial fascia stabilize the proximal and distal fragments, respectively. Types IIA and IIB fractures are usually displaced and unstable, in which the proximal end of the clavicle detaches from the CC ligament, and the distal fragment remains attached to the scapula by the AC capsule. In type IIA injuries, the CC ligaments connect the distal fragment to the coracoid process; however, in type IIB fractures, the conoid is torn, and the trapezoid is presumably intact and attached to distal fragment. Type III fractures occur distally to the clavicle and extend into the AC joint. The CC ligaments remain intact and subsequently stable, with minimal displacement. Type IV fractures are rare, occur mostly in children, and result from disruption of the periosteal sleeve, which causes damage to the physis and superior displacement of the metaphysis. Finally, in type V fractures, the inferior cortical fragment remains attached to the CC ligaments, creating instability of the clavicle.

Nonoperative Treatment

Types I and III fractures can be treated nonoperatively because most of the associated injuries are stable and nondisplaced. During typical treatment, the patient wears an arm sling for 2 weeks, with limited motion of the shoulder until symptoms of pain are reduced. Obtaining repeated radiographs is suggested at 6-week follow-up.

Type II fractures are often displaced, and 28% to 44% rates of nonunion have been reported.[1,9-13] Robinson et al14 noted similar outcomes at 6-year follow-up in patients with displaced fractures treated operatively and nonoperatively, with nonunion observed in 21% of patients. Delayed surgical treatment was performed for 14% of the patients owing to continued signs of symptoms. The study concluded that nonoperative treatement of displaced lateral clavicle fractures in middle-aged and elderly patients resulted in successful mid-term outcomes, in which asymptomatic nonunions did not affect the postoperative results of treatment.

Operative Treatment

Several techniques have been described for operatively treating distal clavicle fractures, including use of transacromial wires, tension bands, the Weaver-Dunn procedure with modifications, arthroscopic-assisted reconstruction of the CC ligament, placement of screws in the CC ligament, and plate fixation.

A study by Fazal et al[9] reported a 100% rate of union after treating displaced distal clavicle fractures, with minimal postoperative complications, using a temporary coracoclavicular screw. Similarly, Zhang et al[15] reported successful fixation of fractures in patients treated using locking plates or hook plates, without difference in union rates and constant shoulder scores. At 6 months postoperatively, complications of the locking-plate group included 1 loss of reduction and 1 nonunion; hook-plate group, 2 losses of reduction, 3 symptomatic hardware, 1 nonunion, and 1 hardware failure. Similarly, Klein et al[16] compared fixation of hook plates and use of locking plates augmented with fixation of sutures in the CC ligament. Functional outcomes of patients were similar, although more complications were reported with use of hook plates, which required removal of the implant. Finally, Tiren et al[17] reported a 96% rate of union at 5-year follow-up in 28 patients with distal clavicle fractures treated using hook plates. Complications associated with use of the hook plate included shoulder impingement, arthrosis of the AC joint, and subacromial osteolysis that resolved after removal of the plate. At our institution, severe fractures are commonly treated using hook plates (Figures 1A through 1C).

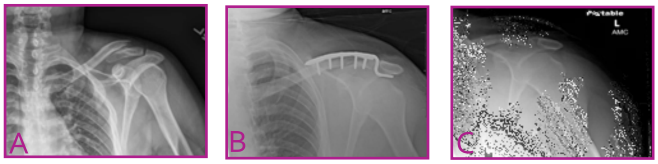

Figure 1. Radiographs of a 21-year-old man with a distal clavicle fracture resulting from a collision on a mountain bike, showing anteroposterior-view progression of operative treatment using hook plates. (A) Preoperatively. (B) Intraoperatively, with the hook plate fixed onto the clavicle. (C) Postoperatively, with successful healing after removal of the hook plate.

Separation of the Acromioclavicular Joint

To help choose effective treatment of AC joint separations, physicians often use the Rockwood[18] classification to identify specific types of injury. These categories, ranging from types I through VI, describe damage to the CC ligaments, AC ligaments, and deltopectoral fascia. Types I, II, and III are typically treated nonoperatively, whereas operative techniques can be effective in successfully treating types IV, V, and VI joint separations of the AC.

Rockwood Classification

The Rockwood classification has been commonly used in describing AC joint separations. In type I injuries, radiographs do not show signs of the injury; the distance of the CC ligament is between 1.1 to 1.3 cm; AC ligaments are sprained; the CC ligaments and deltopectoral fascia are intact; and deformities are not visible, although the patient may be tender to palpation of the shoulder. In type II injuries, the distance of the CC ligament is displaced by a maximum of 25% compared with the uninjured shoulder; AC and CC ligaments are disrupted and sprained, respectively; and the deltopectoral fascia is intact. Type III classifications include displacement of the CC ligament by 25%; disruption of the AC ligament, CC ligament, and deltopectoral fascia; and possible reduction of the AC joint by applying upward force at the elbow. Types IV and V injuries also involve disruption of the AC ligaments, CC ligaments, and deltopectoral fascia. Specifically, in type IV separations, posterior displacement of the clavicle into the trapezius muscle can be noted in radiographs with axillary-lateral views. Type VI injuries typically include decreased distance of an intact CC ligament, with disruption of the AC ligament and deltopectoral fascia.

Nonoperative Treatment

Nonoperative treatment of Rockwood types I and II injuries typically involves use of a sling for 1 to 2 weeks, with gradual increase of shoulder motion and avoidance of sports-related activities and heavy lifting for 3 months. However, no gold standard exists for treatment of type III separations.

A systematic review by Korsten et al[19] reported no difference in objective shoulder function between conservative and operative treatment of patients with type III injuries. A higher complication rate was noted with the operatively treated group, yet the resulting cosmesis between the two groups was similar, with presence of a prominence or operative scar, respectively. No conclusive evidence was noted for treatment recommendations. Furthermore, Press et al[20] discussed treating type III separations and reported similar treatment outcomes between operative and nonoperative methods at 32-month follow-up. Additionally, a case report by Watson and Wyland[21] found a full return to sports-related activity in a high school-aged baseball pitcher, with proposed play in college after successful nonoperative treatment of a type II AC joint separation and an extensive rehabilitation period.

Operative Treatment

Joukainen et al[22] found no functional difference between operative (using two transarticular K-wires and suturing of the AC ligament) and nonoperative treatments of types III and V separations; however, the operatively treated group showed fewer presences of prominence at the AC joint. Development of arthritis and calcification of the AC joint and CC ligament, respectively, was equal between the two groups at 20-year follow-up. On the other hand, Struhl and Wolfson[23] described promising results after performing a clavicle-to-coracoid procedure using an endobutton and imbrication of the AC capsule, with repair of the deltopectoral fascia and CC ligament. At 5-year follow-up, a mean distance of the CC ligament was noted at 1.1 cm.

One study[24] reported a postoperative complication rate of 27% after anatomical fixation of the CC ligament using cortical buttons and tendon allografts. Complications included fracture of the coracoid, ruptures of allografts, hardware failures, loss of reduction, signs of pain resulting from the hardware, and fracture of the clavicle. The ability to successfully maintain reduction of the AC joint in all patients was reported at 86% at 12 months postoperatively.

Yoon et al[25] compared fixation techniques using hook plates or ligament reconstruction for treating temporary, unstable AC joint separations. Postoperative results were not significantly different, yet findings of long-term follow-up indicated that the the hook plate improved possible reduction of the AC joint (ie, distance of the CC ligament reduced by 106% and 134% in hook-plate and ligament-reconstruction groups, respectively). Overall results of using a hook plate were more promising, despite performing implant-removal procedures for preventing subacromial erosion that occurred in 37.5% of patients. This outcome may be caused by implant removal at nearly 8 months postoperatively and can be avoided by successful initial placement of the hook plate (Figures 2A and 2B).

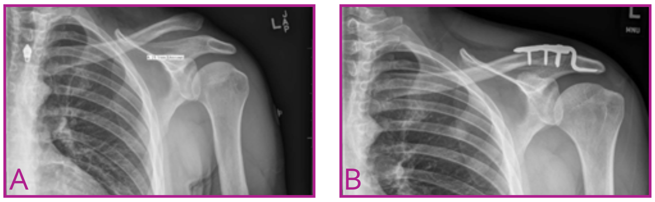

Figure 2. Radiographs of a 16-year-old soccer player, who fell onto his left shoulder, which show anteroposterior views. (A) Preoperatively, showing signs of a type V separation of the acromioclavicular joint, with the distance of the coracoclavicular ligament displaced at greater than 100%. (B) Postoperatively, showing successful fixation with use of hook plate.

Osteolysis

In identifying osteolysis of the distal clavicle, a study by Cahill[3] reported that 46 of 47 patients with osteolysis were weight lifters, whereas Scavenius and Iversen[26] reported that 28% of weight lifters had osteolysis and associated signs of pain, swelling, and tenderness at the shoulder. Findings of radiographs included osteopenia, subchondral lysis, cysts of the distal clavicle, and an intact acromion. Furthermore, results of magnetic resonance imaging often show an increased signal on T2 and STIR (short T1 inversion recovery) sequences with osseous fragments, irregularity, and presence of fluid in the AC joint (Figures 3A and 3B). The condition is typically treated nonoperatively, with careful progression to operative techniques if initially unsuccessful.

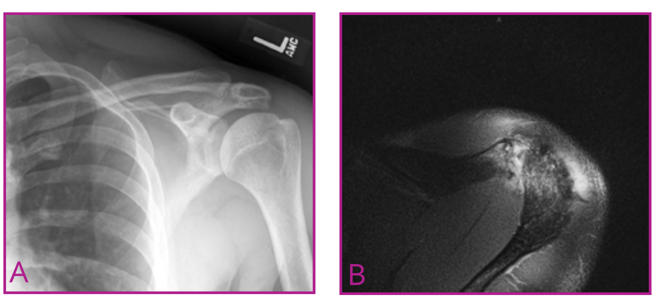

Figure 3. Imaging tests of a 22-year-old weight lifter, who presented to our clinic with worsening shoulder pain and limited shoulder activity at 1 year after initial injury. (A) Postoperative radiograph, showing anteroposterior view, with presence of osteopenia, subchondral lysis, and cysts at the acromioclavicular (AC) joint. (B) Postoperative magnetic resonance imaging, showing axial view, with osseous fragments, irregularity, and fluid noted in the AC joint.

Nonoperative and Operative Treatment Methods

Initial treatment of osteolysis of the distal clavicle can be conservative, with recommendation to modify current levels of activity. Use of corticosteroid injections may be considered to provide temporary relief of pain and can result in promising surgical outcomes after performing distal clavicle excision (DCE).[4]

Operative treatment can be performed if conservative treatment proves unsuccessful or patients cannot change their weight-lifting routines. Surgical procedures include open and arthroscopic DCE. Slawski and Cahill[27] noted successful return to activity in sports and work of 14 weight lifters who underwent open DCE. Furthermore, Zawadsky et al[28] reported similar results of treatment between arthroscopic and open DCE techniques (excluding trauma-related injuries).

Treating Osteoarthritis of the Acromioclavicular Joint

Nonoperative procedures for treating symptomatic arthritis of the AC joint include physical therapy and modification of activity levels. Additionally, use of corticosteroid injections can be therapeutic and provide a helpful diagnostic tool if signs of pain continue despite change in activity levels. When symptoms of pain persist, treatment with open or arthroscopic resections of the distal clavicle can be considered. Pensak et al[29] compared studies on open and arthroscopic DCE and noted a shorter time in returning to activities after arthroscopic treatment; however, long-term outcomes were similar between the two techniques. Unsuccessful treatment was reported with posttraumatic arthritic and workers' compensation injuries.

Concomitant Injuries

Diagnosis of AC joint arthritis occasionally occurs during evaluation of concomitant shoulder injuries, including rotator cuff tears and impingement of subacromial structures.

Operative treatment of asymptomatic AC joint arthritis, diagnosed radiographically, has not been recommended. Oh et al[30] reported no difference in functional outcomes or healing after resection of asymptomatic AC joint arthritis, using arthroscopic methods to repair rotator cuff tears. Postoperative complications of DCE included AC joint subluxation (viewed on radiographs), gross protrusion of the bone, and expressed tenderness at the AC joint. Furthermore, Park et al[31] compared results of repairing rotator cuffs with and without DCE for treating symptomatic AC joint arthritis. The study reported that 33% of patients who underwent DCE continued to experience pain in the AC joint. Additionally, treatment of isolated rotator cuff tears resulted in fewer observable symptoms of the injury, compared to treatment with concomitant injuries (despite progression of arthritis of the AC joint as seen in radiographs) in 80% of patients.

Conclusion

Operative and nonoperative methods exist for treating the various injuries and conditions affecting the distal end of the clavicle (ie, fractures, AC joint separations, osteolysis, and arthritis of the AC joint with or without concomitant injuries). Neer and Rockwood classifications of distal clavicle fractures and AC joint separations can be helpful in determining appropriate methods used for treatment.

Operative treatment is often considered in high-grade AC joint separations and distal clavicle fractures owing to high rates of symptomatic nonunion. When operative treatment of distal clavicle fractures and AC joint separations is indicated, use of hook plate fixation is the technique of choice at this institution. Despite reported complications, use of hook plates can achieve adequate reduction of distal fractures that cannot be stabilized with fixation of plates. To avoid associated hardware complications, surgeons at our institution routinely schedule removal of implants at 3 months postoperatively. Symptomatic arthritis of the AC joint can be treated similarly to osteolysis of the clavicle, including use of open and arthroscopic DCE. However, treatment of arthritis of the AC joint with concomitant shoulder injuries (eg, during repair of the rotator cuff) may not result in successful outcomes, and the decision to perform an operative procedure shoulder be given careful consideration.

Although indications for treatment are not always clear, severe injuries of the distal clavicle may be effectively treated using operative techniques. Physicians should initially explore nonoperative methods, with careful progression to operative treatment if the symptoms continue.

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Conflict of Interest

The author reports no conflict of interest.

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Splinting Method for Preventing Thermal Injuries in Patients with Malleolar Fractures of the Ankle after Operative Treatment Performed Under Regional Anesthesia

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Abstract

After performing open reduction and internal fixation (ORIF) for treating malleolar fractures of the ankle, surgeons typically use plaster splints during postoperative recovery of patients. Use of regional anesthesia during ORIF has been noted as a risk factor for burns in patients using plaster splints, possibly owing to inability to feel pain after undergoing regional block. We describe a successful postoperative splinting technique used for preventing thermal injuries in this patient population. We reviewed medical records of patients between 2011 and 2013 at our institution with malleolar ankle fractures who had underwent ORIF under general anesthesia, peripheral nerve block, or a combination of both. Patients without follow-up were excluded; therefore, 154 were included. No thermal injuries were noted, operative reduction of the fracture was maintained, and the cost of each splint was $13.19. Use of the current technique in applying plaster splints may help effectively prevent postoperative thermal injuries.

Introduction

Use of plaster splits in patients immediately after performing open reduction and internal fixation (ORIF) for treating malleolar fractures of the ankle is common and can help maintain alignment of the bone, protect the lower extremity during weight bearing, and improve the healing of soft tissues.[1] However, complications associated with use of plaster splints have included compartment syndrome owing to tight circumferential placement of the splint and pressure spots resulting in breakdown of the skin.[2] In particular, skin burns have been commonly reported in patients using plaster splints at temperatures as low as 40°C,[3-6] which result from an exothermic reaction between the plaster material and water.[7,8] Gannaway and Hunter[1] noted increased risk for thermal injuries in patients with soft-tissue injuries, compromised vascular or neural structures, and postoperative changes in the ankle.

Notably, patients placed under regional anesthesia during operative treatment have been described as at risk for thermal injuries, possibly caused by the inability to feel issues with splints owing to altered sensation in the skin, which can persist for several hours postoperatively.[2,9] At our institution, patients typically receive regional anesthesia with ORIF in an attempt to reduce high levels of postoperative pain associated with malleolar ankle fractures.[9-11] We describe use of a successful technique for postoperative splinting in preventing thermal injuries in patients with malleolar ankle fractures who had undergone ORIF under regional anesthesia.

Technique

Approval from our Human Research Review Committee was obtained for this study (HRRC #15-186). A retrospective chart review of patients who underwent ORIF for treatment of malleolar ankle fractures between 2011 and 2013 was performed. Type of anesthesia administered (ie, general or peripheral nerve block) and development of any thermal-related skin complication or loss of alignment requiring revision treatment were noted. Patients without postoperative follow-up were excluded from the study; subsequently, 154 patients were included, aged 19 to 68 years.

Before undergoing ORIF, each patient had received intravenous sedation followed by peripheral nerve block, in which sterile preparation was performed. Results of ultrasound were used to visualize the nerve to be blocked and avoid intraneural injection. Patients who would receive calf tourniquets during ORIF were placed in the supine position, in which the injured leg was elevated on a pillow and flexed at the knee. In patients for whom thigh tourniquets were planned during ORIF, patients were placed in lateral position, with the sciatic nerve visualized inferior to the gluteal fold. General anesthesia was occasionally used as an adjunct to the nerve block, depending on the judgment of the anesthesiologist, patient request, and patient comorbidities. Patients who did not receive general anesthesia received sedation analgesia in addition to the peripheral nerve block.

After each patient underwent ORIF under regional anesthesia, a splinting technique was applied on the affected lower extremity (Figure 1). One non-adherent Telfa bandage (Covidien, Mansfield, MA) was placed over the closed surgical incision. Held in place using a roll of sterile 10.2-cm (4 in) Webril, an abdominal pad was placed over the incision and another was placed dorsally across the ankle joint. The hip was flexed to allow 90° of flexion at the knee, relaxing the gastrocsoleus complex to achieve a neutral position of the ankle. A layer of bulky cotton was rolled from the tip of the big toe proximally to the tibial tubercle and secured with 14.2-cm (6 in) cotton Webril. A 10-ply strip of 12.7- by 76.2-cm (5 by 30 in) plaster was cut to the appropriate length and placed on the posterior leg, extending from 5.1 cm (2 in) distal to the popliteal fossa to the tip of the big toe. Plaster was dipped into room-temperature water and wrung to remove excess liquid. The wet plaster was placed over the cotton Webril to keep the Webril at 5.1 cm below the popliteal fossa, allowing the knee to flex. Excess plaster proximally and distally was removed with scissors. A separate 5-ply strip of 12.7- by 76.2-cm plaster (to be used as a stirrup) was dipped into water and wrung. The apex of the stirrup was centered over the plantar aspect of the foot, overlying the dorsal plaster strip. Elastic bandages of 10.2 and 14.2 cm were used to cover the distal and proximal aspects of the splint, respectively. The splint was held in place until the material hardened, with the ankle in a neutral position. The leg remained uncovered for a minimum of 30 min, elevated on a folded blanket set atop a pillow. In general, excess plaster material was removed and the plaster was never placed directly on the skin. Cost per plaster splint was $13.19.

Of the 154 patients, none were found to have thermal injuries at any postoperative visit. Additionally, none of the patients required a return to the operating room owing to loss of alignment while in the postoperative splint. Before undergoing ORIF and subsequent splinting, a total of 137 patients had received peripheral nerve block alone or a combination with general anesthesia, and 17 patients had received general anesthesia. Most patients (110) were treated at outpatient clinics, and all patients were operatively treated using a thigh or calf tourniquet (Table 1).

Figure 1. Result of the current technique used for applying a postoperative plaster splint on one of the 154 patients who underwent open reduction and internal fixation under regional anesthesia for treating malleolar fractures of the ankle. Notably, excess plaster material was removed (ie, not folded back on itself) and the plaster was not placed directly on the skin.

Table 1. Demographic and clinical variables for 154 patients who underwent open reduction and internal fixation with anesthesia for treating malleolar ankle fractures between 2011 and 2013

Variable	Patients (n = 154)
Male	87
Female	67
Location of operative treatment	
Inpatient clinic	44
Outpatient clinic	110
Type of anesthesia administered	
General anesthesia	17
Peripheral nerve block	57
Combination of both	80
Placement of tourniquet	
Thigh	134
Calf	20
Anatomical structure treated	
Lateral malleolus	31
Medial malleolus	28
Medial and lateral malleoli	55
Syndesmosis	7
Lateral malleolus and syndesmosis	20
Medial malleolus and syndesmosis	2
Medial and lateral malleoli and syndesmosis	6
Medial, lateral, and posterior malleoli	3
Medial, lateral, and posterior malleoli and syndesmosis	1
Lateral and posterior malleoli	1

Discussion

Use of a plaster splint in patients who underwent ORIF for treating malleolar ankle fractures is common and has been shown to help improve postoperative function of the injured ankle.[1] However, complications such as burn-related injuries to the skin have been noted, and risk indications such as patients who underwent regional anesthesia during ORIF have been discussed.[2,9] In the current study, a total of 154 patients administered regional anesthesia during ORIF were successfully treated postoperatively using the described plaster splint technique, in which no patient developed burns or loss of alignment of the bone.

More recently, an in vivo study reported significant increases in skin temperature after exposed to prolonged periods in plaster splints, which may emphasize the importance of technique used in minimizing risk for thermal injury.[12] Studies have described technical variables that affect skin temperature, including plaster thickness and orientation, amount of cotton used in the plaster, and use of pillows and blankets.[13] Notably, in the current study, excess plaster material was removed (ie, not folded back on itself) and the plaster was not placed directly on the skin.

Results of the current study may reveal use of a safe and cost-effective technique for applying postoperative plaster splints to prevent thermal injuries in patients who underwent ORIF and received peripheral nerve block.

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Conflict of Interest

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Predicting Vancouver Types B1 and B2 Periprosthetic Fractures of the Femur

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Abstract

Background: Periprosthetic fractures of the femur after primary total hip arthroplasty (THA) can be complex and difficult injuries to treat. Because of the increased prevalence of THA, an overall increase is anticipated in the incidence of this complication. Vancouver types B1 and B2 periprosthetic femur fractures (defined as fractures around or just below the stem, with well-fixed and loose femoral stems, respectively) are particularly challenging to accurately classify and thereby treat owing to the difficulty in interpreting stability of stems on initial radiographs. To determine whether the method of stem fixation (ie, cement or press fit) may be a predictor of types B1 and B2 fractures, we performed a PubMed search and independently assessed data from 11 studies with 293 patients.

Methods: Studies were included that provided individual patient data (ie, fracture type, method of stem fixation, and stability of stem at the time of revision procedure). Only patients with Vancouver types B1 and B2 fractures were included. Statistical analysis was performed using a random-effects model, estimated with a restricted maximum likelihood method.

Results: A total of 59 and 92 cemented stems were found to be loose and well fixed, respectively (39% and 61%, respectively; n = 151). A total of 17 and 63 uncemented stems were loose and well fixed, respectively (22% and 78%, respectively; n = 80). The overall estimate of the odds ratio was 0.96 (95% confidence interval, 0.86–1.06).

Conclusions: Our findings suggest that fixation method of stems cannot significantly predict the likelihood of having Vancouver types B1 and B2 fracture patterns.

Introduction

Periprosthetic fractures of the femur are relatively uncommon complications, with occurrence rates between 0.1% and 3.5% after primary total hip arthroplasty (THA). Patient mobility and level of activity after THA have increased notably in the past decade.[1] This and the growing number of THA performed for treating the aging population of the United States[2] have resulted in an increasing incidence of periprosthetic fractures noted in recent studies.[2,3]

These fractures are typically classified using the Vancouver system, which is based on the radiographic characteristics of fractures and stability of the femoral stem.[4] In particular, Vancouver types B1 and B2 fractures are defined as fractures around or just below the stem, with a femoral stem that is well fixed (type B1) or loose with healthy proximal bone stock (type B2).[2] Differentiating between types B1 and B2 fractures is critical because each is treated using different methods. Type B1 fractures can typically be treated with open reduction and internal fixation (ORIF) while leaving the femoral stem in place. Type B2 fractures, on the contrary, require a revision of the femoral stem. These two procedures may necessitate different setup of the surgical suite, instrumentation, and operative techniques.[6]

Both Vancouver types B1 and B2 periprosthetic fractures involve complex fracture patterns, and thus the status of stem fixation can be difficult to predict before intraoperative treatment.[3] Risks of re-fracture and stem failure have been associated with treatment of type B1 fractures and attributed to initial misinterpretation of stem stability.[2] In identifying well-fixed or loose stems and thereby successfully categorizing type B1 or B2 fracture, respectively, multiple studies have explored the use of radiographic techniques,[1] other imaging methods, and revision THA instead of ORIF when the classification remains uncertain.[2]

Because of the challenges in confirming stem stability in Vancouver types B1 and B2 fractures, surgeons must increasingly plan ahead of the treatment to confirm availability of implants and operating room staff to treat either fracture pattern. As such, a reliable radiographic indicator for stem loosening may provide invaluable data to successfully prepare for and treat these fractures. We conducted a mta-analysis of studies on periprosthetic femur fractures after THA and included data on method used for stem fixation. We hypothesized that fixation method would significantly correlate with loosening of the stem in types B1 and B2 periprosthetic fractures of the femur.

Methods

In this meta-analysis, a total of 292 articles were initially identified by searches of PubMed with Boolean modifiers of "periprosthetic femur fracture," "Vancouver classification," "Vancouver B fractures," and "cemented versus uncemented stem." Clinical research with humans and supplemental references used in prominent studies were included. We excluded case reports, duplicate titles, and studies without individual patient data on whether the stem was cemented or uncemeted, Vancouver fracture type, and stability of the stem at the time of revision treatment. After further excluding patients with fractures classified as Vancouver types A, B3, and C, we found that data for 231 patients in 11 articles met the inclusion criteria. No study directly addressed our hypothesis and compared cementation status to stem loosening (Table 1).

A meta-analysis of the odds ratio was applied to use of cemented and uncemented stems, with regards to being well fixed or loose, in which patient sample size and heterogeneity were considered. The analysis was based on a random-effects model using restricted maximum likelihood. All 11 of the studies were included in the random-effects model for computing the odds ratio. Calculations were performed using R version 3.0.1 (The R Foundation, Vienna, Austria).

Results

Vancouver types B1 and B2 fractures were noted in 155 (67%) and 76 (33%), respectively, of the 231 included patients. A total of 59 (39%) and 92 (61%) of the cemented stems (n = 151) were loose and well fixed, respectively. A total of 17 (22%) and 63 (78%) of the uncemented stems (n = 80) were loose and well fixed, respectively. Results of statistical analysis using the random-effects model produced an overall estimate of odds ratio at 0.96 (95% confidence interval, 0.86–1.06; Figure 1).

Method of treatment used was available for 166 patients (72%). Of these, a total of 101 patients (60%) underwent ORIF without revision of the femoral stem, and well-fixed stems or type B1 fractures were noted in 90 (89%). Fifty-four patients (32%) underwent a revision procedure for stem fixation. Eleven (6.6%) of the patients were treated with nonoperative management or traction for 6 weeks.

