CURRICULUM VITAE

DANIEL KHARRAZI, M.D.

Kerlan-Jobe Orthopaedic Clinic
6801 Park Terrace
Los Angeles, CA 90045
(310) 665-7205
Fax: (310) 215-3966

CURRENT AFFILIATION:

ORTHOPAEDIC SURGEON
KERLAN-JOBE ORTHOPAEDIC CLINIC
(1999 to present)

BUSINESS ADDRESSES:

Kerlan-Jobe Orthopaedic Clinic

6801 Park Terrace, Los Angeles, CA 90045

301 North Lake Ave., Suite 201, Pasadena, CA 91106

2400 East Katella Ave., Suite 400, Anaheim, CA 92806

FELLOWSHIPS:

SPORTS MEDICINE FELLOWSHIP
Kerlan-Jobe Orthopaedic Clinic,
Los Angeles, CA

(August 1998-August 1999)

ADULT HIP AND KNEE RECONSTRUCTION FELLOWSHIP
Kerlan-Jobe Orthopaedic Clinic,
Los Angeles, CA
(January 1998-August 1998)

ACADEMIC APPOINTMENTS:

STAFF ORTHOPAEDIC SURGEON
ORTHOPAEDIC TRAUMA SERVICE
HARVARD MEDICAL SCHOOL, BOSTON, MA
Massachusetts General Hospital
(July 1997-December 1997)

RESIDENCY PROGRAM:

HARVARD COMBINED ORTHOPAEDIC SURGERY RESIDENCY PROGRAM
HARVARD MEDICAL SCHOOL, BOSTON, MA
Massachusetts General Hospital, Boston, MA
Brigham and Women's Hospital, Boston, MA
Beth Israel Hospital, Boston, MA
Children's Hospital Medical Center, Boston, MA
(July 1993-July 1997)

INTERNSHIP:

HARVARD SURGICAL SERVICE
HARVARD MEDICAL SCHOOL, BOSTON, MA

New England Deaconess Hospital, Boston, MA
General surgery Internship
Outstanding General Surgical Resident Award
(July 1992-July 1993)

EDUCATION:

UNIVERSITY OF CALIFORNIA,
SAN FRANCISCO
SCHOOL OF MEDICINE
Doctor of Medicine
Alpha Omega Alpha
UCSF School of Medicine Outstanding
Graduate, Class of 1992
USCF School of Medicine Alumni-Faculty
Association Academic Excellent Award
(1988-1992)

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Bachelor of Science, Biochemistry
Phi Beta Kappa
Summa Cum Laude
Highest departmental Honors,
Department of Chemistry & Biochemistry,
U.C.L.A.
U.C.L.A. College of Letters & Science Honors
Golden Key National Honor Society
(1984 - 1988)

CERTIFICATION:	Diplomate National Board of Medical Examiners- 1993 Massachusetts Medical License Number 180852- 1995 California Medical License Number G 083471- 1996 Diplomate, American Board of Orthopaedic Surgery Member, American Academy of Orthopaedic Surgeons Qualified Medical Evaluator, Industrial Medical Council, State of California Agreed Medical Evaluator
BOARD CERTIFICATION:	Diplomate, American Board of Orthopaedic Surgery Fellow, American Academy of Orthopaedic Surgeons Diplomate of the National Board of Medical Examiners
LICENSURE:	State of California Medical License (No. G 083471)
HOSPITAL APPOINTMENTS:	Kerlan-Jobe/ Surgery Center, Los Angeles, CA Centinela Hospital Medical Center, Inglewood, CA Century City Hospital, Los Angeles, CA Anaheim Memorial Hospital, Anaheim, CA