Table 1. Data of 11 studies and 231 patients that met inclusion criteria on Vancouver types B1 and B2 periprosthetic fractures of the femur[a]

First author	Total (included) No. patients	Year published, journal	Country of research	Topic or conclusion
Grammatopoulos[1]	21 (20)	2011, *Injury*	UK	Collarless stems in VB2
Zuurmond[3]	71 (40)	2010, *Injury*	Netherlands	Complications in operative treatment
Bryant[5]	10 (10)	2009, *Injury*	USA	Fixation with ORIF for treating VB1
Holley[7]	99 (45)	2007, *HSS J*	USA	Vancouver-based treatment algorithm
van der Wal[8]	14 (8)	2005, *Int Orthop*	Netherlands	Vancouver-based treatment algorithm
Buttaro[9]	14 (14)	2007, *J Bone Joint Surg Am*	Argentina	Locking compression plates in treating VB1
Old[10]	20 (20)	2006, *J Bone Joint Surg Br*	USA	ORIF without using allograft struts for treating VB1
Tsiridis[11]	18 (9)	2005, *Acta Orthop*	UK	ORIF with dynamic compression plates for treating VB1
Cooper[12]	6 (5)	2009, *HSS J*	USA	Early VB2 fractures with non-cemented stems in preoperative morphology
Leonidou[13]	27 (19)	2013, *Injury*	Greece	Poor bone quality and high fracture angle in fracture patterns
Moloney[14]	58 (41)	2014, *Arch Orthop Trauma Surg*	USA	ORIF and stem lengths in predicting VB1 re-fracture rates

USA, United States of America; UK, United Kingdom; VB2, Vancouver type B2 fractures; ORIF, open reduction and internal fixation; VB1, Vancouver type B1 fractures.

[a] Preferred method of fixation of the stem (ie, coating or using collared prosthetics) was not available for most studies and thus was not used to determine the authors' classification of the stem as loose or well fixed.

Study	Cemented Loosening	Cemented Well Fixed	Uncemented Loosening	Uncemented Well Fixed	Relative Risk [95% CI]
Buttaro	14	0	0	0	1.93 [0.27 , 13.76]
Byant	6	0	4	0	1.03 [0.72 , 1.47]
Cooper	0	0	0	5	6.00 [0.22 , 162.53]
Grammatopolous	7	13	0	0	0.71 [0.09 , 5.51]
Holley	18	18	7	2	0.64 [0.40 , 1.04]
Leonidou	7	8	4	0	0.52 [0.29 , 0.95]
Moloney	10	0	31	0	0.97 [0.85 , 1.11]
Old	13	0	7	0	1.03 [0.84 , 1.26]
Tsiridis	7	2	0	0	1.50 [0.20 , 11.00]
Van Der Wal	0	0	6	2	0.69 [0.09 , 5.12]
Zuurmond	10	18	4	8	1.07 [0.42 , 2.75]
RE Model					0.96 [0.86 , 1.06]

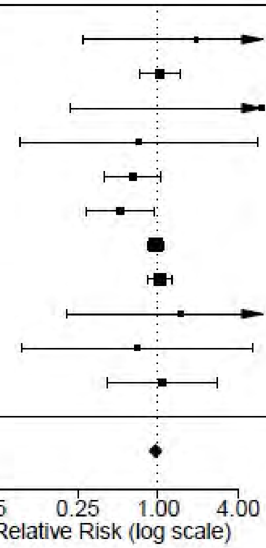

Figure 1. Results of statistical analysis using random-effects (RE) model to calculate the overall estimated odds ratio on each of the 11 studies[1,3,5,7-14] that met our inclusion criteria. Shows relative risk and indication of Vancouver types B1 and B2 periprosthetic femur fractures (classified by well-fixed and loose stems, respectively) based on the cemented or uncemented status of stems.

Discussion

The fixation method of femoral stems used during primary THA was not a statistically significant predictor for Vancouver types B1 and B2 periprosthetic femur fractures. We did note a slight trend toward a higher rate of stem stability in press-fit rather than cemented stem fixation at the time of operative treatment of types B1 and B2 fractures. These findings indicate that the femoral stem fixation method used for THA may not reliably predict the Vancouver classification of the fracture.

Reports of periprosthetic femur fractures with uncemented stems are limited, but van der Wal et al[8] found that use of larger-size uncemented stems was a possible risk factor for periprosthetic fractures owing to the greater implant stiffness. However, it was not clear how many of these fractures were iatrogenic complications of the primary THA procedure. Additionally, data on stem type and size were unavailable for our use from the studies included in this meta-analysis.

Our study has several limitations. The 11 articles used for data collection did not address the same clinical question as we did. Consequently, we could not apply consistent definitions of stem fixation descriptions such as “loose” and “well fixed.” Additionally, the studies did not delineate between iatrogenic fractures at the time of initial THA and postoperative fractures related to another mechanism of injury. Furthermore, the Vancouver classification, which was originally described for fractures about cemented stems,[4] was applied to both cemented and uncemented stems in our study. Finally, we estimated our statistical confidence interval after the presence of empty data sets to compare the studies.

We did not find a statistically significant correlation between stem fixation method (ie, cemented or uncemented) and whether the stem was well fixed or loose in treating the periprosthetic fracture around or just distal to the femoral stem. Our findings support the use of intraoperative assessment of stem stability as the more reliable method to confirm a diagnosis of Vancouver types B1 or B2 periprosthetic femur fractures, and the results also reinforce the notion that a surgeon must be prepared to treat both fracture types if otherwise uncertain. Further research into risk factors and predictors for stem stability in periprosthetic femur factures is needed to help surgeons in effectively planning treatment of these complex fractures.

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Conflict of Interest

The authors report no conflicts of interest.

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Psychosocial and Demographic Factors Influencing Pain Scores of Patients with Knee Osteoarthritis

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Abstract

Background: Noted levels of pain in patients with diagnosed osteoarthritis (OA) of the knee are commonly assessed by using a numeric scoring system. However, the results of pain levels in patients with knee OA may be influenced by factors other than the patient's actual physical discomfort or disease severity, including demographic and psychosocial variables. We retrospectively examined 355 patients with knee OA who had reported associated pain levels using a 0- to 10-point rating scale.

Methods: Data obtained from the medical records of patients were Kellgren-Lawrence (KL) grade, demographic characteristics, body mass index (BMI), concomitant disorders, drug use, alcohol use, smoking, health insurance status, knee OA treatment, and knee-surgery recommendation. Univariate and multivariate analyses determined correlation with reported pain scores.

Results: KL grade showed no correlation with pain scores ($P = 0.2$). Younger age, ethnicity, and higher BMI were significantly associated with higher scores ($P = 0.03$, $P < 0.001$, and $P < 0.001$, respectively). Native American or Hispanic ethnicity remained significant on multivariate analysis ($P < 0.001$). All psychosocial factors and other categories showed correlation, excluding diagnosis of posttraumatic stress disorder ($P = 0.2$); current opioid prescription and depression retained significance with higher pain scores ($P < 0.001$ and $P = 0.002$, respectively).

Conclusions: To provide more effective care, clinicians should be aware that demographic and psychosocial factors may be important determinants of pain levels reported by patients.

Introduction

More than 9 million people in the United States have symptomatic knee osteoarthritis (OA),[1] with pain being the primary reason patients seek care and the leading cause of disability from the disease.[2,3] Patients who present with OA are usually asked to describe their level of pain, often by referencing a numeric rating scale. However, a discrepancy between patients' reports of their pain level and OA disease severity as assessed by radiographic studies has often been observed.[4-6] Therefore, it has been suggested that demographic and psychosocial factors may influence pain reports.

Factors that have been assessed for their possible relation to reports of OA-associated pain include age, sex, body mass index (BMI), race/ethnicity, substance abuse, and psychological variables such as depression, hopelessness, overall well-being, and social stress.[4,7-10] The results of such correlation studies have varied, however, and some factors that may affect pain-level reports have not been examined.

Because little research has been done on a possible link between patients' reported pain levels and clinical decision making, we examined possible correlation between pain score and severity of OA as assessed radiologically with use of the Kellgren-Lawrence (KL) classification system,[11] as well as several demographic and psychosocial characteristics. We posited that demographic and psychosocial variables would correlate with patients' reported levels of pain.

Methods

We received approval from our Human Research Review Committee (HRRC #13-523). We retrospectively reviewed the medical records of 611 new patients who presented to our orthopaedics clinic and received a primary diagnosis of knee OA between January 1, 2013 and December 31, 2013. In each case, the diagnosis was confirmed by an evaluation of the patient's medical history, a physical examination, radiographic studies, or a combination of these methods. Patients with a concurrent ligamentous injury, inflammatory arthritis, or bilateral knee OA were excluded from the study; therefore, a total of 355 were enrolled.

The record review obtained the following data for each patient: age; sex; race or ethnicity (self-reported by patient checking a box on intake form); BMI; current tobacco, alcohol, and illicit drug use (both illegal drugs and overuse of legal drugs); current prescription for an opioid, gabapentinoid, or antidepressant agent; current diagnosis of depression, fibromyalgia, or posttraumatic stress disorder (PTSD); health-insurance status (yes or no); previous injection of a corticosteroid agent or hyaluronic acid in the affected knee; and whether the patient's clinician recommended surgical treatment of the knee OA during the initial presentation. Information on smoking, alcohol, and illicit drug use was obtained with a self-report intake form that did not allow specification of the level of use or the type of illicit drug.

Outcome measures included self-reported pain scores and radiographs. At their initial presentation, all patients had been asked to describe their pain level with respect to a number from 0 to 10, with 0 representing "no pain" and 10 "the worst pain imaginable." This numeric scale is commonly used to assess arthritic pain.[12] At the time of the medical-record review, radiographs obtained during the initial patient visit were assessed by a musculoskeletal radiologist who was blinded to all patient information in the records, including pain scores. The radiologist assigned each image a KL grade of 0, 1, 2, 3, or 4 on the basis of the extent of degenerative changes observed.

In estimating the appropriate sample size for the study, we assumed that most clinicians would consider a difference in pain score of 2 to be clinically important and we wanted to limit the Type I error to 0.05 or lower and achieve a power of 90%. Because we anticipated simultaneous analysis of up to 22 independent variables, we used a Type I error of 0.002 (on the basis of the Bonferroni inequality). Under these assumptions, we calculated that the study should include about 310 patients.

Standard summary statistics were calculated for all variables. Univariate analysis was used initially to assess the possible relation between pain score and each independent binary variable studied. The Student t-test or Mann-Whitney test was applied as appropriate. Analysis of variance was used to examine the possible relation between pain score and each of the following: age, BMI, race or ethnic group, and KL grade. A P value of less than 0.05 was considered to indicate a statistically significant difference.

Multivariate analysis was performed by using a general linear model algorithm and maximum-likelihood estimation. Variables that were significantly associated with pain score in the univariate analysis were sequentially fitted into the model with use of adjusted R^2 analysis. The variables were removed sequentially until only those that had a significant relation with pain score remained in the model. All statistical analyses were performed with Statgraphics Centurion XV software (StatPoint, Herndon, VA).

Results

Table 1 shows characteristics of the 355 patients in the study. The overall mean (SD) pain score was 5.0 (2.9), whereas the most common KL score was 3, indicating moderate OA. KL grade was one of the three variables not related to reported pain scores ($P = 0.2$; Figure 1).

The mean pain scores (SD) according to KL grade were 4.33 (1.89) for grade 0, 4.93 (0.84) for grade 1, 4.70 (0.63) for grade 2, 4.89 (0.54) for grade 3, and 5.74 (0.65) for grade 4.

The patients ranged in age from 24 to 90 years. Most of the patients were white women, but our cohort was also diverse in that Native American and Hispanic patients each comprised more than 10% of the total. Average BMI was 31.0 kg/m^2 (range, 19.1–61.9 kg/m^2). The mean pain scores in white, Native American, Hispanic, "other," and black patients were 4.5 (3.0), 6.3 (2.7), 6.4 (2.5), 4.7 (3.1), and 5.8 (2.8), respectively. The "other" category included two patients who indicated that they were Asian and 27 who reported that they were "other" than white, Native American, Hispanic, or black.

On univariate analysis, age had a significant inverse relation to pain score, with younger subjects having significantly higher scores ($P = 0.03$). Sex of the patient was not related to pain score ($P = 0.2$). Compared with white patients, Hispanic or Native American patients had significantly higher pain scores ($P < 0.001$ for both comparisons; Figure 2), but there were no other significant differences among racial or ethnic groups. Patients with higher BMIs also had higher pain scores ($P < 0.001$). On multivariate analysis, Native American or Hispanic ethnicity remained in the model, indicating a significant relationship with pain scores ($P < 0.001$).

With respect to binary variables of psychosocial factors (Table 2), patients with a current opioid prescription, depression, fibromyalgia, illicit drug use, current antidepressant or gabapentinoid prescription, uninsured status, and smoking had significantly higher pain scores than those without these characteristics. Patients who said that they drank alcohol had significantly lower pain scores than those who said that they did not. Diagnosis of PTSD

Table 1. Demographic and clinical variables for 355 patients with knee osteoarthritis[a]

Variable	Value[b]
Mean age, y (SD)	58.6 (11.8)
Male	139 (39)
Female	216 (61)
Mean BMI, kg/m^2 (SD)	31.2 (7.3)
Ethnicity[c]	
White	191 (64.7)
Native American	35 (11.9)
Hispanic	30 (10.2)
Black	10 (3.4)
Other	29 (9.8)
Comorbidities/insurance/history	
Current smoking	56 (15.9)
Alcohol use	157 (46.6)
Illicit drug use	18 (5.4)
Opioid-agent prescription	75 (21.6)
Gabapentinoid prescription	43 (12.4)
Antidepressant prescription	84 (24.2)
Depression	94 (27.1)
Fibromyalgia	22 (6.4)
Posttraumatic stress disorder	7 (2.0)
Health insurance	318 (91.4)
Previous knee injection	110 (32.3)
Surgery recommended by clinician	59 (16.8)
Kellgren-Lawrence grade[d]	
0	9 (2.8)
1	46 (14.2)
2	82 (25.4)
3	110 (34.1)
4	76 (23.5)

BMI, body mass index.

[a]There were no significant differences between the groups.

[b]Values represent number of patients (percentage of the indicated group), unless otherwise stated.

[c]Race or ethnic group was self-reported.

[d]A Kellgren-Lawrence grade of 0 (no osteophytes or joint-space narrowing) indicates no osteoarthritis; a grade of 1 (questionable osteophytes), possible osteoarthritis; a grade of 2 (definite osteophytes, no joint-space narrowing), mild osteoarthritis; a grade of 3 (≤ 50% joint-space narrowing), moderate osteoarthritis; and a grade of 4 (≥ 50% joint-space narrowing), severe osteoarthritis.

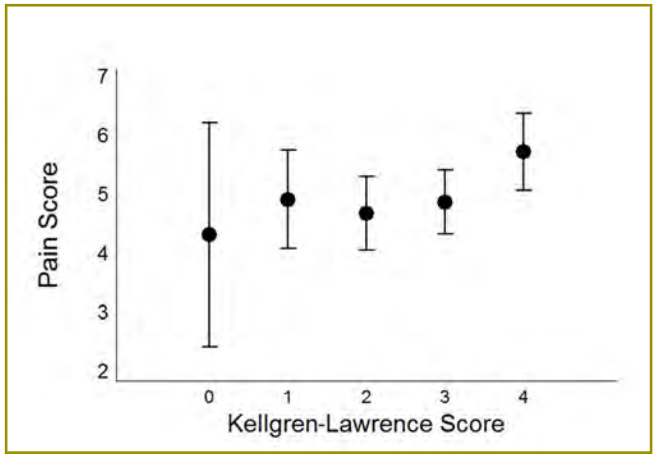

Figure 1. Mean knee-pain scores in 355 patients with knee osteoarthritis, according to Kellgren-Lawrence grade. The error bars represent 95% confidence intervals adjusted by using the Tukey procedure for multiple comparisons. There were no significant differences between groups.

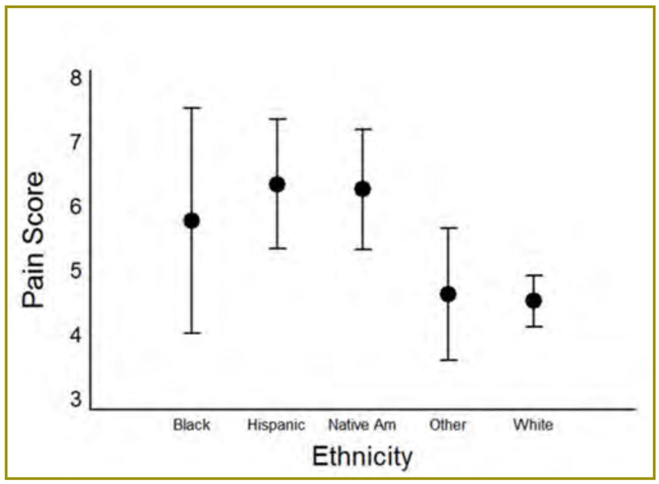

Figure 2. Mean knee-pain scores in 355 patients with knee osteoarthritis, according to patients' ethnic or racial group. The error bars represent 95% confidence intervals adjusted by using the Tukey procedure for multiple comparisons. The difference between Hispanic and white patients and between Native American and white patients was significant (P < 0.001 for both comparisons).

was not related to reported pain levels (P = 0.2). On multivariate analysis, current opioid prescription and depression were significantly related with pain scores ($P < 0.001$ and $P = 0.002$, respectively).

Pain scores also correlated with binary values of previous knee injections and surgeon recommendation for operative treatment of OA (Table 2). On univariate analysis, previous knee injections and surgeon recommendation were significantly related with pain scores ($P = 0.03$ and $P = 0.04$, respectively).

Table 2. Binary variables independently and significantly associated with pain score on univariate analysis

Variable	Mean (SD) score, 95% CI	*P* value
Opioid-agent prescription		
Yes	6.84 (2.94), 6.36-7.32	
No	4.48 (2.08), 4.13-4.83	< 0.001
Depression		
Yes	6.19 (2.52), 5.67-6.71	
No	4.58 (2.94), 4.22-4.95	< 0.001
Fibromyalgia		
Yes	6.77 (2.07), 5.86-7.69	
No	4.86 (2.93), 4.54-5.18	0.003
Illicit drug use		
Yes	6.89 (2.58), 5.60-8.18	
No	4.88 (2.91), 4.55-5.20	0.004
Antidepressant prescription		
Yes	5.76 (2.77), 5.15-6.36	
No	4.73 (2.96), 4.37-5.09	0.005
Gabapentinoid prescription		
Yes	6.14 (2.53), 5.36-6.92	
No	4.82 (2.96), 4.48-5.15	0.006
Alcohol use		
Yes	4.53 (2.73), 4.10-4.96	
No	5.36 (3.04), 4.91-5.81	0.009
Health insurance		
Yes	4.90 (2.93), 4.57-5.22	
No	6.27 (2.66), 5.27-7.26	0.01
Smoking		
Yes	5.82 (2.39), 5.18-6.46	
No	4.85 (2.99), 4.50-5.19	0.02
Previous knee injection		
Yes	5.47 (2.94), 4.92-6.02	
No	4.75 (2.92), 4.37-5.13	0.03
Surgery recommended by clinician		
Yes	5.69 (2.94), 4.92-6.02	
No	4.87 (2.92),4.53-5.20	0.04

CI, confidence interval.

Discussion

Many of the factors analyzed have not, to our knowledge, previously been correlated with pain score: Hispanic or Native American ethnicity, age, opioid prescription, fibromyalgia, illicit drug use, antidepressant prescription, alcohol use (inverse relation), gabapentinoid prescription, health-insurance status, smoking, previous knee injections, and recommendation for surgical versus nonoperative treatment of knee OA. In the current study, KL grade had no significant relationship with reported pain scores. This discordance has been seen in other studies.[4-6] Our findings may reflect another manifestation of a difference in health perception, or just differences in communication and reporting of pain and symptoms.

Demographic factors such as age, sex, ethnicity, and BMI that may influence reported pain levels have been somewhat explored in other studies. Interestingly, although the prevalence of knee OA increases with age, pain scores were significantly higher in our study's younger patients. In agreement with earlier findings,[7,8] the sex of the patient was not correlated with pain scores.

Earlier studies that examined a possible link between knee OA-associated pain and race/ethnicity included only black and white patients and provided evidence that black patients reported higher pain scores than white patients.[4] One of the few studies of the rheumatic disease experience to include Hispanic patients found that global estimates of their health were significantly poorer compared with physicians' estimates.[13] In our study, we found no differences between black and white, black and "other", or white and "other" patients, although it is important to note that we included only a small number of black patients. Additionally, findings may have been due to more demanding occupational tasks, higher rates of depression and emotion-focused coping rather than problem-focused coping, all of which have been suggested to explain higher knee-OA pain in black patients.[14,15]

Studies of arthritis-associated pain in Native Americans are scarce; however, in an investigation by Kramer et al[16] in which face-to-face interviews were conducted with 56 Native Americans living in an urban area, most interviewees commented on their cultural practice of minimizing pain complaints and reported that American Indians do not readily discuss pain. Because our multivariate analysis accounted for possible confounding factors, including age and obesity, this discrepancy may have resulted from differences in patient population. Nevertheless, both our study and that of Kramer et al indicate the importance of clinician awareness of possible ethnic-group differences in reporting their OA pain experience.

Obesity, a known risk factor for development of OA, has been linked to an increased severity of OA-related pain, although Somers et al[17] found that BMI was not correlated with pain scale scores. Our results show that patients with higher BMI were significantly more likely to have higher knee-pain scores. Clinicians counseling obese patients with OA knee pain should consider suggesting weight loss as a possible method for alleviating pain.

The association between a current opioid agent prescription and higher pain scores may have been due to neuromodulation of pain sensitivity from chronic opioid use.[18,19] Although possible that some of our patients with an opioid prescription reported greater pain as a manifestation of drug-seeking behavior, the differences in pharmacodynamics and opioid receptor interactions as well as the bioavailability of a particular opioid dose in one patient versus another likely plays an important role in whether patients are getting sufficient pain relief. The use of a pain-assessment instrument that evaluates patients' functional abilities[20] might be useful when pain assessment is unclear.

Previous studies found that depression affects reported pain in patients with rheumatoid arthritis,[21] and an influence of depression on pain severity in patients with OA has been suggested.[6,22] The higher reported pain scores might reflect pain catastrophizing, which is a tendency to focus on negative pain sensations, thereby exaggerating the pain experience and enhancing feelings of helplessness.[23] It was previously shown that depression can lead to increased pain through pain catastrophizing in patients with musculoskeletal conditions,[24] and pain catastrophizing has been linked to higher pain scores in patients with OA.[25]

The association between current prescription for an antidepressant or gabapentinoid agent and higher pain scores may reflect the presence of a general chronic pain experience, as these agents are commonly prescribed for chronic pain. Although the relationship with antidepressants may simply reflect a link between chronic pain and depression,[26] it is also possible that the reported pain scores in patients prescribed these agents is instead a characterization of neuropathic pain, fibromyalgia-associated pain, or another form of chronic pain.

In terms of age, younger adults with OA have been shown to have higher rates of depression and depressive symptoms than older adults with the disease.[27,28] In addition, life stress and hypochondriasis, which are associated with higher pain scores, are more prevalent in younger people.[10]

Pain catastrophizing similar to that which can occur in patients with depression has been shown to be a prominent clinical symptom of fibromyalgia[29] and may explain the higher knee-pain scores in our patients with the disorder. Cognitive behavioral therapy aimed at reducing catastrophizing in patients with fibromyalgia has been observed to produce better outcomes than pharmacologic therapy.[30] Psychotherapy may be an effective approach to pain along with pharmacologic or surgical treatment in patients with a diagnosis of both OA and fibromyalgia or depression.

Earlier studies failed to show an association between knee pain from OA and behaviors such as substance abuse and smoking.[7,8] Our results suggest that it may be appropriate for clinicians to counsel patients that cessation of smoking and illicit drug use, aside from its numerous other health benefits, may help alleviate OA-related pain.

The association between higher pain scores and uninsured status is probably related to socioeconomic status because OA pain and symptomatic knee OA have been correlated with lower income levels[7] and the poverty rate in a community,[31] respectively. In addition, "feeling helpless" has been found to constitute an important determinant of higher pain scores,[8] and patients without health insurance may have an increased tendency to experience this feeling, perhaps accompanied by a feeling of disenfranchisement.

The reason for the relation between pain-level reports and previous knee injections or a recommendation for surgery is unclear. Perhaps clinicians had an increased tendency to recommend a more invasive therapy to patients with more pain. However, some patients may have inflated their pain scores because nonoperative management had not provided sufficient pain relief and they wanted to be considered candidates for surgery. The prospect of surgical treatment was previously found to instill hope in some patients with knee OA.[32]

Our study had the usual limitations of a retrospective, observational investigation. In addition, there may have been interactions among the variables assessed that our study design could not identify. Some factors not examined, such as whether the patient was currently involved in a workers' compensation evaluation, might have influenced pain-score reports. Additionally our study had a small number of black patients, with a large percentage of Hispanic and Native American patients. This unique ethnic distribution, however, is a reflection of our state's composite population. Finally, the pain-evaluation method that was used was a simple numeric rating scale. This assessment can be administered quickly, but it may not sufficiently characterize a patient's pain experience.

Our results indicate that psychosocial and demographic factors significantly affect patients' reports of their level of OA-related knee pain and that patients with OA do not constitute a homogenous group for which the same management approaches will suffice. The usefulness of a pain assessment based primarily on a numeric pain score is of variable utility, and extensive reliance on such an assessment in clinical decision-making may be inappropriate, especially when invasive procedures are being contemplated. Moreover, pain-treatment decisions should not be based primarily on KL grade, but the entire patient presentation. Clinicians who are aware of the various psychosocial and sociodemographic characteristics that affect their patients' reports of OA-related knee pain may provide more effective, patient-centered care.

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Conflict of Interest

The authors report no conflicts of interest.

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Estimation of Simulated Blood Loss by Orthopaedic Residents Before and After Brief Training

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Abstract

Background: Accurate estimation of blood loss (EBL) may be helpful for patient safety during certain operative procedures; however, medical students and residents are rarely instructed in EBL. In a series of two tests, we attempted to reveal any significant improvement in accuracy of EBL after a brief training session.

Methods: Fourteen orthopaedic residents were recruited. Participants estimated the amounts of simulated blood before and after a training session that involved a visual of 110 cm^3 of the spilled fluid. Three volumes of 50, 237, and 531 cm^3 of simulated blood were spilled on a lap sponge, blanket, and trash bag, creating nine stations total for estimating blood loss.

Results: The EBL for each surface was inaccurate, particularly on the absorbent material (ie, sponge and blanket). Of the 126 initial estimates, a total of 13 (10%) were within 20% of the true value. After a brief training session, a total of 43 estimates (34%) were within 20% of the true value spilled. Individual estimates maintained a wide range in both tests.

Conclusions: Although EBL is a difficult skill to learn, training may result in significant improvement of accuracy. Healthcare professionals should be aware of the complications in estimating blood loss and possible benefits of formal instruction.

Introduction

Intraoperative estimation of blood loss (EBL) may be important for patient safety. Hematocrit values can be poor indicators of short-term blood loss, whereas accurate EBL helps guide fluid resuscitation and transfusion. EBL can be especially useful in treating pediatric patients with low blood levels and possible blood-level shifts after operative procedures involving higher potential blood loss and risk of cardiovascular disease. Additionally, accurate EBL may help in comparing surgical and pharmacological techniques for reducing short-term intraoperative blood loss.[1]

However, medical schools and residency programs do not normally include formal training in EBL. Irrigation fluid, absorbent materials, and drying of blood can complicate intraoperative EBL. Furthermore, confusion exists on fluid amounts (eg, ounces, milliliters, and cubic centimeters). Even if surgeons are familiar with such measurements and corresponding container sizes, it is difficult to distinguish that amount of fluid when spilled on various surfaces.

We tested the ability of orthopaedic residents to estimate blood loss using methods encountered in the operating room. Because blood and fluid spread on lap sponges, blankets, and floors are different than those in containers, we hypothesized that initial EBL would be inaccurate.

Methods

Liquid with color and viscosity similar to blood was created using corn syrup, water, and red food coloring. Three volumes (50, 237, and 531 cm^3) of simulated blood were each poured onto three surfaces (lap sponge, blanket, and flat white trash bag), creating nine stations total.

Fourteen orthopaedic surgery residents in post-graduate years 1 to 5 were recruited and informed consent was given. The participants proceeded through each station and gave amount estimates (126 total) of simulated blood. This process was repeated after residents were briefly shown the appearance of 110 cm^3 of simulated blood on a lap sponge.

Results

For each station, initial mean EBL was lower than the true value spilled (Table 1). Of the 126 initial estimates, five (4%) were greater than the true value. Seven of the 13 estimates (10%) within 20% of the correct amount involved the lesser volume. For higher amounts of fluid used (237 and 531 cm^3), initial mean EBL was most and least accurate on the nonabsorbent trash bag and lap sponge, respectively.

After visual training, accuracy of EBL and number of estimates within 20% of the true value improved (Table 2). Forty-three of the 126 (34%) post-training estimates were within 20% of the true fluid volume. Forvhigher fluid amounts, half of the average estimates were within 10% of the true value. Range of estimates was great, and 21% of individual estimates was within 20% of the true fluid value. Post-graduate year of resident did not correspond to the accuracy of estimate before or after training.

Table 1. Before a brief training session, estimations (126 total) by 14 orthopaedic residents of three amounts of spilled simulated blood on three different surfaces

Surface	True value[a] (cm^3)	Mean (cm^3)	Median (cm^3)	Range (cm^3)	Within 20% of true value (%)	Underestimate (%)	Overestimate (%)
Lap sponge							
	50	25	20	5-50	29	79	0
	237	47	41	20-100	0	100	0
	531	107	82.5	30-300	0	100	0
Blanket							
	50	20	20	5-50	7	93	0
	237	116	73	20-400	0	86	14
	531	118	77.5	20-400	0	100	0
Trash bag							
	50	22	17.5	10-50	14	86	0
	237	135	77.5	30-500	29	86	14
	531	284	180	60-1000	14	93	7

[a]Actual amount of simulated blood poured on the material.

Table 2. After a brief training session, estimations (126 total) by 14 orthopaedic residents of three amounts of spilled simulated blood on three different surfaces

Surface	True value[a] (cm^3)	Mean (cm^3)	Median (cm^3)	Range (cm^3)	Within 20% of true value (%)	Underestimate (%)	Overestimate (%)
Lap sponge							
	50	68	60	40-110	57	7	57
	237	144	145.5	50-240	36	93	7
	531	319	315	50-600	14	86	14
Blanket							
	50	67	60	25-150	36	21	57
	237	364	275	100-1000	36	36	64
	531	484	300	200-2000	14	86	14
Trash bag							
	50	55	50	20-100	50	29	29
	237	259	250	100-500	36	43	57
	531	509	490.5	150-1000	29	64	36

[a]Actual amount of simulated blood poured on the material.

Discussion

Results of other studies have shown similar difficulties in estimating blood loss. Ashburn et al[2] used stage blood to study the EBL of emergency department attending physicians and residents, with only 8% of estimates within 20% of the true value present. No significant differences were noted between residents' and physicians' estimates. Additionally, Duthie et al[3] found that visual estimation of blood was inaccurate during childbirth.

In our study, improved mean accuracy but wide range of individual estimates after training concur with findings of other studies. Dildy et al[4] noted both occurring after instructing medical personnel to estimate blood loss. Moscati et al[5] educated emergency medical technicians to estimate blood loss, and the mean percent error decreased from 65% to 52% at 1 month post-training.

Limitations of this study include unmatched characteristics of the simulated blood to its true form. However, significant improvement in accuracy using real blood is unlikely because the main difficulty involved guessing the amount of spilled fluid on various surfaces. Because this is a preliminary investigation with limited participants, clinical relevance and possible improvement in accurate EBL has yet to be determined. Our findings reaffirm the importance of educating healthcare professionals in estimating blood loss.

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Conflict of Interest

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Comparison of Blood Loss Between Short-Stem and Conventional Femoral Implants in Total Hip Arthroplasty

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Abstract

Background: Although the postoperative results of total hip arthroplasty (THA) are generally successful, the standard technique and implant design have many proposed modifications. The purpose of the current study was to determine if using short-stem femoral implants minimized the intraoperative blood loss during THA when compared with conventional THA.

Methods: The medical records of patients who underwent THA using short-stem and conventional femoral implants between 2009 and 2013 were reviewed. Patients with previous surgical procedures for treating the acetabulum or proximal femur and patients without reported hematocrit levels were excluded; subsequently, a total of 53 patients for each group (short-stem or conventional implants) were included. Demographic and outcome variables were collected and analyzed for statistical significance using the Fisher exact test.

Results: No significant difference was noted in the patient mass index, preoperative hematocrit level, postoperative decrease in hematocrit level, and mean operating time between the groups. On unadjusted analysis, age, sex, transfusion rates, and blood loss were significant between the groups ($P < 0.001$, $P = < 0.001$, $P = 0.04$, and $P = 0.01$, respectively). On adjusted analysis for age and sex, no significant difference in transfusion rate was noted ($P = 0.12$ and $P = 0.01$, respectively).

Conclusions: The use of short-stem implants may not be significantly related to a reduced blood loss compared with conventional implants. However, further studies are needed to analyze the clinical significance between blood loss and implant use.

Introduction

More than 330,000 total hip arthroplasty (THA) procedures are performed in the United States annually.[1] Despite generally successful postoperative results, the standard technique and implant design have many proposed modifications, especially when used on younger patients. Use of neck-preserving, short-stem femoral implants in particular may be a potential alternative to conventional femoral stems. Results of biomechanical studies have shown that these implants can reproduce anatomical hip kinetics and may decrease risk of periprosthetic fractures.[2,3]

Short-stem implants rely primarily on metaphyseal fixation. Reports of their use in laboratory studies indicate a physiological load transfer and reduction of stress shielding through this mechanism.[4-6] Additionally, results of medium-term follow-up in younger patients with short-stem femoral components are encouraging.[7-9] Decreased thigh pain, ease of revision, and reduced rate of dislocation have been reported using short-stem implants in THA.[10,11]

However, no study to date has analyzed intraoperative blood loss for comparing the effectiveness between use of short-stem and conventional femoral implants. We reviewed the medical records of patients to determine if using short-stem devices diminished the blood loss during THA. We hypothesized that short-stem femoral implants would result in lower intraoperative blood loss and transfusion rates compared with conventional femoral implants.

Methods

Approval from our Human Research Review Committee was obtained for this study (HRRC #13-548). The medical records of patients were reviewed electronically at our university hospital for patients who underwent THA using Metha Short Hip Stem (Aesculap Implant Systems, Center Valley, PA) between 2009 and 2013. A total of 53 patients matched the search criteria and were compared with a control group of 53 patients who underwent THA using conventional femoral stems between the same years. Exclusion criteria were patients with previous surgical procedures for treating the acetabulum or proximal femur. Additionally, patients without noted preoperative and postoperative hematocrit levels were not included.

All surgical procedures were performed by the senior author, using a standard posterior approach to the hip in the lateral position. Tranexamic acid was not used in treating any of the patients.

Patient demographics in the short-stem and conventional implant groups were recorded. Outcome variables of transfusions performed, pre- and postoperative hematocrit levels, operating time, and blood loss were also noted. Measurement of postoperative hematocrit level was reported at 24 hours postoperatively. Operating time was obtained from the record of the surgical nurse at the time of operative procedure. The surgeon recorded blood loss immediately after the procedure.

The Fisher exact test was used for statistical analysis. A *P* value of < 0.05 was considered to represent a statistically significant difference between the groups treated with short-stem and conventional femoral implants.

Table 1. Demographics of 106 patients who underwent total hip arthroplasty using conventional or short-stem implants

Variable	Patients with conventional implants (n = 53)	Patients with short-stem implants (n = 53)	*P* value
Sex			< 0.001
Male	17	36	—
Female	36	17	—
Mean (range) age, y	59.2 (31-80)	49.9 (18-60)	< 0.001
Mean (range) BMI	33.9 (19-52)	31.8 (19-45)	< 0.19
Mean (range) PHL	42.6 (34-50)	42.9 (28-51)	0.82

BMI, body mass index; PHL, preoperative hematocrit level.

Results

Concerning patient demographics (Table 1), no significant difference was noted in body mass index and preoperative hematocrit level between short-stem and conventional femoral implant groups.

However, sex and age were significant, with the patients' mean age at 9.3 years younger in the short-stem implant group compared with conventional implants. In the short-stem implant group, women had a significantly increased transfusion rate ($P = 0.02$).

Postoperative variables corresponding to blood loss are shown in Table 2. Decrease in postoperative hematocrit level and mean operating time were not significant between the groups. Transfusion rates were significant, with patients in the short-stem implant group receiving fewer transfusions ($P = 0.04$). Additionally, blood loss was significantly less for patients in the short-stem implant group ($P < 0.01$).

Adjusted statistics for age and sex were analyzed after significant differences were noted between group demographics. No significant difference in transfusion rate was identified between groups when data were adjusted for sex ($P = 0.12$) and age ($P = 0.01$).

Table 2. Unadjusted outcome variables of 106 patients who underwent total hip arthroplasty using conventional or short-stem implants

Variable	Patients with conventional implants (n = 53)	Patients with short-stem implants (n = 53)	*P* value
Transfusions performed (%)	17 (32.1)	7 (13.2)	0.04
Mean decrease in PHL[a]	26%	25.7%	0.86
Mean operating time, min	127.9	131.4	0.5
Mean blood loss, mL[b]	552.8	397.7	0.01

PHL, postoperative hematocrit level.

[a]Hematocrit levels were reported at 24 hours postoperatively.

[b]Blood loss was recorded immediately after the procedure.

Discussion

Many potential benefits have been proposed with the use of short-stem femoral implants in THA. Reports of long-term outcomes are still lacking, but early results are promising regarding level of function, wear rates, and patient outcomes.[5-7] Despite the theoretical decrease in blood loss caused by abbreviated canal preparation, we found no statistically significant difference in blood loss between the short-stem and conventional implant groups. Although we noted a difference in transfusion rates, the significance was eliminated when adjusted for age and sex. No significant difference was observed in mean operating time between the groups.

The current study has several limitations. As commonly reported, accurate measurements of intraoperative blood loss are inherently difficult. Additionally, transfusion criteria may differ depending on other patient and physician factors. Finally, because we obtained data through electronic records, any statistical significance in the demographic differences between groups was likely the result of surgeon preference. Short-stem implants were preferentially used in younger patients and mostly male patients, presumably because of a perceived increase in demand of these devices.

Despite the theoretical benefits of short-stem implants used in THA, it remains unclear whether these devices contribute to diminished intraoperative blood loss compared with conventional implants. Subsequently, prospective randomized controlled trials would be useful in addressing the limitations of bias in our retrospective review. Larger sample sizes may show a significant difference.

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Conflict of Interest

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Investigating Potential Role of Surgeons in Sternal Wire Failure by Biomechanical Tests

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Abstract

Background: Stainless steel wires are commonly used to close the sternum after cardiac-related operative procedures. However, complications have been reported associated with fracture of wires and subsequent migration into the chest cavity. The objective of this study was to biomechanically evaluate the role of surgeons in contributing to wire failure. We hypothesized that surgeons may impose damage to the sternal wire, which may be exacerbated by postoperative wire degradation and patient movement.

Methods: A biomimetic sternal model and custom test fixture simulated a median sternotomy. The sternum was closed by a fellowship-trained cardiothoracic surgeon using figure-of-eight and simple closure techniques. Closures were completed using No. 7 gauge wires made of 316 L stainless steel. Force data were collected at each costal cartilage level (six or eight levels), at each closure stage (three or two stages), for all 10 figure-of-eight and simple closures (n = 20 bones), respectively. Post hoc analysis of ultimate tensile stress in the wires determined potential for failure.

Results: The mean (SD) force for all tests was 220.5 N (59.4 N) using the figure-of-eight technique and 182.8 N (79.5 N) using the simple technique. The mean ultimate stress in the wires was 346 MPa and 286 MPa for figure-of-eight and simple techniques, respectively. We found that a significant number of observed forces exceeded the yield strength of the wire during closure (figure-of-eight, 126 of 178; simple, 73 of 160).

Conclusions: Weakened areas of the wire likely define the locations of wire fracture, initiated by the surgeon, but exacerbated by wire degradation or patient movement.

Introduction

Median sternotomy is the most common procedure performed for open-heart cardiac operations. The sternum is cut longitudinally and the sternal halves are separated to allow access to the chest cavity. After the procedure, the sternum is traditionally closed with stainless steel wires. However, numerous complications have been reported when the wires fracture, causing migration of wires into cardiac chambers, great vessels, and the abdomen.[1-10] Several studies have focused on wire degradation and corrosion or patient movement as the reason for failure of sternal wires, which has resulted in those complications.[11-18] This process may be exacerbated by wire degradation caused by long-term implantation or postoperative movement of patients.

Furthermore, during closure of the sternum, surgeons typically exert axial forces on the wire. These force-based loads may introduce mechanical stresses that exceed the yield strength of the wire material (ie, point at which the material begins to permanently deform, but not fail), thereby weakening the wire. To our knowledge, no research has examined the role of surgeons in sternal wire failure. Furthermore, no studies have quantified the axial force applied by surgeons during placement of sternal wires.

We evaluated the potential role of surgeons in contributing to wire failure by measuring axial forces applied to sternal wires. Forces were placed by a fellowship-trained cardiothoracic surgeon using figure-of-eight and simple closure techniques until appropriate approximation of sternal edges was found. We hypothesized that surgeons may impose damage to sternal wires during operative procedures.

Methods

All tests were performed using a biomimetic sternum specially designed by the manufacturer with a density of 50 pcf (Sawbones, Pacific Research Laboratories, Vashon Island, WA) and included the manubrium, xiphoid process, and costal cartilage. The model was divided midline using a bandsaw to simulate a median sternotomy.

A custom test fixture was designed to simulate sternal attachment to ribs and provide resistance to re-approximation of the bones (Figure 1). The fixture used a crossed-rail system, which allowed for lateral movement of the sternal halves during re-approximation (ie, along the y-axis) and superior-inferior positioning of the sternum for placing each closure level over the load cell during repair (ie, along the x-axis). The sternal halves were fixed to the testing apparatus through the manubrium and most distal costal cartilage. Lateral forces were applied using medium strength TheraBand, held taut before closure, to replicate the forces exerted by the pectoral muscles (The Hygenic Corporation, Akron, OH). The testing apparatus was rigidly attached to a 15-kN axial load cell for testing. An MTS FlexTest 100 controller and Basic Testware software recorded the force applied during the procedure (MTS Systems, Eden Prairie, MN).

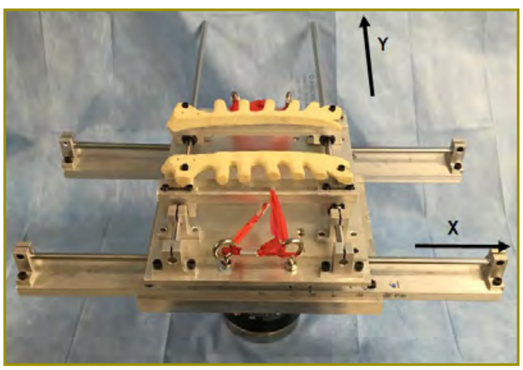

Figure 1. Experimental test setup showing sternal halves positioned in the custom designed testing fixture. A force of 15 kN is positioned under the fixture to collect data on applied axial load during closure.

The sternum was closed by a fellowship-trained cardiothoracic surgeon using six or eight wires for the figure-of-eight and simple closure techniques, respectively. All closures were completed using No. 7 surgical steel wires made of 316 L stainless steel, with ultimate tensile strength and yield strength at 515 MPa and 205 MPa, respectively (ASM Aerospace Specification Metals, Inc, Pompano Beach, FL). Placement of wires for the figure-of-eight closure began near the xiphoid process and ended at the manubrium. Placement of wires for the simple closure began at the manubrium, ending near the xiphoid process.

During testing, the data collection was segmented by stages of closure. The figure-of-eight closures had three stages: approximation, initial twist, and slack. The approximation stage involved the positioning of the wires into their appropriate locations and crossing the wires over the sternum to secure positions. The initial-twist stage included wire tensioning and an initial twist was placed in each individual wire. The slack stage involved the twisting of the wires until the sternotomy had been appropriately re-approximated. Two stages composed the simple closures: initial twist and slack. Ten full sternal closures (ie, experiments) were performed using each closure technique. Force data were collected at each level of costal cartilage (six or eight levels) and closure stage (there or two stages) for all 10 figure-of-eight and simple closures (n = 20 bones), respectively. Maximum applied axial force for each test was recorded. A one-way analysis of variance (commonly known as ANOVA) with the Tukey honestly significant difference (HSD) post hoc test was used to compare all experiments, wires, and stages for each closure type.

Results

The data for two wires in the approximation stage of a single sternum (experiment) fixed with figure-of-eight wire were not collected because of controller error, and 344 of 346 independent maximum force observations were collected for analysis (178 figure-of-eight, 160 simple). Owing to large sample size, only relevant post hoc significances were reported.

Figure-of-Eight Technique

The force (SD) for all combined tests was 220.5 N (59.4 N). Results of ANOVA testing showed statistically significant differences in force between experiments (P = 0.0001), wires (P = 0.01), and stages (P = 0.0001). Applied forces in experiments one, two, and three were lower than in all other experiments except five (Figures 2A and 2B). Applied forces for placement of wires one and two were lower than required for placement of wire six (Figures 3A and 3B). Forces applied in the initial twist stage were lower than those applied in the approximation and slack stages (Figures 4A and 4B).

Simple Technique

The force (SD) for all combined tests was 182.8 N (79.5 N). Results of ANOVA testing showed statistically significant differences in applied force between experiments (P = 0.01) and stages (P = 0.0001). Force in experiment one was lower than the measured force in experiment two. Additionally, the forces applied in the initial-twist stage were lower than those applied in the slack stage.

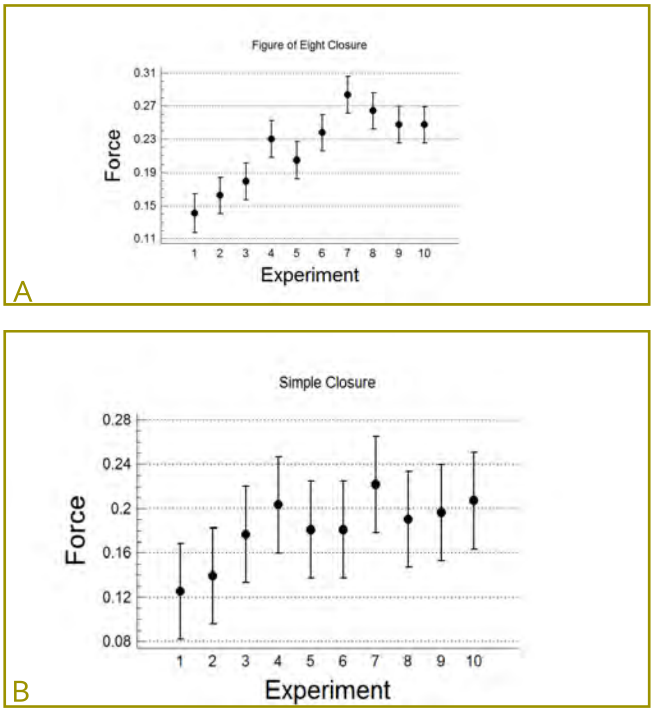

Figure 2. Means and 95.0% Tukey honest significant difference intervals of force (kN) by experiment for (A) figure-of-eight and (B) simple closures. Results include data for all wires and stages for each experiment.

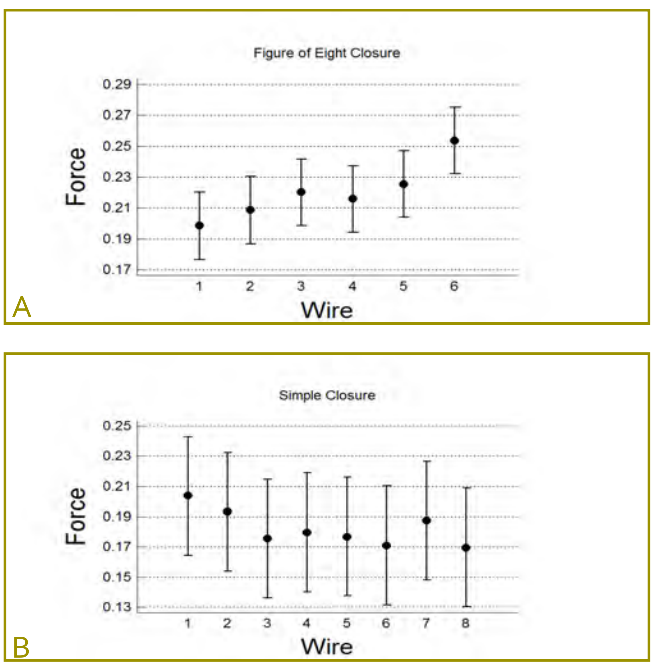

Figure 3. Means and 95.0% Tukey honest significant difference intervals of force (kN) by wire for (A) figure-of-eight and (B) simple closures. Results include data from all stages and experiments.

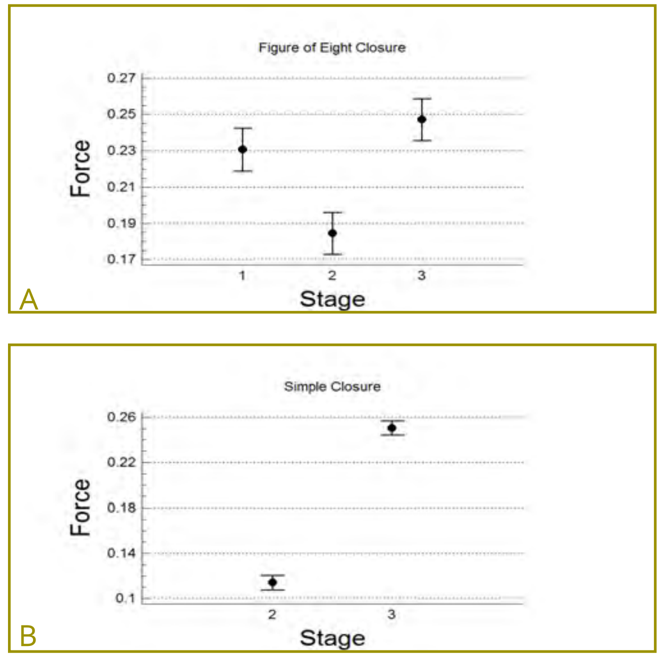

Figure 4. Means and 95.0% Tukey honest significant difference intervals of force (kN) by stage for (A) figure-of-eight and (B) simple closures. Results include all wires across all experiments at each stage.

Ultimate Stress in Wires

Knowing the maximum loads of each observation (n = 344) and the cross-sectional area of the No. 7 surgical steel wire (0.9 mm), the ultimate tensile stress applied to each wire was calculated using the following equation for uniaxial loads:

$$\sigma = \frac{F}{A}$$

$$where\ \sigma = tensile\ stress, F = instantaneous\ ultimate\ force, and$$
$$A = instantaneous\ cross\ sectional\ area$$

The mean ultimate tensile stress applied was 346 MPa and 286 MPa for figure-of-eight and simple wires, respectively.

Discussion

Significant difference was minimal in applied force by wire between techniques. Notably, wires that experienced the highest applied force were placed in the region of the manubrium. The wires placed in the manubrium passed through the bone and experienced greater resistance when being pulled tightly to approximate the sternal halves during stage three of closure. Sternal wires placed around the sternal body were subject to less friction when pulled.

In comparing stages of each technique, the slack stage required the greatest amount of force because it was the last stage of the procedure and tight approximation of sternal halves was required to prevent sternal dehiscence. The 95% Tukey HSD tests within each stage in the data collected were narrow, indicating a very consistent determination of re-approximation by the surgeon. The consistency is further demonstrated by the fact that the experiments were performed on different weeks.

The current study has several limitations. Statistically significant differences were observed in force by experiment between use of wires one, two, and three for figure-of-eight methods and wire one for simple techniques, which introduced a factor that was controlled for during testing. During the experiments, the surgeon was on the top step of a two-step stool but chose to step down to the first step for subsequent tests. He felt as if he would not be positioned so high above an actual patient when performing operative treatment. This height difference of 22.7 cm (9 in) resulted in a significant change in applied force by the surgeon, indicating that surgeon height may be a factor in the level of force and thereby the level of potential damage to the wire induced by use of the surgical technique. Height difference had less effect on the simple than figure-of-eight procedure.

Notably, in the currente study, post hoc calculation of the ultimate tensile stress applied to the wires. Mean ultimate tensile stress applied to figure-of-eight and simple wires was 286 MPa and 346 MPa, respectively. In comparison with ultimate tensile strength (515 MPa) and yield strength (205 MPa) of No. 7 stainless steel surgical wires, a significant number of observed forces exceeded the yield strength of the wire during closure (figure-of-eight, 126 of 178; simple, 73 of 160). Mechanically, any applied stresses that exceeded the yield strength of the wires were causing unrecoverable deformation to the material. These weakened areas of the wire likely define the locations of wire fracture, initiated by the surgeon, but exacerbated by wire degradation or patient movement. Further research may help investigatemclinical impact of the role of surgeons in sternal wire failure, with larger cohorts and alternative gauge wire commonly used for this procedure.

Funding

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Conflict of Interest

The authors report no conflicts of interest.

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Design of a Robotic Apparatus for Simulated Motion of the Human Hand

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Abstract

Background: The hand is complex, in that any small disturbance to the flexor tendons, extensor tendons, and intrinsic muscles can result in dysfunction of the entire structure. We designed a robotic device to consistently load a native thumb carpometacarpal (CMC) joint in assessing the effects of ligamentous damage on stability of the thumb CMC joint.

Methods: The device consisted of a mechanical plate in which to fixate a cadaveric hand, a tendon-suture routing system, a bracket to couple multiple suture lines to a cable to maintain equal force among sutures and tendons, and the finger-thumb force measurement devices. To apply force to the sutures, a cable was run from the suture coupling device to the tendon actuator and from the finger-thumb force measurement devices to the control system. The device was controlled using a Beaglebone Black microcontroller, load cells, rotary encoders, and a liquid crystal display (ie, LCD) touchscreen interface.

Results: The design worked as intended in terms of basic communication, signal processing, and control functions. Cyclic loading resulted in web creep of the tissue. Using closed-loop control, the system was able to settle to a desired load.

Conclusions: Use of the current device may result in improved understanding of joint movement within the hand, which may help surgeons in treating associated injuries. Future revisions to the device will aim to improve the hardware and software to accelerate the time to converging to the desired force and displacement.

Introduction

The hand is one of the most common sites of upper extremity injury and impairment, ranging from traumatic bone and soft-tissue injuries to chronic conditions such as joint osteoarthritis. The flexor tendons, extensor tendons, and intrinsic muscles work together in delicate balance to allow the fine movements of the fingers and thumb. Although it is clear that any small alteration in this delicate balance may lead to dysfunction of the hand, joint movement of the thumb carpometacarpal (CMC) joint is poorly understood.

Because the hand is a complex, balanced, and mechanical-based structure, reproducibility of the dynamic motion of the thumb CMC joint is difficult. To date, no studies have been successful in accurately and consistently simulating the physiologic motion of the hand in a laboratory. However, a clear understanding of joint kinematics is essential for assessing the effects of ligamentous damage and laxity on stability of the thumb CMC joint and determining possible involvement of mechanical-based instability in the development of thumb CMC osteoarthritis. Previous studies have relied on in vivo and cadaveric models to investigate possible change in metacarpal motions of the hand under loads of varying force.[1-4]

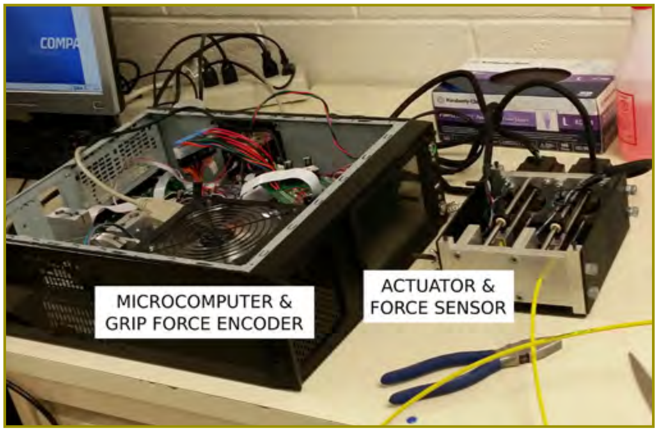
To help improve existing methods used for reproducing the motion of joints in the hand, we designed a device that uses high-fidelity measurements of the actual force of applied loads and amount of displacement to implement closed-loop control. That is, the apparatus automatically simulated the desired amounts of force and displacement.

Methods

System Architecture

The device consisted of two plates. The "dirty" plate included pulleys and components to fixate a cadaveric specimen, which could attached to an aluminum optical breadboard. Furthermore, the structure could be easily cleaned and sterilized. The "clean" plate consisted of the electronics and was located at a safe distance from contaminants. The forces generated by the actuators on the clean plate were transmitted by a standard, disposable cable wire, allowing a technically simple and low-cost operation. Cables were also used to relay the mechanical motion of a grip-force sensor (Figure 1).

A key feature of the design was its modular nature, which provided expandability in the number of degrees of freedom employed. Additionally, a single actuator could be used to apply a uniform load and displacement to more than one tendon by using one of several custom brackets that divided the actuator output.



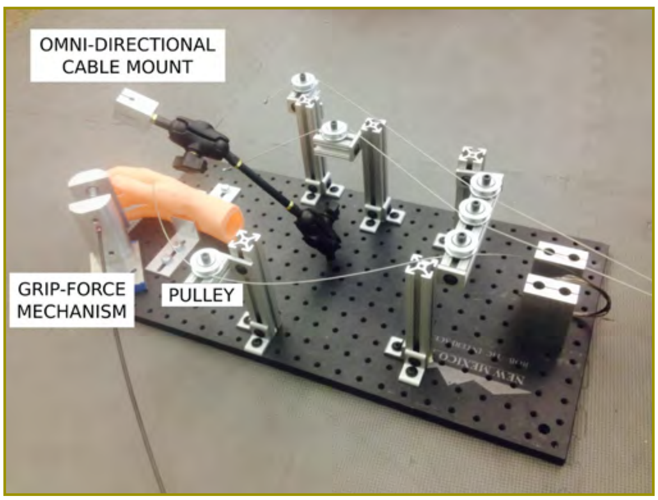


Figure 1. The designed device, capable of applying independent and uniform amounts of load and displacement to the tendon, showing two subsystems connected exclusively by disposable mechanical cables. (Top) The "clean" side, with the computer, sensors, and actuators. (Bottom) The "dirty" side, with fixture-based components and cable routers that can be sterilized.

Data Acquisition and Control Components

The electronics package consists of a standard computer power supply, a customized printed circuit board (PCB), and a BeagleBone Black (BBB) Rev. C microcomputer (Oakland Township, MI). The PCB was designed as a BBB cape and contained the motor drivers of the actuator, force-sensor filter, amplifier subsystem, and other necessary circuitry-related parts. The custom PCB and BBB allowed for a compact form factor and control of the motors, liquid crystal display (LCD), peripheral devices, and the sensors. All measurements were recorded and output as a single comma-separated values (CSV) file. The advantage of this was that recorded data could be post-processed with little difficulty.

The microcomputer (running a Debian Linux software) was controlled remotely by use of a Secure Socket Shell (SSH) connection, which can be achieved using a Universal Serial Bus (ie, USB) cable or connection to an ethernet network. The system could also be controlled using a built-in screen or a localized keyboard and mouse if an external computer and network connection were unavailable or not desired. The software ran a Graphical User Interface (GUI) built on a custom graphics framework that allowed the device to be controlled from any device that could run an X Windows server, including tablets and other handheld machines. The software and GUI framework were all programmed in the C programming language. The code and software were hosted on Github (ie, a repository hosting service for management of source codes) to allow optimal performance and testing across different platforms. Additionally, new releases of code could be easily updated to the device.

Actuator Design

The system included two actuator units. The actuators were placed outside of the computer case and chasis (ie, outer structural framework) in individual modular actuator assemblies, which each consisted of a frame, stepper motor actuator, force sensor, and bicycle cable fastening hardware. The stepper motor had the ability to pull at forces greater than 900 N (200 lb). The actuator drivers provided power to the stepper motor coils, which was provided by an amplified signal from the microcontroller. Actual force was measured using a Futek (FSH00096) load cell, with a range of 0 to 112.5 N (25 lb). In experiments targeting higher levels, alternative models of the same sensor could be used.

Results

Figure 1 shows the complete construction of the system. Basic communication, signal processing, and control functions of the device worked as designed. Preliminary efforts to calibrate the system included relating the amount of displacement of the grip sensor to the mount of force and characterizing nonlinearities in the system (eg, caused by frication and saturation of the electronic components).

Results of testing with a cadaveric specimen revealed that cyclic loading resulted in eventual elongation of the tissue, or tissue "creep." However, use of the closed-loop control allowed the system to settle to the desired load (Figure 2).

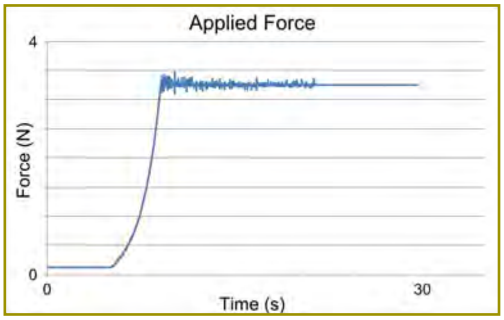


Figure 2. Data obtained from the force sensor after one actuator ramps up to a target load. Closed-loop control of the device ensures that the target load can be reached accurately.

Discussion

The current device was designed to pull at a set amount of force or displacement, which can be ideally used for testing resultant forces caused by pull of the tendons. However, owing to the mechanical operation of the device, the possible uses are not limited to biomedical-related research. Use of the device may also allow effective testing of biological tissues (eg, ligaments), investigation of non-biological filament strength, evaluation of polymer elasticity, and development of stress and strain curves.

In designing the current device, we aimed to facilitate novel research on biomechanics of the hand. The subsequent knowledge may result in improved reproducibility of cadaveric-based research, which often cannot be done in vivo. Better understanding of joint movement and ligament contribution to stability of joints may provide insight into effective methods for surgically treating patients with traumatic and degenerative conditions of the hand. Future work on the device will entail revisions of hardware and software to accelerate the time to converging the desired amounts of force and displacement.

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Conflict of Interest

The authors report no conflicts of interest.

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Diagnosis of Wolff-Parkinson-White Syndrome in a 19-Year-Old Collegiate Football Player Owing to a Routine Clinical Visit: A Case Report

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Abstract

Wolff-Parkinson-White (WPW) syndrome is a heart disorder characterized by an additional electrical pathway from the atria to ventricular chambers and episodes of tachycardia. Although the incidence of WPW is relatively low, the pre-excitation syndrome can result in sudden cardiac death, with a higher prevalence noted in younger patient populations. We present a 19-year-old male collegiate football player in whom WPW syndrome was diagnosed during a checkup at a sports-medicine clinic for a rash on his back. Radiofrequency ablation resulted in successful treatment of WPW syndrome, and the patient gradually returned to increasing levels of sports-related activity. Orthopaedic physicians should be aware of the importance in asking simple questions such as "What else can we do for you today?" to possibly reveal severe conditions that may require multidisciplinary treatment.

Introduction

Wolff-Parkinson-White (WPW) syndrome was first described by a 1930 study[1] on patients who had episodes of arrhythmia. Later research found anatomical evidence of an anomalous conducting tissue that confirmed electrocardiogram (ECG) findings of pre-excitation, including delta waves (slurred upstroke of QRS complex), short PR intervals (< 120 m/s), and abnormalities in ventricular repolarization.[2] The prevalence of ECG patterns suggestive of WPW has been estimated at 0.25% of the general population[3,4] and higher in younger patients with asymptomatic conditions.[5-7] WPW syndrome accounts for at least 1% of sudden cardiac death (SCD) in athletes, with a maximum risk of 0.45% to develop into SCD.[8,9]

Treatment options for WPW syndrome include transcatheter ablation and use of antiarrhythmic medications. Results of treatment with ablation have been about 96% successful, and 3% to 4% of patients have complications.[10] Use of flecainide and propafenone have been effective in 85% of patients who cannot undergo ablation, although side effects have been common. In patient-athletes with WPW syndrome, transcatheter ablation has been recommended for treatment because use of antiarrhythmic medications may hinder the level of athletic performance.[11]

Return to activity after treatment has depended on findings of ECG and follow-up non-invasive cardiac tests. Return to competitive sports of patients has been reported within 1 week after undergoing ablation.[11] We performed radiofrequency ablation (RFA) in a 19-year-old athlete-patient for successfully treating asymptomatic WPW syndrome. Simple questions asked during a routine visit at a sports-medicine clinic for initially evaluating a rash resulted in timely diagnosis of the disorder and subsequent multidisciplinary treatment, with a noted return to previous levels of sports-related activity.

Case Report

A 19-year-old male collegiate football player presented to our sports-medicine clinic for evaluation of a rash on his back. Pityriasis rosea was diagnosed and symptomatic treatment was administered. Before leaving, the patient was asked whether he would like to discuss anything else and revealed that he had "passed out" three times in the past year. His first syncopal episode occurred with prodrome described as "feeling hot, flushed, and dizzy" followed by quick recovery of senses. The second and third occurrences were similarly described. No symptoms of cardiac stress were noted with the episodes, which were not reported to an athletic trainer, nurse, or physician. The patient did not note any palpitations, racing heartbeat, chest pain, chest pressure, or shortness of breath.

His medical history did not include SCD, genetic heart conditions, use of pacemaker and defibrillator implants, or unexplained syncopal episodes and seizures. Vital signs and findings of physical examination were normal. An ECG was ordered from an outside facility, with laboratory tests on complete blood count, levels of thyroid stimulating hormone and free T4, and comprehensive metabolic panel. Results of the tests were within normal range, and the ECG was not yet obtained by the patient.

The patient returned to our clinic at 1 week after initial presentation and reported another episode of syncope that day followed by quick recovery after football practice. Again, no symptoms of cardiac stress were noted and findings of physical examination were normal. He did, however, have a slight viral upper respiratory infection. Because the syncope was possibly related to exercise, physical activity was limited until the patient had a complete cardiac workup.

Findings of ECG showed delta waves, short PR intervals, and T-wave inversions (Figure 1). Electrophysiological evaluation was requested and the diagnosis of pre-excitation was confirmed. An echocardiogram (echo) showed findings negative for valvular heart disease. Results of a stress test were normal, with loss of pre-excitation before peak of exercise. Furthermore, a tilt-table test was performed and results were negative for vasovagal syncope. A new echo of the patient in resting position showed a left ventricular ejection fraction (LVEF) of 46%, with a mildly dilated left ventricle, mild global hypokinesis, and no valvular or structural heart diseases. Findings of magnetic resonance imaging (MRI) were similar to the echo, with a reduced LVEF and mildly diffused hypokinesis but no evidence of fibrosis or inflammatory factors.

It was believed that reduced LVEF could be caused by viral myocarditis owing to the viral upper respiratory infection at the time of his most recent episode, or possibly resulting from prolonged periods of intense exercise. Inflammatory and infiltrative processes were not confirmed by tests on erythrocyte sedimentation rate, C-reactive protein levels, antinuclear antibody count, iron studies, serum protein electrophoresis, and urine protein electrophoresis. Results of each test were within normal range; similarly, radiographs of the chest did not reveal hilar adenopathy that is suggestive of sarcoidosis.

After re-evaluation of the patient, treatment with electrophysiologic study or RFA were recommended, which were considered safe because the shortest pre-excited PR interval measured at 250 m/s. RFA was performed, in which the accessory pathway was identified and ablated in the right anteroseptal location, without complications, despite close proximity between the pathway and the normal conduction system. After this procedure, the ECG showed normal PR intervals without delta waves.

Almost immediately after his procedure, the patient expressed feeling better. He was considerably less fatigued than in the past year, and he had no recurrent episodes of syncope or presyncope. The most recent ECG (5 weeks after RFA) showed normal levels of PR intervals without delta waves or T-wave inversions (Figure 2). Other findings of sinus arrhythmia, J-point elevation, and sinus bradycardia were consistent with symptoms of an athletic heart. The most recent echo, obtained 3 months after his previous echo, showed improvement with LVEF from 51% to 55% with mild global hypokinesis. The patient has been gradually increasing his level of activity, with an expected return to full activity.

Figure 1. Electrocardiogram of the patient at 1 week after initial presentation, showing delta waves and short PR intervals, which confirmed diagnosis of Wolff-Parkinson-White syndrome.

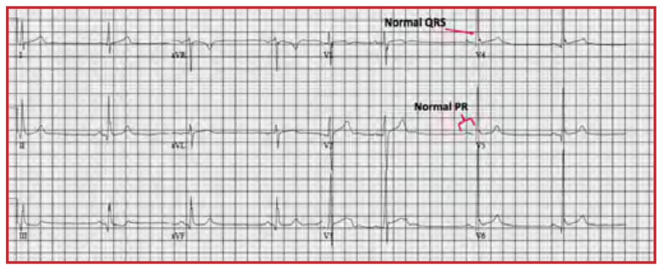

Figure 2. Electrocardiogram of the patient at 5 weeks after treatment with radiofrequency ablation, showing successful resolution of patterns suggestive of Wolff-Parkinson-White syndrome, as noted by normalized levels of PR intervals and delta waves (QRS complexes).

Discussion

The presence of pre-excitation patterns on the initial ECG should raise concerns about risk of SCD, especially in younger athletes. In the current case, diagnosis of WPW syndrome was prompted by a typical clinical checkup for evaluating an unrelated rash. Accurate diagnosis and treatment were complicated by the presence of reoccurring syncope. Notably, WPW syndrome has not typically been associated with a reduced LVEF as seen in our patient, and no case reports have described this connection. The presence of low LVEF on echo and MRI images are typically unrelated to pre-excitation patterns, but atrial fibrillation tends to occur more often in patients with reduced LVEF.

Based on possible associated symptoms and higher risk of developing atrial fibrillation in the current case, the electrophysiologic study was strongly recommended for treatment, and findings showed a high-risk pathway. RFA was successful for treating our patient, and symptoms of cardiomyopathy showed signs of recovery. The risk of SCD was minimized to compare with normal populations, and the patient resumed his physical activities without further symptoms.

The findings of the current case emphasize the importance of asking overlooked questions such as "What else can we do for you today?" to patients seen in orthopaedic clinics. Such questions may be crucial in diagnosing potentially life-threatening conditions and allowing athlete-patients to return to previous levels of sports-related activity. Because conditions unrelated to the musculoskeletal system may be noted, the complete health of the patient should be prioritized by physicians, with multidisciplinary effort for successful treatment.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and he provided verbal consent.

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Postoperative Complications in Patients with Trapeziometacarpal Joint Osteoarthritis Treated With Carpometacarpal Arthroplasty: Report of Two Cases

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Abstract

Osteoarthritis of the carpometacarpal (CMC) joint, specifically, of the thumb trapeziometacarpal (TMC) joint, is a common condition in older women. Complications associated with surgical treatment range from transient tendinitis to wrist instability. We present two patients in whom complications developed after undergoing CMC arthroplasty. In one patient, rupture of the flexor carpi radialis (FCR) was noted postoperatively after using a combination of ligament reconstruction and tendon interposition with complete trapeziectomy. The second patient presented with a flexor pollicis longus (FPL) tendon that was tethered with sutures, in which surgical release of the entrapped FPL tendon led to successful treatment. In the treatment of CMC osteoarthritis, one surgical method of treatment may not be more effective than other methods. Further studies on the long-term clinical impact of both techniques may help assess a standard method for treating TMC joint osteoarthritis.

Introduction

Osteoarthritis of the carpometacarpal (CMC) joint of the thumb, or the thumb trapeziometacarpal (TMC) joint, affects one in four women older than 45 years of age. Symptoms such as pain at the base of the thumb; decreased grip and pinch strength; "shouldering" of the thumb TMC joint in which the base of the metacarpal subluxates dorsally and radially; and adduction contracture of the first web space have been noted.[1] Although no standard method is used in TMC joint arthroplasty for treating osteoarthritis,[2-6] surgeons have been noted to prefer using a combination of ligament reconstruction and tendon interposition (LRTI) and complete trapeziectomy.[7] However, use of the technique has been noted with complications, including weakness in wrist flexion and decreased levels of grip strength.[8,9]

Subsequently, the technique of partial trapeziectomy with capsular interposition has been derived to avoid complications associated with trapeziectomy with LRTI. Use of partial trapeziectomy with capsular interposition has shown promising results with decreased risk of hyperextension of the first metacarpophalangeal (MCP) joint, decreased proximal migration of the thumb, and increase in strength of the hand.[1] We describe two patients with TMC joint osteoarthritis, one of whom underwent LRTI with complete trapeziectomy, and the second who underwent partial trapeziectomy with capsular interposition. Postoperative complications were noted in both patients.

Case Reports

Case 1

A 52-year-old woman presented to our clinic with tenderness and sensitivity over the volar aspect of the left distal forearm. At an outside facility, she had underwent CMC arthroplasty using ligament reconstruction and suspensionplasty with half of the flexor carpi radialis (FCR) tendon for treating intractable thumb basal joint pain. Decreased pain was noted until 4 months postoperatively, at which time the patient fell on an outstretched hand and re-injured her left thumb. She described feeling a pop in her wrist. The patient was evaluated at an outside emergency department after the fall, and radiographs indicated no fractures (Figure 1). A fullness developed over the volar and radial wrist region, which was very tender to touch.

Upon initial presentation to our clinic, the patient did not report hand numbness or tingling. Tenderness and sensitivity were noted over the volar aspect of the distal forearm radially. She stated that her left wrist seemed to "give out" occasionally, which caused her to drop held items. The patient also described weakness in wrist flexion. She was taking ibuprofen to help relieve pain and occasionally used a rigid brace that limited wrist movement and thereby provided some comfort.

Results of physical examination of her left wrist showed a healed incision over the first metacarpal base, without signs of infection. The grind test was negative for CMC joint osteoarthritis, and functional range of motion of the thumb was observed in the second through fifth digits. Hyperextension of the MCP joint was found with a shortened thumb compared to the uninjured thumb. Additionally, weakness in pinch and grip strengths were noted, with a fullness and tenderness to palpation over the volar aspect of the wrist on the radial side. The results of Finkelstein and Durkan carpal tunnel compression tests were negative for carpal tunnel syndrome. The hand was well perfused, with normal findings after the Allen test for arterial competency.

Magnetic resonance imaging (MRI) of the left wrist revealed complete rupture of the flexor carpi radialis, with retraction to the level of the wrist (Figure 2). The FCR tendon rupture was treated nonoperatively with observation. At final follow-up, the patient had continued weakness in pinch and grip strengths of the left hand. She described weakness of wrist flexion with less pain. The patient received anti-inflammatory medication intermittently. The fullness of the wrist and weakness persisted, but the swelling subsided. For further treatment, we recommended observation and continued use of the hand as tolerated without restrictions.

Figure 1. Postoperative radiograph at 4 months in case 1, showing anterior-posterior view of left wrist after the patient fell and re-injured her left thumb, before presentation to our clinic.

Figure 2. Postoperative magnetic resonance imaging at 4 months in case 1, showing left wrist after the patient fell and re-injured her left thumb, with complete rupture of the flexor carpi radialis and with retraction to the level of the wrist.

Case 2

A 56-year-old, right-handed woman presented to our clinic with painful degenerative osteoarthritis of her left thumb CMC joint. She had experienced worsening pain for 5 to 6 years, and her activities were limited owing to the severity of her discomfort. She reported pain when using twisting motions of the hand with force (eg, opening a jar) and putting direct pressure on the thumb (eg, holding a key). On physical examination, the patient had discomfort in the abducted position and tenderness to direct palpation of the area. She had notable shouldering of the MCP joint without numbness. Radiographs of her left hand revealed advanced arthritic changes of the thumb CMC joint (Figure 3).

After attempting nonoperative treatment, the patient returned with progression of symptoms and was scheduled for CMC joint arthroplasty with partial trapeziectomy. Postoperatively, a short-arm thumb spica splint was used, and no complications were noted. At 1-month follow-up, a short-arm thumb spica cast was applied. At 6 weeks postoperatively, the patient started using a thumb-spica brace and began receiving occupational therapy. At follow-up 8 weeks later, full active extension of the interphalangeal (IP) joint of the thumb was not possible. The thumb remained in a flexed position at about 40°. Passive range of motion in about a 20° arc of the thumb was intact, and she could oppose the thumb to the tip of each finger. Mild erythema of the incision site was noted but resolved with antibiotics.

At 3 months postoperatively, the patient presented with residual IP joint flexion contracture, with minimal improvement despite undergoing occupational therapy. She was able to flex and extend her thumb with the MCP joint hyperflexed. However, with the MCP joint extended, she could not fully extend the IP joint. Findings of MRI indicated an acutely angulated flexor pollicis longus (FPL) tethered at the carpometacarpal surgical site and the IP joint held in a flexed position (Figures 4A and 4B).

Subsequently, the surgical site was investigated and we performed tenolysis of the FPL tendon. The FPL tendon was tethered using an ethibond suture (Ethicon, Somerville, NJ). After intraoperative release of the tethered tendon, the thumb could be extended (Figure 5). After tenolysis, she was able to actively flex and extend the IP joint of the thumb to neutral position. At 4.5-month follow-up after the revision procedure, the patient was very pleased with her progress, and results of physical examination indicated promising range of motion of the thumb IP joint.

Figure 3. Preoperative radiograph in case 2, showing anterior-posterior view of left thumb, with advanced arthritic changes of the CMC joint.

Figure 4. Results of imaging tests at 4 months postoperatively in case 2, showing acutely angulated flexor pollicis longus tethered at the site of operative treatment, with the interphalangeal joint held in a flexed position. (A) Magnetic resonance imaging showing angulated flexor pollicis longus (asterisk). (B) Radiograph showing anterior-posterior view.

Figure 5. Radiograph after intraoperative release of the tethered tendon in case 2, showing anterior-posterior view of extension of thumb interphalangeal joint. After intraoperative release of the tethered tendon, the thumb could be extended.

Discussion

Many studies have reported complications associated with using a combination of trapeziectomy with LRTI, in which the FCR tendon is used as an autograft, in treating osteoarthritis of the thumb TMC joint.[8,10-12,]Furthermore, although open trapeziectomy with LRTI was cited to be the surgical treatment of preference, its complication rate has been shown to be 12% greater in comparison with a complete trapeziectomy alone.[3,4,7] Although no technique in treating osteoarthritis of the thumb TMC joint has been significantly proven as the standard method, use of complete trapeziectomy with LRTI may be a more complicated procedure that can result in increased risks of complications in patients.[2,3]

Partial trapeziectomy with capsular interposition does not require tendon harvest and therefore may avoid complications associated with tendon donor sites. The trapezium is not completely excised, negating the problem of proximal migration of the metacarpal.[1] The current report describes two cases of complications associated with surgical treatment of osteoarthritis of the thumb TMC joint. The first complication was an FCR tendon rupture after treatment with LRTI using half of the FCR tendon as an interposition graft. The second case involved a complication after use of partial trapeziectomy with capsular interposition, in which a revision procedure was prompted.

Results of using LRTI with complete trapeziectomy or partial trapeziectomy with capsular interposition were not considerably different between our patients, with complications noted in both. Further, long-term research may help assess the postoperative clinical impact of using each method.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patients were informed that the data concerning the case would be submitted for publication, and they provided verbal consent.

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Postoperative Deep Vein Thrombosis and Pulmonary Embolism after Ankle Fusion in a Patient with Hemophilia A: A Case Report

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Abstract

Deep vein thrombosis (DVT) and subsequent pulmonary embolism (PE) are uncommon postoperative complications of operative procedures for treating injuries of the foot and ankle. Because the disorder of hemophilia A prevents blood clotting and increases bleeding, patients with this condition have been even less likely to develop DVT and PE. We present a 36-year-old man with hemophilia A in whom operative ankle fusion for treating hemophilic arthropathy of the left ankle led to DVT and PE. After decreasing dosage of antihemophilic medication and administering enoxaparin, the symptoms improved and the patient was discharged from the hospital on postoperative day 5. At 3-month follow-up with continued dosage, no complications were reported. Surgeons should be aware of possible DVT and PE in patients with hemophilia A and consider multidisciplinary efforts to successfully treat the resultant symptoms.

Introduction

Deep vein thrombosis (DVT) is an uncommon complication after operative treatment of the foot and ankle, with a documented prevalence between 0.03% and 0.27% in patients after undergoing elective hindfoot fusion.[1,2] Currently, about 43% of physicians have recommended routine use of chemical thromboprophylaxis in operatively treating the foot and ankle of patients without history of DVT.[3] However, the American Academy of Orthopaedic Surgeons has no specific recommendations for DVT prophylaxis after foot and ankle procedures.[4]

In particular, DVT and subsequent pulmonary embolism (PE) rarely occur in patients with hemophilia A, an X-linked disorder of factor VIII. Patients with this condition have difficulties with forming blood clots and are thus at risk for developing spontaneous bleeding into joints, which can severely damage cartilage and result in arthritis. Owing to infrequent blood clotting, it is counterintuitive that patients with hemophilia A could develop blood clots associated with DVT and PE. We performed left ankle fusion to treat hemophilic arthropathy in a 36-year-old man with hemophilia A, which resulted in development of DVT and PE.

Case Report

A 36-year-old man with a medical history of hemophilia A presented to our institution with pain and history of bleeding in the left ankle. Previously, the patient had undergone right ankle fusion for treating severe degenerative hemophilic arthropathy, resulting in almost complete resolution of symptoms. He returned to the clinic several years later, with progressive worsening of pain in the left ankle. Radiographs obtained at evaluation showed arthritic changes suggestive of hemophilic arthropathy about the left ankle joint. Loss of joint space and signs of osteophytes were noted (Figure 1). The patient had considerable pain despite using previous nonoperative methods for treatment.

Preoperatively, the patient underwent a routine evaluation led by hematologists and oncologists. A perioperative plan for dosage of antihemophilic factor VIII (50 units/kg) was established, which included one preoperative dose in the morning and two doses per day after the procedure, with close follow-up monitoring of factor VIII levels.

A total of 5090 units of antihemophilic factor VIII was administered to the patient. He underwent ankle fusion without observed complications (Figure 2) and was after admitted to the hospital for standard care. On postoperative day 1, he began receiving doses of antihemophilic factor VIII twice per day. Initial outcomes were promising, with limited pain and no symptoms of increased bleeding in the left ankle. On postoperative day 3, labored breathing was noted and thereby oxygen levels were increased. The patient underwent a computed tomography angiogram of the pulmonary arteries, during which PE was diagnosed in the right main pulmonary artery with extension into the right-middle and lower-lobe branches. Hematologists and oncologists were consulted. Subsequently, the dosage of antihemophilic factor VIII was decreased to once a day and the patient was administered low-molecular weight heparin (ie, enoxaparin) at doses of 1.5 mg/kg for therapeutic purposes. Clinical signs of improvement were observed during the next 2 days, without further progression of symptoms. He was discharged on postoperative day 5.

Based on factor VIII levels at discharge, the dosage of antihemophilic factor VIII was reduced by 50% and the patient remained on enoxaparin for therapeutic treatment of PE. He was followed at regular intervals by orthopaedic, hematologic, and oncologic physicians. At 3 months postoperatively, symptoms of pain and PE had resolved, without any additional complications. Use of antihemophilic factor VIII and enoxaparin were discontinued.

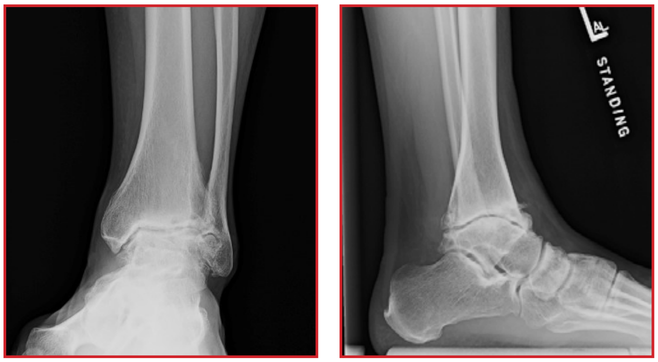

Figure 1. Preoperative radiographs of the left ankle joint, showing arthritic changes suggestive of hemophilic arthropathy, with loss of joint space and presence of osteophytes.

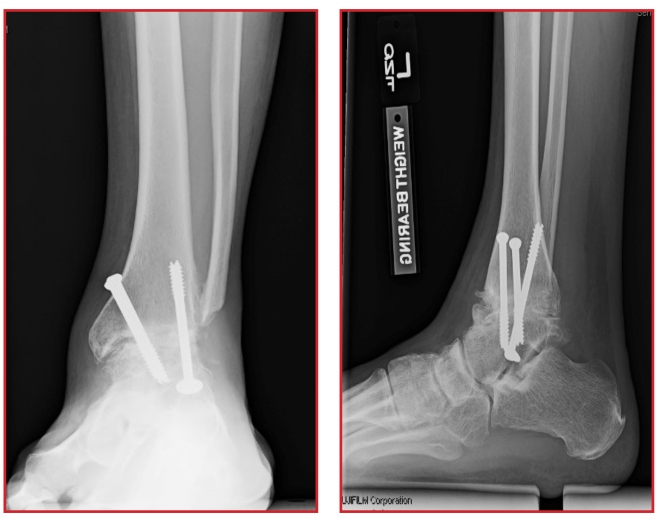

Figure 2. Postoperative radiographs of the left ankle joint obtained immediately after ankle fusion, showing initial improvement of joint space.

Discussion

Hemophilia A is characterized by a deficiency in coagulation of factor VIII, which typically results in hemorrhagic complications after operative treatment. However, the results of the current case suggest that the disorder does not completely prevent development of DVT and PE. Only 13 cases have found non–catheter-related thrombus in patients with hemophilia A, in which none involved operative treatment of the foot and ankle.[5] None of these cases involve surgery about the foot and ankle.

Patients with hemophilia A undergoing replacement therapies of factor VIII (eg, factor VIII inhibitor bypassing activity and recombinant activated factor VII) may have a closer risk factor for DVT and PE to that of the patients without the disorder. In other words, the most prevalent risk factor in patients with hemophilia A could be the presence of replacement therapies. However, the incidence of DVT and PE in patients with hemophilia A undergoing replacement therapies has been low, in which no definitive protocol exists for treating perioperative thromboprophylaxis in major hemophilia treatment centers. Previous case studies have noted that some patients may have a concomitant inheritable prothrombotic condition such as protein c deficiency or factor V Leiden.[5] In treating patients with family history of DVT and PE, Dargaud et al[6] suggested performing a complete thrombophilic evaluation of inheritable risk factors to identify potential indications for thromboprophylaxis.

No standard protocol exists for optimizing the type or dosage of anticoagulation medication using appropriate techniques for replacing clotting factors (ie, factor VIII). Additionally, consensus has not been established regarding the duration of such treatment. Reported cases suggest that low-molecular weight heparin or unfractionated heparin should be used initially for replacement of factors VIII and IX. To simultaneously achieve peak activity levels of factors VIII and IX, therapeutic dosage of heparin has been recommended in precise coordination with replacement medication. The authors recommended a treatment duration of 3 and 6 months for temporary risk factors (eg, operative treatment) and permanent risk factors (eg, inheritable traits), respectively.[6]

The occurrence of DVT and PE in patients with hemophilia A is rare. A detailed personal and family history of clotting should be relayed to hematologists to allow for appropriate workup. The plan for treatment with thromboprophylaxis, if indicated, can be completed before operative treatment. Orthopaedic surgeons should be aware of these possible complications in patients with hemophilia A, in which successful treatment can involve multidisciplinary efforts with hematologists and oncologists.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and he provided verbal consent.

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Simultaneous Dislocation of Both Interphalangeal Joints in the Same Digit of a 56-Year-Old Woman with Workers' Compensation: A Case Report

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Abstract

Dislocation of the interphalangeal (IP) joints of the fingers, particularly on the ulnar side of the hand, is common; however, simultaneous dislocation of both IP joints of the same finger is uncommon, and no studies have reported this injury in patients with workers' compensation claims. We describe a 56-year-old woman with simultaneous dislocation of distal and proximal IP joints, who was successfully treated using a dorsal blocking splint followed by several months of undergoing occupational therapy. She had sustained the injury from a fall on the ground at work and was promptly treated with open reduction at an outside facility. A nearly full return to previous range of motion and strength was noted by 6 months after the initial injury. Although patients with workers' compensation have been described with worsened clinical outcomes, the combination of immediate treatment and multidisciplinary care may help successfully treat this unusual injury.

Introduction

Although dislocations of the interphalangeal (IP) joints are common, simultaneously dislocating two joints in the same finger has been rare.[1-4] The first case[5] of distal and proximal IP joint dislocations was described in 1874, and the injury has often been associated with high-impact sports activities and falling. Successful treatment has typically involved an immediate reduction, which can help minimize the risk of unstable reduction and thereby avoid excessive operative treatment using K-wires that can result in further damage to the joints. Treatment with closed reduction has been preferred, with early active range of movement to prevent joint contracture.[6]

However, no study has reported on treatment of this injury in patients with workers' compensation, who have been described with worse clinical outcomes than patients without work-related claims.[7-10] We present an older woman with workers' compensation who had tenderness in the left ring finger after undergoing operative treatment of simultaneous dislocation of the proximal and distal IP joints at an outside facility. After use of a dorsal blocking splint followed by several months of physical therapy, the patient returned to work-related activity without restrictions.

Case Report

A 56-year-old female engineer fell on the ground in a parking lot at work, which resulted in simultaneous dislocation of both the proximal and distal IP joints of the ring finger of her left hand (Figures 1A and 1B). Initially, the patient was seen at an outside emergency department where the finger was successfully reduced after two attempts and splinted.

On day 4 after her injury, the patient presented for initial evaluation at our facility, at which time reduction had been maintained. The injured hand was neurovascularly intact without evidence of open wounds at the site of injury. On physical examination, the patient was able to flex and extend at the proximal and distal IP joints; however, she was unable to make a full fist and pass the ring finger into full flexion. Additionally, tenderness and edema were noted over the proximal IP joint. Radiographs showed concentric reduction of the distal and proximal IP joints, with volar avulsion fractures of the distal and proximal IP joints. The patient was treated using a dorsal blocking splint, with the proximal IP joint placed at 30° of flexion for 4 weeks. Occupational therapy was also initiated to minimize edema and provide instruction on flexion exercises. Extension of the proximal IP joint was restricted.

At 4-week follow-up, the patient had continued weekly treatment with occupational therapy with a certified hand therapist. She had moderate, persistent swelling in the left ring finger. Results of a neurovascular examination were normal. Her range of motion in passive and active flexions had begun improving. The patient was advised to continue therapy on a weekly basis to advance the possible range of motion to include extension. Use of the splint was discontinued at this time.

At 9-week follow-up, persisted swelling with mild discomfort was noted. A full passive extension of the left ring finger was observed, with maximum extension of 5° to 10° at the proximal IP joint. At the proximal and distal IP joints, about 90° and 30° of active flexion were found, respectively. Further treatment to enhance maximum extension of the finger included nightly use of a therapy-manufactured dynamic extension splint. Treatment with occupational therapy was continued on a weekly basis, and work-related activities such as lifting, pushing, pulling, and carrying baggage when traveling were restricted to 4.5 N (10 lb) of maximum force.

At 15-week follow-up, the patient continued to have mild symptoms of pain and swelling over the proximal and distal IP joints. However, attendance of occupational therapy classes and restriction in weight bearing at work had been maintained, with noted improvements in strength and range of motion of the left hand (Figures 2A and 2B). On clinical examination, she could form a full fist and the signs of swelling and range of motion had improved, although a continued limit to maximum extension of her proximal IP joint was observed. Maximum strength was nearly comparable to the uninjured hand in lateral pinch, three-jaw chuck pinch, tip pinch, and grip strength. Limitation of work-related activity and occupational therapy were continued.

At 6 months after initial injury, a maximum extension of 15° at the proximal IP joint was noted (Figures 3A and 3B). The clinical improvement was believed to have plateaued, and the patient returned to unrestricted work-related duties.

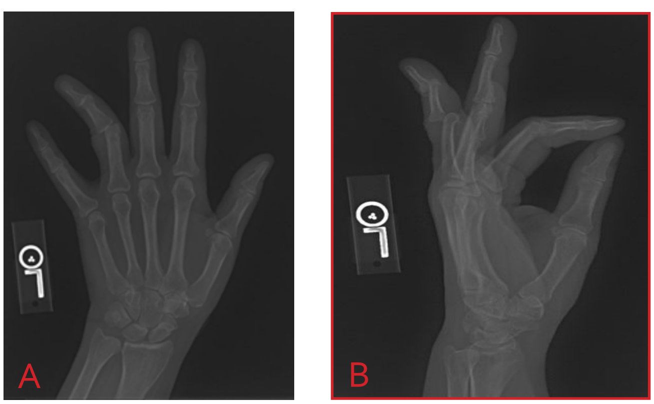

Figure 1. Preoperative radiographs of the left hand, showing simultaneous dislocation of proximal and distal interphalangeal (IP) joints of the left ring finger. (A) Posterior view. (B) Lateral view, with flexion of thumb IP and index distal IP joints.

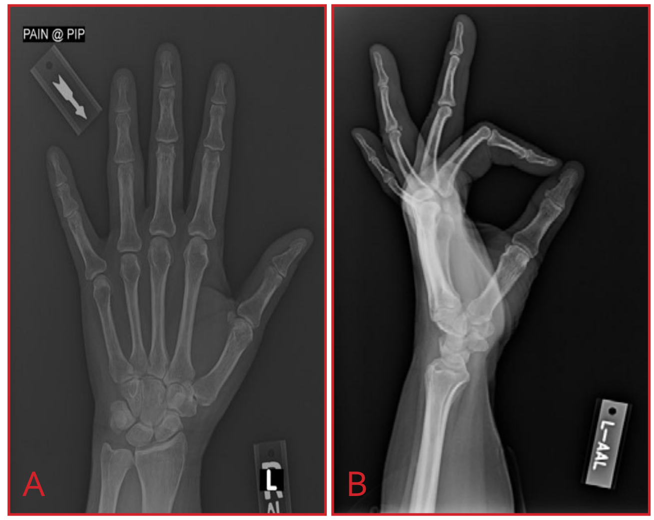

Figure 2. Radiographs of the left hand at 15-week follow-up, showing swelling over the proximal and distal interphalangeal (IP) joints. (A) Posterior view. (B) Lateral view, with flexion of thumb IP and index distal IP joints.

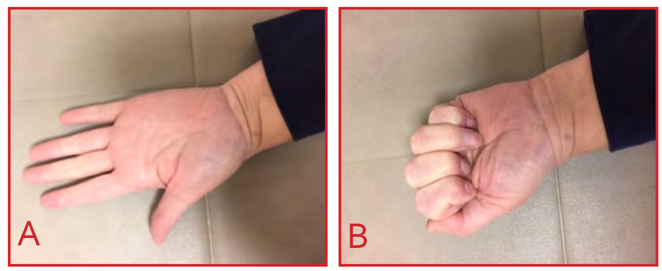

Figure 3. Photograph at 6 months after initial injury, showing nearly full return of range of motion and strength of the left hand. (A) Anterior view, with maximum extension of proximal and distal interphalangeal joints at 15°. (B) Hand successfully positioned into a clenched fist.

Discussion

To our knowledge, no other studies have reported on patients with simultaneous dislocation of proximal and distal IP joints of the same digit, an uncommon injury, and workers' compensation. Worse clinical outcomes have been described in patients with workers' compensation compared with those without the claim, especially in reported levels of pain.[7-10] However, clinical improvement was noted with our patient after treatment, with a nearly full return to previous levels of range of motion and strength at 4 months after injury.

In the current case, closed reduction was successfully achieved immediately after the injury. Additionally, the patient received immediate care from an orthopaedic hand specialist, in which proper immobilization, restrictions, and occupational therapy were initiated. The recovery of the patient was noted with mild pain and swelling of the left hand, although a minimal limit persisted in maximum extension of the proximal IP joint. Immediate operative treatment followed by nonoperative techniques may help in successfully treating simultaneous dislocations of proximal and distal IP joints in patients with workers' compensation.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and she provided verbal consent.

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Metasynchronous Rupture of Both Achilles Tendons in a Patient Undergoing Statin Therapy: A Case Report

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Abstract

In treating cholesterol-related cardiovascular diseases, statins are commonly used as preventative medication and are associated with few side effects. However, recent studies have described a connection between statins and development of tendinopathy. Similar research has noted bilateral rupture of the Achilles tendon, a rare injury, in patients undergoing statin therapy. We describe a 74-year-old man undergoing statin (ie, simvastatin) therapy who presented with pain and swelling in the right ankle after exertional-type activity. Magnetic resonance imaging confirmed a rupture of the Achilles tendon, with rupture of the left Achilles tendon identified 5 weeks later without any obvious trauma-related event. Nonoperative treatment included nonweight bearing in short-leg casts, physical therapy, and eventual temporary discontinuation of simvastatin therapy, which resulted in full return to previous levels of activity by 6-month follow-up. Orthopaedic surgeons should be aware of potential musculoskeletal-related side effects in patients undergoing statin therapy.

Introduction

Rupture of the Achilles tendon is common and generally occurs in weakened tendons and after high-impact force, particularly in men aged 30 to 50 years who play exertional-type sports intermittently.[1] On the other hand, bilateral tendon rupture is rare and may indicate systemic-related causes.[2] These injuries have been associated with renal transplantation,[3] systemic lupus erythematosus,[4] rheumatoid arthritis,[5] fluoroquinolone use,[2] and systemic or locally injected steroid.[6,7]

Recent case reports and retrospective analyses have also noted statin therapy as a possible cause of tendon rupture, specifically in the Achilles tendon.[8] Statins are commonly administered as preventative treatment of cholesterol-related cardiovascular disease.[9] Although statin therapy has generally been considered safe with few side effects, musculoskeletal toxicity and myopathy have been reported.[10] We present a 74-year-old man undergoing statin therapy with ruptures of both Achilles tendons, in whom no traditional risk factor for tendinopathy was noted. By 6-month follow-up, the patient returned to previous levels of activity after undergoing nonoperative treatment such as nonweight-bearing short-leg casts and physical therapy.

Case Report

A 74-year-old man presented to our clinic with pain in the right ankle and a soft ankle brace, having injured his Achilles tendon 9 days earlier after lunging forward in a game of pickle ball. He described the resultant feeling as if he "was hit in the back of the ankle with a two-by-four." He did not have history of autoimmune disease, had not undergone an organ transplant, and did not recently undergo steroid or fluoroquinolone therapy. The patient was undergoing simvastatin therapy, with doses of 20 mg per day for treating hyperlipidemia.

No palpable gap was noted in the Achilles tendon with the patient in prone position, but swelling was observed in the region. Results of the Thompson test were positive for a torn tendon. Notably, the results of the Thompson test were negative for tears in the left Achilles tendon and the patient had no complaints of left-sided pain. Magnetic resonance imaging (MRI) revealed a ruptured Achilles tendon without retraction (Figure 1A). After discussing risks and benefits

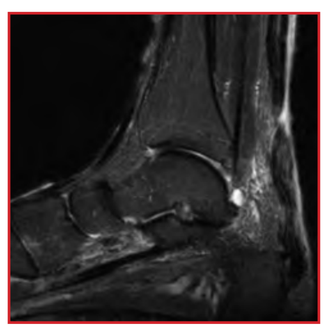

Figure 1A. Magnetic resonance imaging of the right ankle at 9 days after initial injury, showing rupture of the right Achilles tendon.

between nonoperative and operative treatment methods, the patient elected to use nonoperative techniques. His right ankle was placed into a nonweight-bearing short-leg cast in slight equinus position.

At 3 weeks after initial injury, the patient begun to develop pain in his left Achilles tendon. He suspected the pain resulted from overuse owing to the nonweight-bearing status of his right lower extremity. Increased strength of the right lower extremity was observed during right ankle plantarflexion, and use of a short-leg cast was continued.

At 4 weeks after the initial injury, the right Achilles tendon had improved union without any particular swelling on physical examination, and plantar flexion of the ankle against resistance could be performed comfortably with moderate strength. In the left lower extremity, mild swelling was noted, with tenderness around the posterior ankle and Achilles tendon. The tendon seemed to be intact with palpation, with improved strength in plantarflexion. Owing to concern for possible rupture, an MRI was ordered. Until the MRI was obtained, both lower extremities were placed into walking boots with heel lifts.

At 5-week follow-up, findings of the MRI indicated an Achilles tendon rupture of the left ankle (Figure 1B). A short-leg cast was placed on the left lower extremity, whereas the right lower extremity was transitioned into weight bearing with passive range of motion exercises. The concern of statin therapy associated with tendinopathy was discussed with the patient and relayed to his primary care physician. The patient decided to temporarily discontinue statin therapy while the Achilles tendons healed.

At 3 and 2 months after right and left Achilles tendon ruptures, respectively, the patient stopped using walking boots and transitioned into lace-up ankle braces for comfort. Physical therapy was initiated for gait training and progressive strengthening of both lower extremities.

Figure 1B. Magnetic resonance imaging of the left ankle at 5 weeks after initial injury, showing rupture of the left Achilles tendon.

At 6 months after his initial right-sided injury, the patient walked similarly to before the injury and returned to previous levels of daily activity, without use of the brace or other nonweight-bearing devices.

Discussion

To date, no precise mechanism for bilateral rupture of the Achilles tendon has been identified, and the causal relationship between statin therapy and tendinopathy is still in question. A postmarket analysis[8] reported statin-associated tendinopathy (with the Achilles tendon being the most affected) in a small proportion of patients (2.1%) administered low-density lipoprotein. Furthermore, results of another retrospective study[11] indicated no significant increase in tendinopathy among patients undergoing statin therapy compared with age-matched control groups. However, biochemical studies on rodents have reported definite change in the chemical makeup of tendons exposed to prolonged use of statin.[12]

Multiple theories have been suggested for explaining statin-related tendon toxicity, including decreased angiogenesis and vascularization,[13] reduced cholesterol content of cell membranes,[11] and imbalance of matrix metalloproteinases and eicosanoids.[14] To our knowledge, one case report[15] has described bilateral Achilles tendon rupture and attributed the injury to statin therapy because no other risk factors were identified. Two studies have reported more generally on bilateral quadriceps tendon rupture indirectly associated with statin therapy.[16,17] Notably, in the current study, the rare occurrence of metasynchronous bilateral Achilles tendon rupture was noted without identifiable systemic risk factors, and the second rupture involved no apparent trauma-related event.

Although the relationship between statin therapy and tendinous injury remains unclear, orthopaedic surgeons and primary care physicians should consider potential risk for musculoskeletal side effects in patients undergoing statin therapy. In avoiding tendon-type injuries, caution should be taken in prescribing statin for patients with higher risks for tendinous disorders (ie, patients with concomitant fluoroquinolone therapy, high-intensity muscular activity, and healing tendinous injuries).

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and he provided verbal consent.

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Simultaneous Presence of a Transligamentous Recurrent Motor Branch of the Median Nerve and Palmaris Profundus Tendon in a Patient with Carpal Tunnel Syndrome: A Case Report

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Abstract

Carpal tunnel syndrome (CTS) is the most frequently encountered entrapment of the peripheral nerves in the upper extremity. Abnormal anatomical variations involving the recurrent motor branch of the median nerve and presence of a palmaris profundus tendon have been reported. We present a 53-year-old man in whom open carpal tunnel release led to complete resolution of numbness, tingling, and pain in the right hand by 1 month postoperatively. Intraoperatively, the simultaneous presence of a transligamentous recurrent motor branch of the median nerve and palmaris profundus tendon in the carpal tunnel was found and excised. Surgeons should be aware of the potential presence of these abnormalities in successfully treating patients with CTS.

Introduction

Carpal tunnel syndrome (CTS) is the most commonly noted entrapment to peripheral nerves in the upper extremity, with an incidence rate of 1 person per 20 per lifetime in the United States. About 500,000 surgical procedures are performed per year for treating this condition, generating an annual cost greater than two billion US Dollars.[1,2] CTS typically affects the radial three digits. In patients with chronic CTS, symptoms can include pain and paresthesia at night. During the day, similar symptoms typically result from physical activities, loss of dexterity in hand function, and weakness with pinch and grip. Because of the anatomical configuration of the carpal tunnel and its contents, the median nerve is at risk for compression, which can result in decreased levels of epineurial blood flow and clinical symptoms of the syndrome.

Development of CTS is broadly categorized according to anatomic anomalies, systemic medical conditions, and occupational-related exposure to vibratory power tools.[3] Recognizing and understanding the various potential causes of CTS are essential in accurate diagnosis and appropriate treatment recommendations. In planning operative treatment, anatomical variations in the carpal tunnel should be considered and, if encountered, addressed to improve the overall success of treatment.

We describe a 53-year-old patient who presented with pain and numbness in his right hand. Evaluation of medical history, results of physical examination, and findings of diagnostic studies were consistent with CTS. Notably, a transligamentous recurrent motor branch of the median nerve and palmaris profundus tendon in the carpal tunnel were identified intraoperatively.

Case Report

A 53-year-old, right-handed laborer with an uncomplicated medical history presented with an 8-month history of pain in the right wrist and hand, with numbness affecting the thumb, index, and long fingers. The patient did not identify a specific trauma-related event or other clear inciting factor associated with the onset of his symptoms. His occupation required routine manual labor with heavy loads and repetitive tasks, which worsened the symptoms.

Findings of the initial physical examination revealed localized tenderness to palpation in the mid-carpal area, mildly restricted range of motion in the wrist, and weak grip strength relative to the uninjured hand. Additionally, results of a carpal compression test were positive for CTS, and findings of Tinel's sign were positive for irritated nerves at the wrist. No muscle atrophy was observed. Results of diagnostic imaging showed mild ulna minus variance and type 3A avascular necrosis of the lunate bone. Findings of electrodiagnostic studies indicated a prolonged latency of 5.6 ms at the right median motor and decreased amplitude (4.6 mV); sensory latency of 2.4 ms with decreased amplitude (19 μV); and chronic neurogenic changes in the abductor pollicis brevis but not flexor pollicis longus, consistent with damage to the peripheral median nerve of the wrist.

Based on patient preference, open carpal tunnel release was performed. Intraoperatively, a transligamentous recurrent motor branch of the median nerve was identified. It was carefully dissected free of the transverse carpal ligament and maintained in continuity. Additionally, while inspecting the contents of the carpal tunnel, a palmaris profundus tendon was noted adjacent to the ulnar side of median nerve, and it was excised (Figure 1). No complications were noted postoperatively.

At 1 month postoperatively, the patient reported complete resolution of numbness and tingling in the previously affected digits. He described no pain in the right hand and returned to previous levels of physical activity at work, without restrictions or limitations. The timing for surgical treatment of avascular necrosis in the lunate bone was deferred at the most recent follow-up, pending results of treatment of an unrelated medical condition.

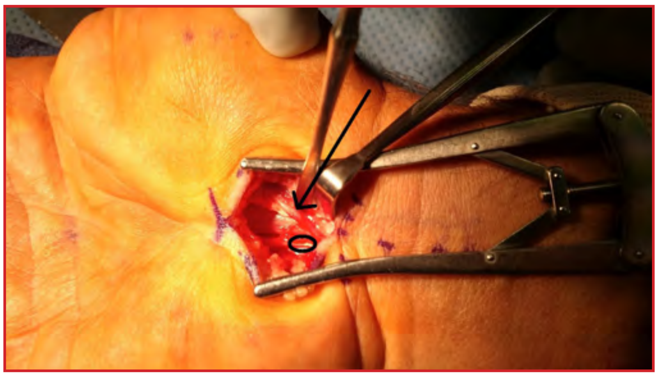

Figure 1. Intraoperative view of the hand during carpal tunnel release, showing the recurrent motor branch (arrow) and the palmaris profundus tendon (circled).

Discussion

Multiple cadaveric and clinical studies have described and reported observations of the anatomy and variations in the recurrent motor branch of the median nerve.[4-7] A classification scheme by Poisel[8] described three subtypes or branching patters of the recurrent motor branch of the median nerve as extraligamentous (type I), subligamentous (type II), or transligamentous (type III). It subsequently was modified and expanded by Lanz[9] to include variation in the course of the thenar branch (type I), accessory branches at the distal portion of the carpal tunnel (type II), high division of the median nerve (type III), and accessory branches proximal to the carpal tunnel (type IV).

The variability of the branching patterns noted in studies may reflect inconsistency in interpreting and reporting findings. The presence of a palmaris profundus tendon in the carpal tunnel is rare, with one study[10] noting only 7 other reports, with patients aged 19 to 70 years. In five of these patients, the results of electrodiagnostic studies were positive for CTS. However, no study has described abnormality of the motor branch. Yet other anatomical variabilities in the carpal tunnel have been noted such as synovitis or proximal origin of a lumbrical muscle.[11]

In the current case, the transligamentous pathway of the motor branch of the median nerve was directly deep to the palmar fascia perforating the transverse carpal ligament, and a palmaris profundus tendon within the carpal tunnel was also found. The palmaris profundus tendon crossed the median nerve and could have contributed to the nerve compression. Meticulous dissection of both the aberrant motor branch and the tendon may have been essential in successful treatment of our patient. Because such a simultaneous presence is rare yet possible, we recommend careful inspection of the carpal tunnel and median nerve to note any anatomical variations when performing carpal tunnel release.

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Conflict of Interest

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Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and he provided verbal consent.

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Idiopathic Thrombocytopenic Purpura in a 21-Year-Old Collegiate Football Player: A Case Report

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Abstract

Muscle cramps are commonly observed in collegiate athlete-patients; however, the condition may be a symptom of severe disorders. In particular, idiopathic thrombocytopenic purpura (ITP) may be a possible diagnosis and involves a decreased number of platelets in the bloodstream. We describe a 21-year-old collegiate player of American football with initially presented with cramping of the neck, abdomen, and forearms. Although findings of physical examination were normal, results of laboratory tests indicated ITP, and the patient was hospitalized for 3 days until the platelet count increased. Because the levels continued to decrease at 6-month follow-up, splenectomy and use of rituximab agents have been discussed with the patient for treatment after the end of the football season, before which dexamethasone will be administered to maintain a minimum platelet count of 50. Physicians should consider coordinating traditional care and specialist consultation to help treat severe conditions such as thrombocytopenia in athlete-patients.

Introduction

Muscle cramps are commonly seen in collegiate athlete-patients. In performing differential diagnosis, muscle cramps can generate various potential causes of noted symptoms, ranging from simple to severe. In particular, findings of associated workup have revealed the presence of idiopathic thrombocytopenic purpura (ITP), an autoimmune disorder characterized by the development of antibodies that reduce the amount of platelets in the bloodstream.[1] The incidence rate in adults is estimated at about 1 in 10,000 patients per year in the United States.[2] Viral infections, medications, malignancy, autoimmune syndromes, and idiopathic features have been associated with the disorder.[3] Bleeding has been rarely described with platelet counts of 10,000 or greater, and intracranial hemorrhage has been the most severe complication.[3]

Currently, no evidenced-based guidelines exist concerning the minimum platelet count required for athletes to participle in high-collision sports.[3] We present a 21-year-old collegiate player of American football with ITP in whom initial hospitalization, followed by a tapering 10-week course of oral prednisone, and eventual administering of high-dose dexamethasone at 6-month follow-up led to temporarily normalized platelet counts but did not resolve reoccurrence of the decrease. Splenectomy or administration of rituximab agents has been discussed with the patient, who will resume competitive play with a minimum platelet count of 50 until the end of the football season and return after for treatment.

Case Report

During preseason football training, a 21-year-old African American linebacker presented to our training room clinic with symptoms of cramping of the neck, abdomen, and forearms. He had a history of cramping after physical workouts but not in those locations. The patient also had 2 days of rhinorrhea, sore throat, and cough. He expressed feeling weak, although no fevers, myalgias, and shortness of breath were noted. Adequate hydration was reported, with normal vital signs and findings of physical examination.

Results of previous blood tests were negative for sickle cell trait, and no changes in urine had been noted. The patient had a history of possible Crohn's disease diagnosed after a bout of diarrhea, with results of colonoscopy and biopsy indicating chronic inflammatory bowel disease of the previous year. The associated symptoms ultimately resolved. At the time of presentation to our institution, he had reported no diarrhea or gastrointestinal symptoms.

Basic laboratory tests (ie, on complete blood count, complete metabolic panel, and levels of creatine kinase [CK]) were performed to rule out electrolyte disturbances and rhabdomyolysis. Findings showed a platelet count of 38, creatinine count of 1.84, and elevated CK levels at 2591; otherwise, findings were normal. Further evaluation and laboratory tests were performed the next day, and results indicated that platelet and CK counts had changed to 21 and 3915, respectively. Because findings had worsened, the patient was admitted to the hospital for monitoring symptoms and treatment. He was hospitalized for 3 days, during which a platelet count nadir (ie, lowest value) of 14 was noted. The levels improved with administration of dexamethasone and intravenous fluids. Hematologists were subsequently consulted, and ITP and rhabdomyolysis were diagnosed. No symptoms were observed during the hospital stay of the patient, and he felt well at time of discharge. The mild rhabdomyolysis was thought to be caused by strength and conditioning workouts.

The patient missed 2 weeks total of preseason training and gradually returned to full participation after findings of laboratory tests had normalized (platelet count, 200). At about 10 days after discharge, however, the platelet count had decreased to 83. The patient was subsequently placed on a tapering 10-week course of prednisone. Hematologists recommended a platelet count of 100 or greater before resuming football-related activity.

At 6 months after his initial hospitalization, the patient was re-admitted to the hospital after a noted platelet count of 5, with upper respiratory viral illness. He was discharged at day 2, with promising results after being administered high-dose dexamethasone and a corresponding tapering course of prednisone. However, 2 weeks after cessation of prednisone tapering, the platelet count had dropped to 35. Subsequently, use of low-dose prednisone until undergoing eventual splenectomy or single-agent rituximab (suggested by hematologists) were discussed with the patient for treatment of ITP.

The patient has been weighing treatment options and will make a definitive choice after the end of the football season. Until then, he will continue to participate in sports-related activity with a platelet count of 50 and greater, followed closely by our sports-medicine team and hematologists.

Discussion

ITP is a relatively common bleeding disorder, but currently no clear guidelines exists regarding return to play of athletes in high-collision sports. The American College of Sports Medicine has recommended to avoid contact-type sports with platelet counts of less than 100, although no significant clinical impact has been reported.[4] The current case is one of the few to report findings of ITP in patient-athletes of high-collision sports.

Several studies have described potential guidelines to follow in return to physical activity of patients with ITP, although no standard exists on athletes in high-collision sports. Two other case reports have reported ITP in patient-athletes of high-collision sports.[1,3] Specifically, Esala and Foy[3] recommended a platelet count greater than 50 before participation in American football, supported by findings of an older study in which bleeding rarely occurred in counts of 50 or greater.[5] Furthermore, current guidelines in obstetric patients have called for a target platelet count greater than 50 to minimize bleeding complications during childbirth.[6] These suggestions have been helpful in treating ITP but do not consider athletes in high-collision sports and subsequent possibility of intracranial hemorrhage. The National Collegiate Athletic Association has not yet incorporated guidelines on minimum platelet count for safe participation.

In the current case, a clear autoimmune link was not established between Crohn's disease and intermittent ITP, despite a thorough evaluation. Glycogen storage diseases were also generated in differential diagnosis as possible causes of symptoms. Findings of extensive examinations such as electromyography, rheumatologic laboratory tests, and muscle biopsy were negative for a clear autoimmune cause. ITP, rhabdomyolysis, and Crohn's disease were identified as separate processes without a clear autoimmune syndrome.

Because symptoms of ITP were not resolved after 6 months, we have discussed reportedly successful treatment options such as splenectomy[7] with our patient and will closely follow him until a decision is made at the end of the football season. Until treatment, dexamethasone will be administered to maintain a minimum platelet count of 50. The findings of our study indicate that further research is required to determine platelet-count thresholds for safe participation of athletes in high-collision sports. Additionally, sports physicians should collaborate with other specialties when confronting cases such as ITP in which no substantial guidelines exist in directing treatment.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and he provided verbal consent.

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Notable Findings of a Preparticipation Examination in an 18-Year-Old Volleyball Player: A Case Report

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Abstract

The preparticipation examination (PPE) is commonly performed to screen for potentially detrimental health conditions in competitive athletes to help decrease rates of morbidity and mortality associated with participation in sports. However, the significant clinical impact of PPE in the United States has yet to be determined. We describe an 18-year-old female athlete who presented with dizziness and a right-sided limp at 8 days after initial injury. Findings of PPE examination indicated that she had unknowingly sustained a concussion during a volleyball match and continued to play, which resulted in injury to the right foot. Despite abnormal findings of magnetic resonance imaging, the symptoms of concussion completely resolved at 3 weeks after initial injury. A modified return-to-play protocol and cast boot for 6 weeks were used, with progressive return to full physical activity. Athletes and coaches should be aware of any possible symptoms of concussion in preventing subsequent injuries during sports-related activities.

Introduction

Preparticipation examination (PPE) is a standard screening procedure to evaluate the health status of high school-aged and college-aged athletes before training and competition. A total of 49 of 50 states have incorporated legal mandates for yearly screening for interscholastic athletes.[1] One goal of PPE is to identify potentially life-threatening conditions, so that appropriate interventions can be made to reduce rates of morbidity and mortality associated with participation in sports. Additionally, findings of PPE can help evaluate history of injury and other pertinent patient characteristics, which may prevent reoccurrence or future complications of injuries. However, further research is required to identify the significant clinical impact of PPE in the United States.[2,3]

Most athlete-patients who undergo PPE are healthy, without medical comorbidities and injuries. We describe a young volleyball player who presented with an injury to her right foot resulting from an unidentified concussion.

Case Report

An 18-year-old female volleyball player presented to the training room at The University of New Mexico for a PPE. She arrived limping and unable to fully bear weight on her right foot, with expressed difficulty in arriving owing to headaches and dizziness caused by a head injury during a volleyball match 8 days earlier. Further discussion with the patient revealed that she had sustained a concussion after being hit in the head with a ball. The patient was not aware of the concussion and had continued to play, which resulted in injury to her right foot in plantar-flexion and abduction-type motions. She noted swelling and difficulty in weight bearing, but did not recall a specific "pop."

The patient filled out the third edition of the Sport Concussion Assessment Tool (SCAT3), which is a standardized checklist that describes 22 different symptoms of concussion and includes a severity scale between 0 and 6 (Figure 1). Results of the SCAT3 indicated 22 symptoms and a total severity score of 84 at 8 days after initial injury.

At the PPE, findings of a complete neurological examination were normal except in the balance test, which was not performed owing to foot pain. With the exception of a mild limp, the results of physical examination were normal. The right foot of the patient did not appear to have signs of swelling or bruising, despite tenderness to palpation over the medial tarsometatarsal joint and pain during flexion and abduction of the foot.

Radiographs of each foot showed slight widening at the Lisfranc joint on the injured side (Figures 2A and 2B), and the patient was given crutches. Results of magnetic resonance imaging (MRI) indicated a nondisplaced stress fracture of the proximal second metatarsal and marrow contusion of the base of the second metatarsal at its articulation with the lateral cuneiform.

Because a research study was underway on athletes with concussions, a structural MRI of her brain was obtained and an abnormal finding within the right anterior temporal lobe was noted. A follow-up T2-weighted MRI using contrast agents revealed an oval area of hyperintensity in

SYMPTOM EVALUATION

3 How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	None	Mild		Moderate		Severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score (Maximum possible 132)

Do the symptoms get worse with physical activity? Yes No

Do the symptoms get worse with mental activity? Yes No

Self rated Self rated and clinician monitored

Clinician interview Self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self.

Please circle one response:

No different	Very different	Unsure	N/A

Figure 1. At 8 days after initial injury, results of the third edition of the Sport Concussion Assessment Tool indicated mild levels of 22 symptoms and a total severity score of 84.

the right frontal subcortical white matter, without presence of mass effect or abnormal enhancement (Figure 3). The abnormal finding was felt to be benign, consistent with signs of gliosis, and a result of previous trauma, infection, or inflammation, rather than the concussion. Less likely causes were found to be demyelinating process or neoplasm.

In treating the concussion, the patient was held out of classes to avoid worsening the symptoms. After the symptoms improved, she returned to classes and volleyball meetings. The symptoms completely resolved by 3 weeks after initial injury, and a modified Zurich protocol was used owing to the foot injury. The protocol consisted of a five-step progression toward increasing activity in minimum 5-day period, ranging from light (eg, warm-up biking exercises) to non-impact full sports.[4] The patient was placed in a cast boot for 6 weeks and allowed to progressively return to full physical activity.

She was referred to a pediatric neuro-oncologist at The University of New Mexico for treating the lesion viewed on the brain MRI. A repeat MRI was recommended 6 months later. Because the patient was unable to present at 6 months, she has been scheduled to return after summer break, at which time conclusive results will be determined.

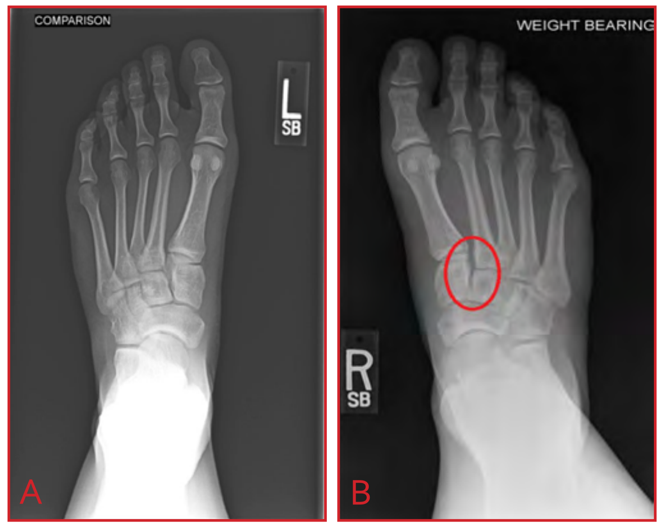

Figure 2. Radiographs of the (A) uninjured left foot and (B) injured right foot, showing slight widening at the Lisfranc joint (circled).

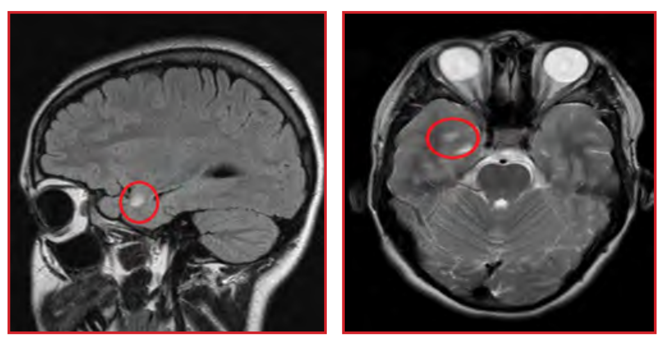

Figure 3. T2-weighted magnetic resonance imaging results of the brain using contrast agents, showing abnormal findings of an enhancement (circled) in the frontal subcortical white matter.

Discussion

The National Collegiate Athletic Association has implemented changes in recent years to improve the awareness of concussions. The organization has a shared-responsibility policy, in which athletes must sign a statement and agree to report signs of concussion to medical staff members.[5] In addition, athletes have received information on identifying symptoms of concussion. However, because our patient was not a collegiate-level athlete, she had not yet undergone this process.

In the current case, our patient was unaware of a concussion sustained during a volleyball match, and thus she continued to play and subsequently injured her foot. The foot injury required more time to heal than did the symptoms of concussion, which resulted in her inability to play competitive volleyball in the fall season.

Furthermore, although young athlete-patients are usually healthy at PPE, abnormal findings were found in the current case. Radiographs of both feet revealed a Lisfranc injury, whereas findings of MRI images indicated a stress fracture of the second metatarsal. Further MRI images revealed a brain lesion, yet it is unclear whether the observed lesion resulted from the concussion. A structural finding of an MRI would be rare and question the diagnosis of concussion. The lesion was likely caused by a previous injury or, less likely, demyelinating and neoplastic process. Findings of a follow-up MRI will help establish more definitive evaluation of the lesion.

Results of the current case highlighted several notable benefits of PPE: the need for athletes, their parents, coaches, and trainers to recognize symptoms of a concussion; the importance of increasing awareness of concussion signs at all ages and levels of sports-related activity; and possible abnormal findings revealed after imaging procedures during PPE. Although clinical significance of PPE has not been verified in the United States, the procedure may help in identifying possible conditions and subsequent preventative measures in treating seemingly healthy populations of younger athlete-patients.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient was informed that the data concerning the case would be submitted for publication, and she provided verbal consent.

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Spare-Parts Technique for Concurrent Treatment of Ectrodactyly of the Feet and Syndactyly of the Hands in a 2-Year-Old Boy: A Case Report

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Abstract

Syndactyly is the most frequently occurring congenital malformation of the limbs. Although common, few studies have reported treating syndactyly using Z-plasty with and without full-thickness grafting. We present a 2-year-old boy who presented to our clinic with ectrodactyly of the feet and simple complete syndactyly of two fingers on each hand. After ectrodactyly reconstruction, we used the excess foot skin to cover finger defects. The patient recovered well postoperatively, with matching skin and no trouble with hair growth. Use of a spare-parts technique can help avoid complications associated with harvesting grafts from other donor sites. The results reinforce the importance of coordinating reconstructive techniques when necessary for operative treatment of syndactyly of the hands.

Introduction

Syndactyly, the most common congenital malformation of the limbs, occurs in about one in 2000 live births and is associated with more than 28 syndromes.[1] The condition is typically classified into a combination of complete, incomplete, simple, and complex categories, based on the degree of tissue involvement and the length of fusion.[2] Both medical and aesthetic considerations are taken into account when considering the best type of surgical intervention.[3,4]

A limited number of studies have explored methods of treating syndactyly using Z-plasty[5] with and without full-thickness grafting.[6,7] Specific management protocols have not been well established in addressing postoperative complications associated with web creep, scarring of the hand and harvest site, loss of autograft, changes in skin flap color, hair growth, and nail deformities.[8] We describe a patient from whom excess skin remaining after treating ectrodactyly of the feet was used as full-thickness skin grafts in treating syndactyly of his left and right hands. The patient recovered well postoperatively, without complications, and his hands and feet healed to near normal function.

Case Report

A 2-year-old boy presented to our pediatric hand clinic, born with syndactyly of the middle and ring fingers of both hands and ectrodactyly of both feet. His parents were concerned with the future function and appearance of the child's hands and feet. The patient was initially sent to our clinic for evaluation at 4 weeks of age by his pediatrician. These deformities were isolated anomalies, and he was otherwise healthy, with no other medical problems or known syndromes.

We first saw the child at 4 weeks of age, at which time he had anomalies of both hands and feet. Simple complete syndactyly of the long and ring fingers of the left hand was noted. In the right hand, complete synbrachydactyly of the long and ring fingers was observed, with a mild contracture of the proximal interphalangeal joint flexion that did not limit function. In the same hand, incomplete syndactyly of the ring and small fingers was noted. Radiographs of his hands indicated no bony abnormalities, confirming simple syndactyly. Both feet had three toes and a wide, deep central cleft. His right foot had simple complete syndactyly of the fourth and fifth toes. Imaging of the right and left feet revealed five metatarsals and three toes (first, fourth, and fifth digits; first, second, and fifth digits, respectively). The child was to return in 1 year for operative treatment of his hands and feet.

For reasons unknown, the follow-up appointment was not kept and the patient returned at about 2 years of age. His parents felt that the syndactyly and camptodactyly now impaired the use of his right dominant hand and that the ectrodactyly impaired his ability to wear shoes. The patient wore soft oversized slippers because no other shoes would fit. To minimize anesthetic exposure, we decided to surgically repair his hands and feet in the same setting.

Operative procedures with the patient under general anesthesia were performed without complication. An orthopaedic hand surgeon and pediatric surgeon worked concurrently to treat the hands and feet, respectively.

The patient's legs, arms, and left side of the groin were prepped and draped (Figures 1A and 1B). Syndactyly reconstruction was done using standard techniques with dorsal commissure flap and Z-plasties. In treating the feet, no bone was removed; instead, the intermetatarsal ligaments were reconstructed, skin was closed in the clefts on each side, and excess skin was removed. Use of this remaining skin avoided the need to harvest skin from the groin and covered the medial proximal finger defects resulting from finger separation during syndactyly release (Figures 2A and 2B). In respect to the hand skin, the foot skin was of near identical color, had no hair, and matched in dermal thickness. Sterile dressings and short-arm casts were applied to all extremities at the completion of the procedures.

Postoperatively, the patient recovered well. The casts were used to maintain the feet in a narrowed position for 6 weeks. His hands and feet healed well without complications (Figures 3A and 3B). Improved function was noted, and the child's parents were pleased with the results. The patient was able to move all fingers independently and use both hands with dexterity and prehensile function. He was able to wear normal shoes with no trouble walking or running.

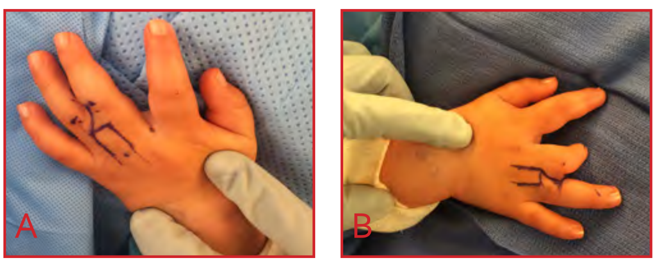

Figure 1. Intraoperative, posterior views of the (A) left and (B) right hands, showing syndactyly between the long and ring fingers.

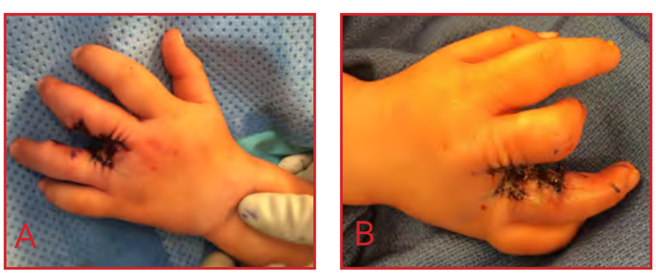

Figure 2. Intraoperative, posterior views of the (A) left and (B) right hands, showing covered areas of skin after using remaining full-thickness grafts from the feet.

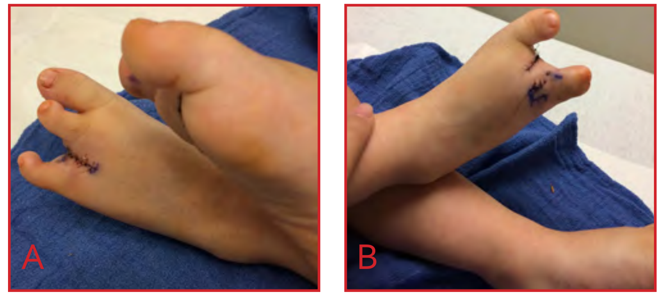

Figure 3. Postoperative, posterior view of the (A) left and (B) right feet, showing promising healing of incisions.

Discussion

Digit separation in humans occurs between the sixth and eighth week of embryogenesis[9] from cell differentiation, apoptosis, and enzyme degradation of limb webbing. A number of genetic and environmental influences can alter this process, leading to the development of incomplete or complete syndactyly in newborn limbs.[10-13] Treatment of this malformation typically requires use of full-thickness skin autografts; however, common complications associated with grafts obtained from the groin, wrist, and medial arm include hair growth on the fingers and pigmentation of the grafts.[7] Furthermore, the penile foreskin has been abandoned as a donor site owing to differences in skin color and integrity. We present the current case as a promising example of using a spare parts technique in reconstructive procedures for treating syndactyly of the hands.

In a retrospective study on full-thickness grafts used for treating 39 patients with syndactyly between 1991 and 2008, Mallet et al[8] reported hyperpigmentation and hair growth in 22% and 5% of cases, respectively. These outcomes may have been avoided in our patient because of the similarity between skin from the donor site and the recipient location. Furthermore, Comer and Ladd[5] reviewed operative treatment of patients with syndactyly and reported a general intervention time between 12 to 18 months old to avoid web creep. More recent studies suggest waiting until the child is 2 years old to avoid long-term anesthesia complications.[14] Yet the results of our case reinforce the fact that grafting technique and severity of syndactyly, in addition to age, may notably impact postoperative complications in children.

Use of excess, well-matched foot skin in covering finger defect may be an excellent option for treating patients with ectrodactyly of the feet and syndactyly of the hands. Most published data on syndactyly management focus on surgical technique,[15] with extensive discussion about using different flaps for reconstructing the digits. However, in treating syndactyly, none report the use of a spare-parts method to minimize the problems associated with graft-site morbidity. It is important to coordinate between different subspecialties to minimize the risks of anesthesia exposure and repeated operative interventions. The results of our case support future research on long-term effects of coordinating reconstructive procedures using a spare-parts technique for operative treatment of syndactyly.

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Conflict of Interest

The authors report no conflicts of interest.

Informed Consent

The patient's family was informed that the data concerning the case would be submitted for publication, and they provided verbal consent.

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Becoming a Hand Surgeon

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Although the hand is a complex part of the body, involving many varied structures from skin to bone, treatment of related injuries has been fragmented and performed by surgeons of many backgrounds. During the 1940s, physicians in the West Coast, New York, Chicago, and Europe devoted their careers to caring for patients with hand problems. The advent of wars, with many resultant upper-extremity injuries, led to the establishment of specific care centers. From there, the hand subspecialty evolved, encompassing care for children, adults, and reconstructive problems.

The evolution of hand surgery as a subspecialty area in the United States (US) is closely linked to the military. Norman T. Kirk, the Surgeon General of the US in the 1940s, was himself an orthopaedic surgeon. Following WWII and the return of injured soldiers in 1944, he commissioned Dr. Sterling Bunnell (a general surgeon in San Francisco, CA) to establish hand-surgery centers for treating war-related injuries. Dr. Bunnell, considered the father of hand surgery in the US, was aged 64 at the time. Yet he traveled around the country, and nine centers were established.

Soon after, the American Society for Surgery of the Hand (ASSH) was born and the first meeting was held in Chicago, IL in 1947, with 35 founding members (Figure 1). It was a 1-day conference, during which actual patients were presented. In the first 10 years, only 50 members were admitted to the society (Figure 2). In the early 1970s, fellowships in hand surgery were organized for graduates of orthopaedic, plastic, and general surgery residencies. Subsequently, by 1976, the number of members increased to 340 (Figure 3). The Journal of Hand Surgery was published in the same year, with articles completely devoted to topics on hand and upper-extremity surgery. At this time, a member of ASSH who completed a post-residency fellowship program in hand surgery could be loosely identified as a hand surgeon. Currently, more than 3000 members make up ASSH, including orthopaedic, plastic, and general surgery specialists. Hand therapists were recently admitted as associate members.

Figure 1. In 1946, a total of 26 of 35 founding members were present at the meeting in Chicago, IL of the American Society for Surgery of the Hand. Reprinted from the American Society for Surgery of the Hand.

Figure 2. Annual meeting in 1957 of the American Society for Surgery of the Hand, showing the 50 members and 4 additional attendees. My own mentors, Lee R. Straub, MD, (top-left circle) and J. Leonard Goldner, MD, (top-right circle) attended. Reprinted from the American Society for Surgery of the Hand.

Figure 3. More than 340 members of the American Society for Surgery of the Hand at the annual meeting of 1980 in Atlanta, Georgia, including myself (circled). Reprinted from the American Society for Surgery of the Hand.

George E. Omer, MD, Professor and Chair of the University of New Mexico Department of Orthopaedics & Rehabilitation, took the lead in promoting hand surgery as a recognized specialty throughout his career. Dr. Omer was the president of the ASSH in 1978 and American Board of Orthopedic Surgery in 1987 (Figure 4). The American Medical Association and the American Board of Medical Specialties were petitioned. Consequently and after approval was granted, a Certificate of Added Qualifications in Surgery of the Hand (CAQ) was established in 1986 by the governing boards of orthopedic, plastic, and general-surgery specialties. At about the same time, the Accreditation Council for Graduate Medical Education (commonly known as the ACGME) approved requirements for hand-fellowship training in each specialty, which were the same. Onsite inspections of programs by residency review committees started in 1989.

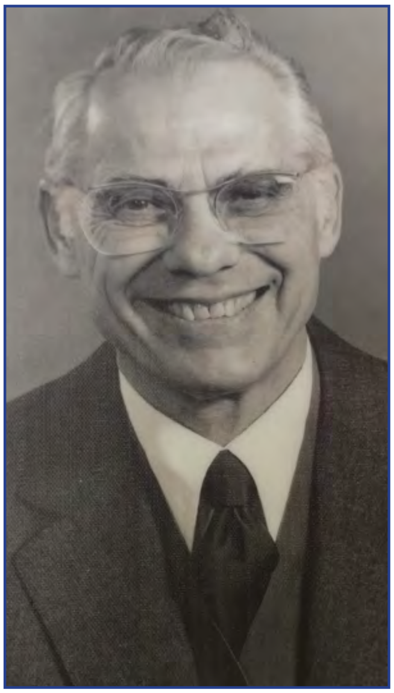

Figure 4. George E. Omer, MD (Professor and first Chair of the University of New Mexico Department of Orthopaedics & Rehabilitation), was a nationally recognized figure in promoting the subspecialty of hand surgery.

The CAQ, later called subspecialty certificate, was offered to surgeons that demonstrated qualifications in hand surgery beyond those expected of other orthopaedic, plastic, and general surgeons by virtue of additional training (12-month fellowship), a practice of most cases in hand surgery (125 cases/year), passing an examination, and contribution to the field of hand surgery. The first examination was held on January 30, 1989. A total of 510 participants attended (412 of whom were orthopaedic surgeons), and 471 were granted a 10-year certificate in hand surgery. The failure rate was 7.7%. A practice devoted to hand surgery, fellowship training, and annual load of cases correlated with successful performance.

A qualified hand specialist is trained to diagnose and treat all related problems of anatomical structures, including the wrist and forearm. Such surgeons have received additional training aside from board-specialty programs. Two major steps solidified the role of hand-surgeon subspecialties in modern society: 1) the organization of hand-care centers and ASSH in the 1940s, and 2) the agreement between governing boards of orthopaedic, plastic, and general-surgery fields to launch a certificate of added qualification in 1989. With the guidelines of certification for hand surgery firmly established, the pathway became and continues to be clear for graduates to pursue this area of medicine.

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Five Lessons Learned during Residency and Fellowship Interviews

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As the interview season in the medical community comes and goes, medical students and residents alike travel throughout the country to make their case for a coveted spot in a field of choice, be it within residency or fellowship programs. For the uninitiated, it is a unique process to say the least. In a competitive field such as orthopaedics, applicants often interview at a dozen or more training programs. The cost of travel is almost exclusively upon the applicant, including lodging and transportation within each city. It can be a time consuming, expensive experience.

Nearing the end of my fourth residency year, I have essentially completed my interview schedule. The process of coordinating, traveling, and interviewing during clinical rotations can be stressful. Yet thanks to this challenging experience, I learned five undervalued and priceless lessons.

Allow your opinion to form. When I traveled the country twice to evaluate programs, I did not know what I truly wanted. And that is okay. Sure, you may know of some good places to live or that you definitely do not want to travel to different hospitals while training. But you almost certainly will not have a completed checklist before the interview. Part of the process, painful as it may be, is to discover what you want. Each interview yields various reactions to certain elements. Some programs that I did not like were useful in helping decide what I *did not* want in my education.

Visit with current trainees. All directors believe that they own the best program in the country and will capitalize on the greatness of the associated curriculum, instructors, and community. But program directors are not residents or fellows. Ask these students about their happiness, fun at work, and liked or disliked aspects of the training. Residents and fellows will often be very honest and present a perfect look into life on the front lines. The pre-interview dinners are usually an excellent time to gather information.

Be your best advocate. The application process prohibits collusion. Do not believe anything said about how to be accepted at programs. The stress is not worth your energy. However, nothing prevents you from letting a program director of your interest. This can be expressed in your interview or an email once you make your decision. Program directors want people who want to be there. They will not know unless you tell them.

Find the perfect fit. It is okay to be greedy during the process of selection. Search for a place where you can truly be happy. Residency is difficult enough without working alongside challenging personalities or in a city that you do not like. Each program is not for everyone.

Blind yourself to names. This lesson is the most challenging to learn, I think. Do people in the real world care if you trained at Famous Hospital X? A little, and mostly in the academic community. If this career path is your goal, then the name of the program may be worth considering. But also consider this—as of 2014, only 13.5% of orthopaedic surgeons practice in an academic setting.[1] Furthermore, the prestige of your training program only matters until someone meets you or sees your work. I would strongly advise you to pick a program that suits your needs, instead of choosing one that you can simply tolerate but employs someone famous. Orthopaedic surgery, and probably every other medical specialty, is no different at Famous Hospital X than Community Hospital Y. I have been to both. The educational resources are mandated by the Accreditation Council for Graduate Medical Education and will not differ dramatically among programs.

I used these five principles to help select my residency program, and I have never regretted it. I am confident that each will aid my selection process for a fellowship as well. That is, forming an opinion throughout the experience; exchanging a word or two with actual students of the program; taking initiative in expressing your interest to the director; compromising your desires only to a certain extent; and understanding that a name means little compared to reality can effectively guide the applicant to the best program *for the applicant*. The Match is a daunting time for anyone. I hope that the lessons I have learned will help future students in considering programs to further their medical education.

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Hosting the Fourth Annual Perry Outreach Program in Albuquerque, New Mexico

Christina Salas, PhD; Sahar Freedman, BA; Deana M. Mercer, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

The Perry Initiative was developed in 2009 to bolster the participation of women in orthopaedic surgery and engineering careers. Representatives from the organization fly to various cities in the United States to help lead an all-day event, the Perry Outreach Program, a hands-on workshop for high school-aged girls. We at The University of New Mexico (UNM) Department of Orthopaedics & Rehabilitation hosted our fourth annual event on Saturday, March 19, 2016. A group of volunteer physicians, residents, and medical and engineering students led about 35 participants in various modules and lectures. The goal of the program was to teach attendees about the intersection of medicine and engineering.

In the morning, Ann Mercer, MD (the mother of Dr. Deana Mercer, MD) intrigued sleepy teenagers with personal tales as a practicing doctor. Participants, residents, medical students, and attending physicians were all engaged in stories of mentorship, struggles, and humorous resolutions. Perhaps with a new perspective on working as a doctor, the attendees shuffled out of the conference room and into workshops on applying arm casts; dissecting a cadaveric hand (Figure 1), and using intramedullary (IM) nails and plates to mend fractured bones.

Figure 1. Ericka Garbrecht, MD, and Aditi Majumdar, MD (in green scrubs) lead the workshop on dissection of a cadaveric hand with forearm, showing participants what actually happens when you feel your pulse.

During lunch, Christina Salas, PhD, and her team of research engineers introduced into a delightful competition—featured for the first time at this year's event. Repaired bones of the IM nail module were tested for maximum strength, using a custom-made load frame (designed by several engineering students at UNM) that applied force until breakage of the bone occurred. The winning group had repaired the bone that withstood the most force (Figure 2). Deana Mercer, MD, joined Dr. Salas in explaining the clinical significance of the test: the type of fracture, region of bone surface, and angle and placement of the nail can drastically affect success of fracture treatment (Figure 3).

Figure 2. Winning group of three high-school participants (blue scrubs) and their medical-student leader, Jessica McGraw, (green scrub) after testing of the bone-implant constructs created in the IM nail module, which was spearheaded by Christina Salas, PhD (gray scrub). Shows custom-made load frame designed by engineering students Rachel Tufaro, (kneeling in black, left) Jodie Gomez, (kneeling in black, right) and Steven Nery (standing in black).

Figure 3. Christina Salas, PhD, (left) and Deana M. Mercer, MD, (right)—who together spearhead the Perry Outreach Program in Albuquerque—discuss the essential relationship between orthopaedic surgery and engineering. Reprinted with permission from the Perry Initiative.

Participants and volunteers soon transitioned into afternoon workshops, including repairing fractures of the distal radius, reconstructing torn knee ligaments, and suturing pig feet. The entire program came to a close with a question-and-answer session, which was attended by participants, their parents, and volunteers. Our next generation of biomedical professionals departed with goody bags, internship opportunities, and an understanding of the essential collaboration between surgeons and engineers (Figure 4).

Figure 4. All of the participants (blue scrubs) and volunteers (excluding those taking pictures!) of the Perry Outreach Program in Albuquerque, March 2016. Reprinted with permission from the Perry Initiative.

We wish to highlight a particular essay submitted to the Perry Initiative during the initial application process for our event, which was written by a high school student. We hope that the program in Albuquerque continues to support the goals and passions of future women—throughout all regions of New Mexico.

> Having been a young girl raised in arguably some of the most rural environments within this great state, I have witnessed the cultural neglect in regards to medicine. The lack of trust, of collaboration between our culture and the modern medical field. Those long mornings high up in the New Mexican timber inspired me to take a chance and attempt to make a change in the lives of the New Mexican people. Through pursuing a career in not only medical research but practicing the art itself, I aspire to reincorporate accountable, affordable, and accessible medicine into the vibrant culture of rural New Mexico. I may be young to have such aspirations, but it is my youth and my experiences therein that propel my dreams forward with a passion.
>
> I know that the path to success will be both a lengthy and strenuous one, which is why I have been seeking out programs that may aid me in taking the first step forward. The Perry Outreach Program is undeniably one of such key programs that can provide a link between my dreams and an educational-based reality. The opportunity to participate in this program will allow me to deepen my knowledge not only of the medical science field, but allow me to bridge the gap between education and culture. I will be surrounded by similar minds, by youths that have passions and aspirations harmonious with my own. Surrounded by people who are prepared to rise to the challenge of improving the quality not only of New Mexican medicine, but of enriching the culture of our communities.
>
> Across this state, underservice in the medical aspect exists. Just as with any relationship, neglect to communicate can be fatal. It is simply unhealthy. Our people have lost communication with modern medicine, and many places have an inability and lack of passion to do so. However, this suffering, this neglect can be changed. But it takes more than a pill, than a drug, than any form of common treatment. It calls for a movement. For a group of individuals with passion in their hearts to band together and make a change. I am such an individual, and the Perry Outreach Program will help me meet many more.
>
> I seek to incorporate affordable, accountable, and accessible medicine into the lives of all New Mexicans. Medicine that is affordable for the impoverished majority of our state citizens to care for themselves, for their children. To care confidently for the health and safety of loved ones without the fear of financial repercussions. Medicine that is accountable because, in times of crisis, medical professionals will offer hope to those in need, an alternative to the pain they live with. Medicine that is accessible to people living in the mountains, plains, and desserts of rural communities, so that they may obtain an interactive and beneficial relationship with medicine. A state in which medical help is localized. Where patients do not have to drive minutes, hours, or days to receive the support they crave. A state where, instead, medical aid is right outside the door, a central component of the community.

With this future blaring in my mind's eye, I desire to participate in this amazing opportunity. I know that it will provide a foundation for the building blocks I must set in place to obtain my goals for the greater good of not only my community, but my state, and my culture.

Lorena Velasquez, Junior in High School

Acknowledgments

We thank the following volunteers: Manuela Restrepo and Nicole Ray (Perry Initiative); Quincy Gonzalez (Summit Medical); Ann Mercer (Mercer Enterprise); Jessica Avila (New Mexico Institute of Mining and Technology); Julia Bowers, Joy Van Meter, Selina Silva, Thomas DeCoster, Angelina Rodriguez, Heather Menzer, Katherine Gavin, Ericka Garbrecht, Brielle Payne, and Aditi Majumdar (UNM Department of Orthopaedics & Rehabilitation); Mary Logue, Ericka Charley, Jessica McGraw, and Yvonne Talamantes (UNM School of Medicine); Rachel Tufaro, Jodie Gomez, Steven Nery, Neal Wostbrock, Rochelle Piat, Alexander Hamilton, and Christopher Buksa (UNM School of Engineering); and the many employees of UNM whose time and efforts in helping with initial planning made the program possible.

Funding

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The Groundwork and Legacy of Our First Chair, George E. Omer Jr, MD, 1970–1990

Thomas A. DeCoster, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

In the 1960s, Dr. George E. Omer Jr had considered offers to become chief of orthopaedics at prestigious institutions such as Vanderbilt University and the University of Texas Medical Branch at Galveston. However, both positions were in divisions of general surgery, and the division of hand surgery was dominated by plastics and general surgery rather than orthopaedics. Additionally, private practice opportunities existed in San Antonio, Texas, but offered no association with teaching or administration.

Dr. Omer's attention turned toward the West, and he viewed the infancy phase of The University of New Mexico (UNM) School of Medicine as a promising rather than dismal prospect. Furthermore, the location of the school itself appealed to him thanks to his life-long appreciation of New Mexico's colossal mountain views and his growing interest in Native American art. In 1970, Dr. Omer accepted an offer from Robert Stone (the school's dean) and Dr. James Weaver (chief of the orthopaedics division), who both wanted to preserve the fragile UNM orthopaedic residency program.

Orthopaedics as a Separate Department

Dr. Omer insisted that orthopaedic surgery was a crucial component of any hospital and requested department status. He supported "independent cooperation." A department of orthopaedics, encompassing general and subspecialty treatment, needed to be untethered of restraints to growth and scope of practice and have some free reign to provide the best possible education and patient care within the hospital.

According to Dr. Omer, "We can do something good if we put the right people in place and give them fundamental assistance. They will produce the results that will make us recognized and support future growth." His charisma and persistence fueled the process of establishing a new department.

A Clinical Enterprise

Obtaining departmental status was just the beginning. Dr. Omer saw residency training as the basis of a successful academic department and organized the existing clinical facilities of New Mexico into a cohesive medical group. UNM School of Medicine initally had no orthopaedic space whatsoever, with very little clinical activities at the affiliated hospital, Bernalillo County Medical Center (BCMC, Figure 1). However, several unaffiliated hospitals in the region provided orthopaedic care, and association with those entities could greatly benefit the new residency program at UNM.

As the first chairman, Dr. Omer incorporated these various institutions into forming the UNM orthopaedics department. These organizations included the Carrie Tingley Children's Hospital in Truth or Consequences; Veterans Affairs Hospital; Lovelace Hospital; Gallup Indian Medical Center; and the existing but limited clinical affiliation with BCMC (which became UNM Hospital in 1978).

For his first year as chairman, Dr. Omer was the only full-time, exclusively university-based orthopaedic surgeon; however, as relationships strengthened with the other hospitals, more doctors began working within the school in adjunct positions. These medical affiliations provided 1) regimented training beyond clinical apprenticeship to the new residency program; 2) an increased supply of orthopaedic physicians to New Mexico and the entire Western United States; and 3) a lasting academic and administrative foundation.

Figure 1. Bernalillo County Medical Center, which was renamed to The University of New Mexico Hospital in 1978.

Division of Hand Surgery

As the residency program and department administration became more established, Dr. Omer solidified the growing division of hand surgery and founded a hand fellowship—both being among the first in North America. Dr. Omer knew that an excellent reputation was necessary and emphasized high-quality tertiary care of hand injuries. By the end of Dr. Omer's tenure, the hand surgery division had become a flagship program and service at UNM Hospital (Figures 2A and 2B).

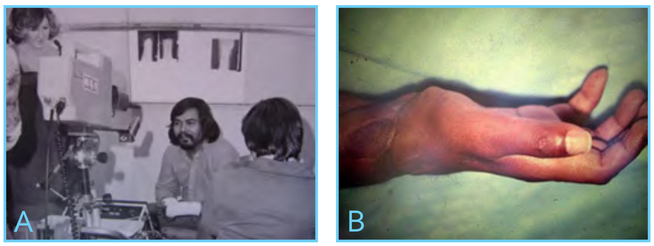


Figure 2. (A) Filming the first hand reattachment procedure in New Mexico performed in 1977, and (B) the hand.

Rehabilitation

When Dr. Omer negotiated for department status of the orthopaedics division, he had agreed to incorporate "Rehabilitation" in the title. During his first 3 years as chairman, however, limited clinical activity occurred in this service. Yet, as the hospital's reputation grew, so did the number of patients who needed rehabilitation.

Dr. Omer respected the work of physical and occupational therapists, which was crucial in the successful rehabilitation of young patients with musculoskeletal or hand injuries. Unfortunately, such a workforce was lacking in New Mexico. In response, in 1973, the BCMC organization was revised and Dr. Omer became chief of the physical medicine service. A division of physical therapy soon followed, created within the orthopaedics department.

That collaboration laid the groundwork for yet another division within the orthopaedics department: sports medicine. Dr. Omer worked with the UNM Athletics Department in recruiting faculty members for the sports medicine division (a lasting collaboration to this day). Sports medicine remains one of the most active and productive divisions within the orthopaedics department.

Legacy

Dr. Omer's career represents more than a half century of selfless dedication and exemplary commitment to improving the field of hand surgery and education of countless doctors (who now carry on his life's work as their own!) Dr. Omer earned and cherished the friendships of colleagues all over the world. These individuals recognize him as a pioneer in hand surgery and acknowledge that his skill, dedication, work ethic, and integrity have set him apart from his peers. The ongoing orthopaedic research within UNM—academic and clinical—continues to prosper under the enormous foundation established by Dr. Omer (Figure 3). For that, all who have followed him in the Department of Orthopaedics & Rehabilitation as faculty, residents, fellows, and staff owe him a deep debt of gratitude.

Figure 3. The University of New Mexico Department of Orthopaedics & Rehabilitation faculty members in 1997. First row, sitting, left to right: Drs. Richard Miller, Moheb Moneim, and Elizabeth Mikola. Middle row: Drs. George Omer, Frederick Sherman, James Fahey, and Keikhosrow Firoozbakhsh. Back row: Drs. Thomas Grace, Thomas DeCoster, Dennis Rivero, Daniel Wascher, Rick Gehlert, Christopher McGrew, Paul Echols, and Robert Schenck.

Acknowledgments

I would like to thank the following individuals whose influence on Dr. Omer, contributions to UNM Department of Orthopaedics & Rehabilitation, and overall impact in the field of orthopaedics made this paper possible: Colonel Milton Thompson; Dr. Harold Dunn; Dr. William Minear; Marleece Kendrick; Elizabeth Barnett; Julia Stephens; Dr. Bill O'Brien; Fred Rutan; Dr. Leon Griffin; LF "Tow" Diehm; Larry Willock; Dr. Charles Eberle; Dr. James Drennan; Dr. John Ritterbusch; Dr. Rod Hidalgo; Dr. Robert McRoberts; Dr. Marvin Hays; Dr. Donald Vichick; Dr. Gerald Demarest; Dr. Richard White; Dr. Dwight Burney; Dr. Frederick Sherman; Dr. Randall Marcus; Dr. Fred Balduini; Dr. Tom Bernasek; Dr. John Veitch; and Dr. Dan Downey.

My Tenure as Department Chair, 1990–2006

Moheb S. Moneim, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

George E. Omer, MD, the founder of the University of New Mexico (UNM) Department of Orthopaedics & Rehabilitation, stepped down in July 1990, after serving for 20 years. Dr. Leonard M. Napolitano (Dean, UNM School of Medicine) appointed me as interim chair for 6 months and, after a national search, as professor and chair in January 1991. I had the fortune of working with Dr. Omer since my arrival to UNM in 1976. At this time, many of the orthopaedic services in the country were placed in divisions of general surgery. That was not the case at UNM because Dr. Omer was successful in getting approval from the faculty senate to establish an orthopaedic department, including separate budget, faculty, residents, and administration.

The productivity of the UNM Health Sciences Center had tremendous growth in the 1990s, with the addition of the Ambulatory Care Center that housed faculty offices and added much-needed space for clinics. Furthermore, a new parking structure was built to improve patient access to the UNM Hospital. During this time, the mission and visions of the department were articulated.

In brief, the mission was to provide compassionate, comprehensive, and quality musculoskeletal care for the people of New Mexico and Four Corners region. The vision was to offer our patients advanced treatment by the alliance of patient-centered care, research incentives, resident education, and the expertise of faculty members in subspecialties of orthopaedic surgery. To help achieve these goals, I focused heavily on expanding full-time faculty positions (Figure 1).

With the aid of UNM Hospital and School of Medicine practice-plan organizations, funds were available to hire doctors with subspecialty qualifications. A structural chart helped establish divisions, sections, programs, and an administrative infrastructure. At this time, both physical and occupational therapy programs were housed in the department. In 2001, we consisted of 32 full-time faculty members (including physical and occupational therapists) and 83 volunteer faculty members from the providers in the community. Furthermore, when Carrie Tingley Hospital was moved to Albuquerque, a division of pediatric orthopaedics was organized.

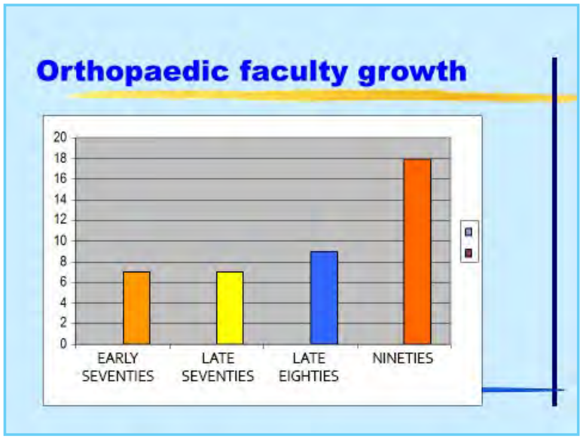


Figure 1. Expansion of faculty in the Department Orthopaedics & Rehabilitation, which increased from 7 members in the 1970s to 18 in the 1990s.

Research efforts were enhanced by establishing a biomechanics research laboratory and adding a full-time, PhD research faculty position. This was the beginning of collaboration with the UNM School of Engineering on north campus and encouraging a graduate program in biomechanics, which resulted in 20 peer-reviewed publications. Faculty members were encouraged to publish and present their scholarly work at regional and national meetings. Furthermore, a clinical track was established for faculty at the school of medicine to recognize high activity in clinical work and education. The microsurgery teaching laboratory (established in 1977), the offering of replantation procedures for treating severed extremities, and the successful surgical re-attachment of a completely severed hand continued to attract applicants to the Hand Fellowship Program. The inclusion of microsurgery continues to be a valuable clinical and educational aspect of the program.

Clearly, there was a need to expand clinic space and hospital access to better care for our patients. In recognition of the added value to both the patients and hospital, the Outpatient Surgery and Imaging Services (commonly known as OSIS) was opened in September 2003 (Figure 2). Finally, through the collaboration of the school of medicine, hospital, and department, an offsite specialty clinic located on Medical Arts Avenue was incorporated in 2004.

The challenges met, during these 17 years, were the recruitment of outstanding faculty members (Figure 3);

improved hospital market share by adding clinics and operating rooms; the addition of fellowships in trauma and sports medicine; and furthering research efforts by hiring a full-time PhD and encouraging a graduate program in biomechanics.

Figure 2. The opening of the Outpatient Surgery and Imaging Services (known as OSIS) in 2003.

Figure 3. Faces of the outstanding, full-time faculty members in 2005. Left to right, listed by orthopaedic subspecialties (unless otherwise noted): top row includes oncology, spine, adult reconstruction, foot and ankle, and research; second-to-top row, hand; middle row, pediatrics; second-to-bottom row, sports medicine; bottom row, first two faculty members in trauma, last two worked at the Veterans Affairs Hospital.

As I reflect on my tenure as department chair, I feel fortunate that I spent 17 years in that position. It has been said that being a department chair in an academic medical school is the best leadership position there is. A chair is free to allocate time between clinical care, research, administrative responsibilities, and UNM Health Sciences Center outside departmental boundaries. My additional positions as chief of the medical staff, president of the UNM Medical Group, and member of the UNM Hospital Board enabled me to help the medical school community in many areas, advocating for the entire faculty and community at large.

Faculty recruitment and retention have been some of my primary goals, as faculty members are the foundation of a successful enterprise. They can create a productive and healthy environment to serve the community and train future orthopaedic surgeons. Although one can often feel lonely at the top—especially when fundamental decisions need to be made—I greatly appreciate this opportunity given to me.

My Chair Story: Listening with Leadership, 2006–Present

Robert C. Schenck Jr, MD

Department of Orthopaedics & Rehabilitation, The University of New Mexico Health Sciences Center

I moved the Schenck clan to Albuquerque, New Mexico, in August 2000. Driving into Bernalillo, my youngest son, George, aged 7, woke up and asked me, "You moved us to the desert?" Indeed, we moved to the 505 and The University of New Mexico (UNM) to lead the Sports Medicine Division and Lobo Athletics, while also fulfilling my dream of working with Division I Football and living near a beautiful mountain, similar to the one I had grown up with in Colorado. In addition to loving the climate and beauty of the Sandia Mountains, I quickly worked on making great relationships with UNM coaches and athletes, especially after one of my friends (who used to coach high school football), Rocky Whitworth, paid a visit to Lobo Land to see his old college teammate, Coach Rocky Long.

My first 7 years as head team physician for the UNM Lobos resulted in some of my most pleasant memories at UNM—traveling with the football team, working in the training room, and putting my personal touch on occasionally strained relationships. The faculty members, staff members, and students behind UNM Athletics were amazingly kind to the Schenck family, allowing me to have an unforgettable experience (Figure 1). My surgical practice in sports medicine was extremely rewarding and added to what I call, "happy at work." Together with my wife, Trish, and the Schenck children (Lillian, Gus, Helen, George, and Marian, who all graduated from Sandia High School), I enjoyed New Mexico and the Southwest immensely. It was bittersweet when Trish and I became Burque empty nesters in 2011 (Figure 2).

Figure 1. The University of New Mexico football game of 2006 in War Memorial Stadium, Laramie, Wyoming. The Lobos beat the Wyoming Cowboys, 20-16. Coach Rocky Long came up to me while the field was being plowed and said, "You love this stuff!"

Figure 2. The last Schenck family photograph before the nest dispersed at our home on Osuna road. Left to right: Marian, Helen, myself, Trish, Lillian, Gus, and George.

During my first few years, Dr. Moheb "Mo" Moneim would refer to me as a "cheerleader," and more than once asked if I would consider being chairperson when he was ready to step down. I had already been offered the position at The University of Texas at San Antonio in the late 1990s, but knowing I wanted to move closer to the mountains and drier climate, I had declined the opportunity. Both Mo and Dr. George Omer (the first chair of UNM orthopaedics) were persistent, and I accepted the position in December 2005.

UNM had and has a phenomenal orthopaedic residency program. My main vision, as chair, was to improve upon this already well-established curriculum with a more user-friendly emphasis, and thereby help make it even greater. In the past 10 years, I believe I have accomplished that, thanks to amazing faculty members, residents (whom I refer to as junior-junior faculty), and an essential combination of leadership with listening.

Leadership has many definitions, which are described in countless book titles to read. But the ability to actively listen, take time to reflect, and act—all the while doing the right thing—was a process that I had used successfully for years, even since my days of student government in high school. In addition to re-reading Dale Carnegie's book, *How to Win Friends and Influence People,* I was referred to Jim Collins' publication, *Good to Great*. In a nutshell, this concept of "G2G" speaks to an atmosphere of creating greatness from an already "good" program by making new leaders . . . stressing responsibility and freedom for junior leaders to make decisions, with the CEO (or chair) taking responsibility for mistakes while acknowledging the victories to those working. In essence, Collins noted the companies that moved from "good to great status" had a leader who would look out the window when crediting successes (never say, "I accomplished it," and always point to those responsible) and, most importantly, the leader needed to look into the mirror for blame. If pressed on to accept responsibility for a success (I have incorporated the following solution personally), the leader uses the adage, "I guess we got lucky." I have strived to be this humble leader and acknowledged achievements to our faculty. Let us all adopt the G2G approach in moving forward.

This approach can pose problems. Occasionally, the G2G method is interpreted as a weakness, not unlike taking the time to listen and think before speaking and acting. But my Western roots and upbringing were directly in line with this philosophy. I also found the concepts easy to incorporate within this department (or "Orthopaedic family," as we often say at UNM), especially with our faculty and residents (Figure 3). Anyone leading or creating a cultural change faces challenges, and finding a roadmap as I did in the idea behind G2G can be very useful (Figures 4 and 5).

Lastly, I think listening is the most important part of my work, particularly when turning problems into successes. Active listening, as we teach in medical school with patients, is ultimately crucial in defining what the challenge is . . . furthermore, this kind of listening solves the issue in the majority of circumstances, often by just letting someone speak about the issue. Finally, you must take time daily for exercise, or just get outside and take a walk. It is during those moments in which the most amazing solutions simply appear or, at least, your problems do not seem so difficult.

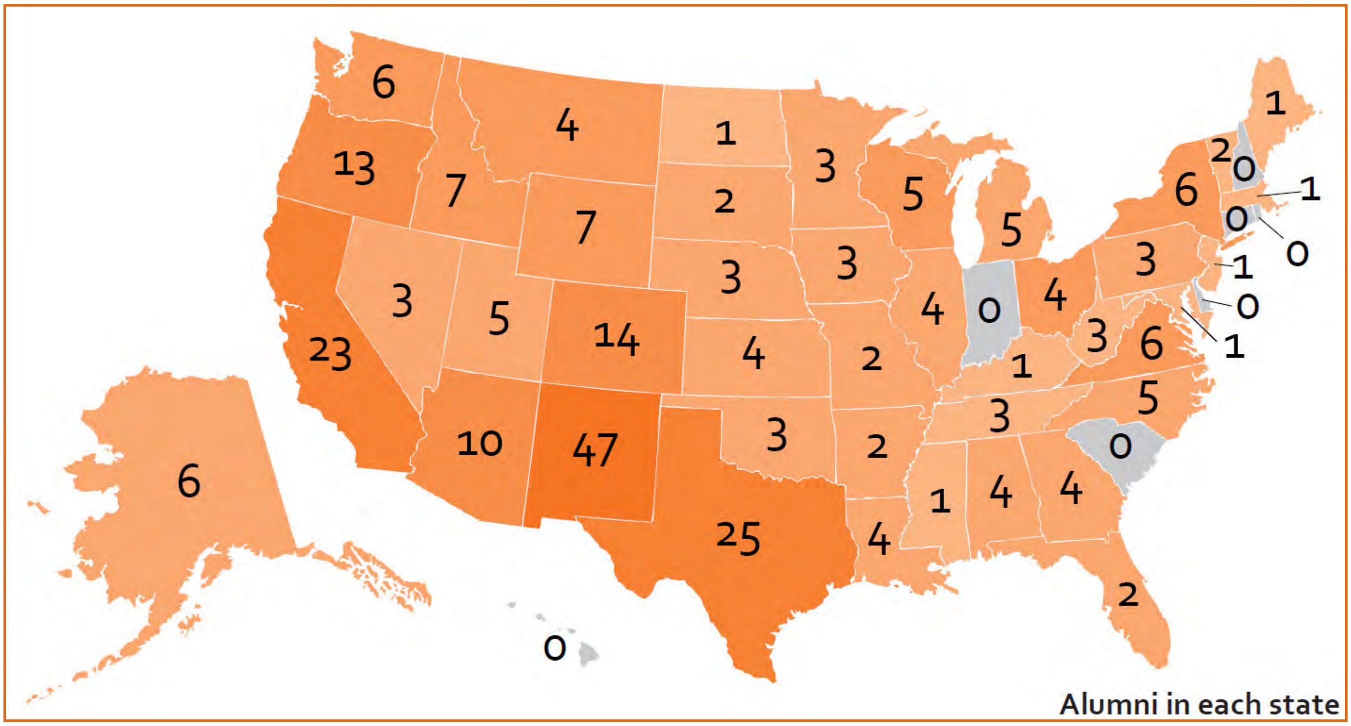
Some final thoughts as I look to the bright future of UNM Department of Orthopaedics & Rehabilitation. For other much younger leaders, I have a few precious nuggets of wisdom that may be useful—adopted from Bartlett's Familiar Quotations, Joel Osteen, and yours truly.

> No one is in charge of your happiness but
> you—and it is a daily decision.
> When it comes to going after what you love in
> life, don't take no for an answer.
> Love problems, they create your future.
> When solving problems, "no" is often the first
> answer before "yes."
> As a leader, always say yes to an idea.
> When in doubt, take the next small step.

Figure 3. Women faculty members and residents of The University of New Mexico (UNM) Department of Orthopaedics & Rehabilitation ("UNM Ortho Women.") in 2013. I wanted a billboard with this picture that ran, "Our Ortho Women Are Better Than Your Ortho Men." UNM freaked out, saying that I was just bragging . . . no kidding.

Figure 4. Residents and family of the Department of Orthopaedics & Rehabilitation, on a hike at the top of the Sandia Mountains in fall 2012. Any orthopaedic program is only as good as the residency program, which should be memorable and fun.

Figure 5. Our department's residents and I in 2010, paint balling out by the Double Eagle II Airport in Albuquerque.



University of New Mexico Department of Orthopaedic Surgery Alumni

Hand Surgery Fellows

Damon Adamany (AZ) 2007
Ahmed Afifi (OH) 2008
Jeffrey Aldridge (OR) 1987
Valdemar Ascencio (CA) 1984
John Bax (WI) 1985
William Blair (TX) 1979
John Bolger (WI) 1980
Daniel Boudreau (TX) 1973
Boyd Bowden* 1972
Bradlet Britt* 1984
Mark Buchman (NE) 1989
Randy Bussey (CO) 1980
David Capen (TX) 1975
Edwin Castaneda (IA) 1988
James Clark (NM) 2013
Anthony Dalton 1980
Cory Calston (NM) 2014
Alex de Carvalho (KS) 2005
William Doherty (MA) 1993
Gregory Duncan (CA) 1992
Thomas Eiser (OK) 1979
Edgardo Espirtu (TX) 1985
Hani Fahmy (EG) 1993
Ronald Ford (MI) 1997
Bruce Freedman (VA) 1988
Eric Freeh (NM) 1983
Bonnie Fraser (NV) 2007
Jeffrey Garst (IL) 1994
David Gerstner (MI) 1988
Richard Gobeille (NM) 1985
Douglas Gordon (OH) 1987
Matthew Green (UT) 2012
Dominic Gross (ID) 1997
Robert Hamas (TX) 1974
Conrad Hamilton (NM) 2011
Terry Happel (AZ) 1986
John Hayden (AZ) 1983
Aaron Hoblet (OR) 2013
Karl Hofammann (AL) 1983
Thomas Howey (SD) 1992
Jing Hsien (CA) 1986
Patrick Hudson (NM) 1978
Davis Hurley (CO) 2003
Tariq Hussain (NY) 2002
Perry Inhofe* 1994
William Irey (IA) 1982
Glenn Johnson (MN) 1998
Jann Johnson (CA) 1984
David Johnston (CANADA) 1995
Terrell Joseph (CO) 2006
Jon Kelly (CA) 1993
Alan Koester (WV) 1995
Shankar Lakshman (CA) 2004
Scott Langford (MO) 2000
Kenna Larsen (NM) 2009
Thomas Lehman (OK) 2002
Charles Leinberry (PA) 1990
Andrea Lese (WV) 2015
David Long (OR) 1971
Paul Luce (MI) 1999
Joseph Mann (CA) 1981
Matthew Martin (MI) 2014
Deana Mercer (NM) 2010
Elizabeth Mikola (NM) 2001
Gary Miller (MO) 1986
Steven Miller (AZ) 2009
Robert Morrow (LA) 1980
Anastasos Mourikas (GR) 2004
Louis Murdock (ID) 1996
Abdul Mustapha (OH) 2000
Thomas Narsete (TX) 1981
William Niedermeier (WI) 1979
Gavin O'Mahony (OK) 2012
Gerald Olmstead (WA) 1971
Don Oschwald (NC) 1985
Larry Patton (UT) 1979
Ralph Pennino (NY) 1986
Charles Phillips (FL) 1971
Jeffrey Pokorny (NC) 2002
Ram Prabhakar (CA) 1980
Charles Pribyl (NM) 1989
Milos Radwick (MD) 1971
Michael Ravitch (NV) 1974
Allison Richards (NM) 2008
Hector Rosquete* 1990
John Russin (NM) 1984
Robert Saide (AZ) 1983
Ehab Saleh (MY) 2005
Scott Schemmel (IA) 1987
Joseph Serota (CO) 1983
Swati Shirali (VA) 1999
Victoria Silas (WA) 1996
Richard Sleeper 1988
Duret Smith (OH) 1982
Osama Suliman (FL) 1985
Scott Swanson (CO) 2010
Steven Taylor (WI) 2006
Ronald Tegtmeier (KS) 1976
Kenneth Teter (KS) 1993
Norfleet Thompson (TN) 2015
Erik Torkelson* 1984
James Trusell (AR) 1973
Gregory Voit* 1996
Catherine Walsh (CA) 2011
Howard Weinberg 1978
InSok Yi (CO) 1998

Robert Yoo (MA) 1977
Steven Young (IL) 2001
Elmer Yu 1979

Sports Medicine Fellows

Roy Abraham (IA) 2006
Tamas Bardos (HUNGARY) 2015
Todd Bradshaw (TX) 2014
Blake Clifton (CO) 2015
Lindsey Dietrich (TX) 2014
Matthew Ferguson (TX) 2013
John Jasko (WV) 2010
Adam Johnson (NM) 2012
A. John Kiburz (NM) 2009
John Mann (AL) 2010
Ben Olson (CO) 2002
Toribio Natividad (TX) 2011
Ralph Passerelli (PA) 2007
Brad Sparks (AK) 2008
Brad Veazey (TX) 2007
Jonathan Wyatt (AR) 2012

Trauma Fellows

Stephen Becher (GA) 2014
Shahram Bozorgnia (GA) 2008
Max de Carvalho (MN) 2011
Fabio Figueiredo (ME) 2007
Shehada Homedan (NY) 2006
Victoria Matt (NM) 2005
Gary Molk (WY) 2010
Urvij Modhia (NM) 2013
Leroy Rise (NM) 2012
Ahmed Thabet (TX) 2015
Zhiqing Xing (AL) 2009

Residents

Alexander Aboka (VA) 2011
Christopher Achterman (OR) 1977
Brook Adams (TX) 2011
Zachary Adler (CA) 2007
Amit Agarwala (CO) 2002
Owen Ala (AK) 2013
Lex Allen (UT) 2002
Alan Alyea (WA) 1986
Frederick Balduini (NJ) 1981
Adam Barmada (OR) 2001
Jan Bear (NM) 1991
Jeremy Becker (OR) 1997
Kambiz Behzadi (CA) 1994
Robert Benson (NM) 1973
Eric Benson (NM) 2007
Ryan Bergeson (TX) 2008
Thomas Bernasek (FL) 1986
C. Brian Blackwood (CO) 2011
David Bloome (TX) 2001
Dustin Briggs (NM) 2013
William Burner (VA) 1980
Dwight Burney (NM) 1980
Dudley Burwell (MS) 1987
Dale Butler (CA) 1973
Everett Campbell (TX) 1973
Bourck Cashmore (AZ) 1997
Richard Castillo (NM) 1988
Zachary Child (TX) 2011
Joel Cleary (MT) 1985
Mitchell Cohen (CA) 1992
Harry Cole (WI) 1992
Matthew Conklin (AZ) 1988
Clayton Conrad (NM) 2009
Geoffrey Cook (AZ) 1988
David Cortes (WA) 2005
Mark Crawford (NM) 1994
Aaron Dickens (NV) 2013
Grant Dona (LA) 1993
Daniel Downey (MT) 1992
Shakeel Durrani (NC) 2010
Paul Dvirnak (CO) 1996
Paul Echols (NM) 1978
Daniel Eglinton (NC) 1983
Scott Evans (VA) 2015
James Fahey (NM) 1978
James Ferries (WY) 1995
Thomas Ferro (CA) 1990
Jennifer FitzPatrick (CO) 2010
John Franco (NM) 2003
John Foster (NM) 1974
Orlando Garza (TX) 1977
Jan Gilmore (NM) 2012
Jenna Godrey (CA) 2014
Robert Goodman (CO) 1980
Stan Griffiths (ID) 1989
Speight Grimes (TX) 2004
Christopher Hanosh (NM) 2001
Gregg Hartman (CA) 1997
Robert Hayes* 1975
William Hayes (TX) 1996
David Heetderks (MT) 1990
Thomas Helpenstell (WA) 1991
Fredrick Hensal (AL) 1982
Bryon Hobby (NM) 2012
Daniel Hoopes (UT) 2013
David Huberty (OR) 2005
Sergio Ilic (CA) 1977
Kayvon Izadi (NE) 2008
Felix Jabczenski (AZ) 1989
Taylor Jobe (VA) 2014
Robert Johnson (ND) 1981
Orie Kaltenbaugh (ID) 1978
Daniel Kane (IL) 1977
David Khoury (WY) 2007
Roger Klein (CA) 1984
Dennis Kloberdanz (NM) 1988
Ken Korthauer (TX) 1985
John Kosty (TX) 1983
Sean Kuehn (TN) 2015
Letitia Lansing (AZ) 2010
Loren Larson (WA) 2006
Earl Latimer (NM) 1993
Robert Lee (ID) 1995
Corey Lieber (CA) 2006
Peter Looby (SD) 1995
Joel Lubin* 2001
Norman Marcus(VA) 1983
Charley Marshall (UT) 2005
Roberto Martinez (FL) 1984
Victoria Matt (NM) 2002
Timothy McAdams (CA) 2000
Victoria McClellan (OR) 1984
Seth McCord (AK) 2014
Thomas McEnnerney (NM) 1984
Kevin McGee (NM) 2008
Laurel McGinty* 1991
Michael McGuire (NE) 1995
Matthew McKinley (NM) 1998
Deana Mercer (NM) 2008
Richard Miller (NM) 1990
Brent Milner (WY) 2003
Frank Minor (CA) 1982
Rosalyn Montgomery (OR) 1991
Kris Moore (OR) 2008
Nathan Morrell (RI) 2014
Ali Motamedi (TX) 1998
David Munger (AZ) 1969
Fred Naraghi (CA) 1981
Joseph Newcomer (IL) 1998
Lockwood Ochsner (LA) 1986
Charlotte Orr (NM) 2014
Andrew Paterson (NM) 2004
L. Johnsonn Patman (NM) 2012
William Paton (AK) 1977
Matt Patton (NM) 2002
Chris Peer (MO) 2005
Eugene Pflum (CO) 1976
Dennis Phelps (CO) 1985
Gregg Pike (MT) 2004
Mario Porras (NV) 1977
Julia Pring (PA) 2009
Jeffrey Racca (NM) 2000
Shannah Redmon (AZ) 2009
Stephen Renwick (OR) 1994
Jose Reyna (NM) 1983
Allison Richards (NM) 2002
Dustin Richer (VA) 2015
Brian Robinson (NM) 1998
Peter Rork (WY) 1984
Kenneth Roth (CA) 1967
Michael Rothman (NM) 1974
David Rust (MN) 2012
Peter Schaab (AK) 1990
Ted Schwarting (AK) 2003
Jonathan Shafer (WA) 2006
Sanagaram Shantharam (CA) 1992
Paul Shonnard (NV) 1995
Selina Silva (NM) 2010
Robert Simpson (NY) 1976
James Slauterbeck (VT) 1993
Christopher Smith (WY) 1974
Dean Smith (TX) 2000
Jason Smith (LA) 2007
Robert Sotta (OR) 1987
Richard Southwell (WY) 1980
Daniel Stewart (TX) 2012
Greg Strohmeyer (CA) 2015
Christopher Summa (CA) 1995
Kenneth Teter (KS) 1993
Eric Thomas* 2004
Gehron Treme (NM) 2006
Krishna Tripuraneni (NM) 2009
Randall Troop (TX) 1989
William Tully (CA) 1972
Cathleen VanBuskirk (CO) 1999
Tedman Vance (GA) 1999
Andrew Veitch (NM) 2003
John Veitch* 1978
Edward Venn-Watson (CA) 1975
Eric Verploeg (CO) 1987
Joseph Verska (ID) 1994
David Webb (TX) 1977
Richard White (NM) 1979
John Wiemann (OH) 2011
Michael Willis (MT) 2000
Bruce Witmer (CA) 1982
Heather Woodin (AZ) 2015
Jeffrey Yaste (NC) 2009

*Deceased

Journal Submissions

The University of New Mexico Orthopaedics Research Journal Submission Instructions for Authors

The University of New Mexico Orthopaedics Research Journal (UNMORJ) highlights research done by the faculty, fellows, residents, students, staff, and alumni associated with the UNM Department of Orthopaedics & Rehabilitation.

General Policies

Articles are accepted for exclusive publication in the UNMORJ; previously published articles are not accepted.
Each author warrants that his or her submission to the journal is an original work.
All reports of prospective clinical trials submitted for consideration for publication must have been registered in a public trial registry such as clinicaltrials.org.
All manuscripts describing a study with human subjects must include a statement that the subjects provided informed consent to their participation and that the study was approved by an institutional review board.
All manuscripts describing a study in animals must include a statement that the study was approved by an institutional animal use committee.
The UNMORJ uses the criteria for authorship of the International Committee of Medical Journal Editors (ICMJE). That is, all persons designated as authors must (1) make substantial contributions to the conception and design of the work or the acquisition, analysis, or interpretation of data; and (2) draft the manuscript or revise it critically for important intellectual content; and (3) provide final approval of the version of the manuscript to be published; and (4) take responsibility for all aspects of the work, especially with respect to its accuracy and integrity.
All sources of financial support for research described in a submitted manuscript must be identified on the title page.
The UNMORJ does not require authors of articles published in the journal to assign copyright to the journal; copyright is retained by the authors.

Manuscript Format

The UNMORJ invites submission of the following types of original articles: reports on clinical or basic science research, case reports (including case series), reviews, technical notes, and reflections.
Manuscripts must be submitted as Microsoft Word documents. Use Times New Roman 12-point typeface and double space everything, including the list of references and the tables. Use 1-inch margins on the top, bottom, and both sides of each page. Do not justify the right-hand margin; use "ragged right." Number all pages in the manuscript continuously, beginning with the title page, in the upper right-hand corner. With some minor exceptions, the UNMORJ follows the style, format, and usage guidelines described in the *AMA Manual of Style* (10th edition).

Title Page

Titles of manuscripts should be concise, specific, and informative. Do not use abbreviations in the title.
Aside from the title, the title page should include (1) the authors' full names, highest academic degrees, and affiliations; (2) the name and address of the corresponding author, including his or her telephone number, fax number, and email address; and (3) any sources of funding for the research described.

Abstract

An abstract must be included on the second page of the Word file containing the manuscript. Abstracts of original-research reports and reviews are limited to 250 words; abstracts of case reports and technical notes must be no longer than 150 words. Original-research reports require a structured abstract with the following headings: Background/Purpose, Methods, Results, and Conclusions. Reviews, case reports, and technical notes do not require a structured abstract.

Text

Define all abbreviations at first mention. Use generic names for drugs and SI units for measurements.

Original-Research Reports

Original-research reports are limited to 2500 words, excluding the reference list, with the text organized under the following headings: Introduction, Methods, Results, and Discussion. Include a paragraph describing the limitations of the study at the end of the discussion section. No more than 25 references should be cited.

Case Reports

Case reports should be no longer than 1200 words, excluding the reference list, with the text organized under the following headings: Introduction, Case Report(s), and Discussion. Case reports should not contain an extensive review of the literature; the maximum number of references is 25.

Reviews

The maximum length of a review is 3200 words, excluding the reference list, which is limited to 40 references. The headings used depend on the topic.

Technical Notes

Technical notes describe a modification of, or a helpful "tip" for, a previously documented procedure. Technical notes are limited to 1200 words, excluding the reference list, with the text organized under the following headings: Introduction, Technique, and Discussion. Technical notes should not contain an extensive review of the literature; the maximum number of references is 15.

Reflections

The UNMORJ also welcomes submission of opinion essays and personal reflections on orthopaedic-related topics. Abstracts, acknowledgments, and structured headings are not required, although tables, figures, and references are accepted. Reflections are limited to 1000 words, excluding the reference list, and adhere to the basic formatting style for manuscripts.

Acknowledgments

The acknowledgments section is placed at the end of the text, before the new page on which the reference list begins. People listed in the acknowledgments section are those who helped with some aspect of the reported research but do not meet the criteria for authorship described above. Examples of those who might be acknowledged are statisticians, laboratory technicians, physicians who contributed patient data but were not involved in the study design or preparation of the manuscript, administrators who secured funding for the research, and people who provided writing or editorial assistance.

References

All references must be cited in the text of a manuscript, in the order of their mention in the text, by using a superscript number. The reference list should not be alphabetized. "Personal communications" cannot be included on the list of references.

The reference list should begin on a new page placed after the end of the text of the manuscript. References are to be formatted in AMA style except that the abbreviations for journal titles and book titles are not italicized, there is no period after the abbreviation, and the complete number of the last page of the reference is not given (for example, use 345-9 instead by 345-349). Use the abbreviations for journal titles specified by the National Library of Medicine (PubMed). The names of all authors of each reference should be provided unless there are more than six, in which case the names of only the first three are given, followed by "et al." Examples of the UNMORJ reference style are shown below:

Journal Article

Coughlin MJ, Schenck RC Jr, Grebing BR, Treme G. Comprehensive reconstruction of the lateral ankle for chronic instability using a free gracilis graft. Foot Ankle Int 2004;25(4):231-41.

Cheema T, Salas C, Morrell N, Lansing L, Reda Taha MM, Mercer D. Opening wedge trapezial osteotomy as possible treatment for early trapeziometacarpal osteoarthritis: a biomechanical investigation of radial subluxation, contact area, and contact pressure. J Hand Surg Am 2012;37(4):699-705.

Nakamura K, Hirachi K, Uchiyama S, et al. Long-term clinical and radiographic outcomes after open reduction for missed Monteggia fracture-dislocations in children. J Bone Joint Surg Am 2009;91(6):1394-404.

Book Chapter

Schon LC, Mann RA. Diseases of the nerves. In: Coughlin MJ, Mann RA, Saltzman CL, eds. Surgery of the Foot and Ankle. Vol 1. 8th ed. Philadelphia, PA: Mosby Elsevier; 2007:613-85.

Entire book

Tile M. Fractures of the Pelvis and Acetabulum. 2nd ed. Baltimore, MD: Williams & Wilkins; 1995.

Graphic Elements (Tables and Figures)

Tables and figures should complement, not duplicate, the text of a paper. Neither the tables nor the figures are embedded within the text of the manuscript: the tables are placed at the end of the Word file, whereas the figures are submitted separately as graphic files.

Tables

Tables are placed in the Word document after the reference list, with one table to a page. Use the Word table function, not PowerPoint or a spreadsheet, to compose tables. Each table must be numbered (Arabic numerals) and have a title at the top.

Figure Legends

All figure legends must be placed together, in the order of their citation in the text, on the last page of the Word document containing the text and tables. The figure legends should not be placed on the figures themselves. All figures must be numbered (Arabic numerals). Figures can have more than one part (for example, Figure 1A, Figure 1B, etc).

Figures

Each figure must be submitted separately in EPS, TIFF, PPT, or JPEG format.

Magnification, internal scale markers, and stains must be included on the figures when appropriate. Make sure that any information that could be used to identify a patient has been removed from photographs or other images.

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