PROFESSIONAL MEMBERS:	American Board of Orthopaedic Surgery American Academy of Orthopaedic Surgeons American Orthopaedic Society for Sports Medicine California Orthopaedic Association
PROFESSIONAL APPOINTMENTS:	Kerlan-Jobe Orthopaedic Clinic -Los Angeles, California -Anaheim, California -Pasadena, California
ORTHOPAEDIC CONSULTANT:	Los Angeles Lakers Basketball Los Angeles Sparks WNBA Team Los Angeles Dodgers Baseball Los Angeles Angels of Anaheim Baseball Los Angeles Kings Hockey Anaheim Ducks Hockey
HONORS AND AWARDS:	Alpha Omega Alpha (AOA) Honor Medical Society *Summa Cum Laude* Graduate, UCLA Phi Beta Kappa National Honor Society UCLA College of Letters and Science Honors Program
RESEARCH: (1992-Present)	Various topics in orthopedic surgery with specific

attention to shoulder, elbow and knee reconstructive and arthroscopic surgery(see publications)

(1990-1992)

Shriners Hospital for Crippled Children,
San Francisco, California
Orthopaedic Biomechanics Laboratory
Assessment of pre and post-operative gait in children with spastic cerebral palsy treated with selective posterior rhizotomy.

(1989)

UCLA School of Medicine
Department of Surgery, Division of Surgical Oncology
Utilization of a radioimmunoassay of quantitate H2 receptors on melanoma cells (using various cell lines) and investigation of modulation of these receptors by H2 blocking drugs.

(1987-1988)

UCLA School of Medicine
Division of Clinical Immunology and Allergy
Investigation of the nature and effect of humeral factors on synthesis of immunoglobulins by B cell lines.

(1986)

Department of Chemistry & Biochemistry UCLA
UCLA Division of Honors Research Grant Award
Investigation of the biochemical nature of the phagocytic anti-microbial activity of polymorphonuclear leukocytes.

PUBLICATIONS:

Kharrazi, FD, Rodgers, WB, Waters, PM, Koris, MJ. Dislocation of the Elbow Complicated by Arterial Injury. Reconstructive strategy and functional outcome. *Am J Orthop* 1995 May; Suppl: 11-5.

Rodgers, WB, **Kharrazi, FD,** Waters, PM, Kennedy, JG, McKee, MD, Lhowe, DW.The Use of Osseous Suture Anchors in the Treatment of Severe, Complicated Elbow Dislocations. *Am J Orthop.* 1996 Nov; 25(11): 794-8.

Kharrazi, FD, Rodgers, WB, Kennedy, JG, Lhowe, DW. Parturition-Induced Pelvic Dislocation: A Report of Four Cases. *J Orthop Trauma* 1997 May; 11(4): 277-81: discussion 281-2. Erratum in: J Orthop Trauma 1997 Oct; 11(7): 543.

Kharrazi, FD, Rodgers, WB, Kennedy, JG, Coran, DL, Kassar, JR, Hall, JE. Protrusio Acetabui and Bilateral Basicervical Femoral Neck Fractures in a Patient with Marfan Syndrome. *Am J Orthop. 1997 Oct; 26(10): 689-91.*

Rodgers, WB, Coran, DL, **Kharrazi, FD,** Hall, JE, Emans, JB. Increasing Lordosis of the Occipitocervical Junction after Arthrodesis in Young Children: the Occipitocervical Crankshaft Phenomenon. *J Pediatr Orthop.* 1997 Nov-Dec; 17 (6): 762-5.

Kharrazi, FD, Chandler, RW, Spitzer, Al. Supracondylar Periprosthetic Femur Fractures Following Total Knee Arthroplasty. *Current Opinion in Orthopedics* 1999; 10: 27-33.

Hornicek, FJ, Gebhardt, MC, Wolfe, MW, **Kharrazi, FD,** Takeshita, H, Parekh, SG, Zurakowski, Mankin, HJ. P-Glycoprotein Levels Predict Poor Outcome in Patients with Osteosarcoma. *Clin Orthop, 2000; 373: 11-17.*

Kharrazi, FD, Chandler, RW, Spitzer, Al. High Tibial Osteotomy for the Treatment of Unicompartmental Arthrostis of the Knee. *Current Opinion in Orthopedics* 2000; 1:26-34.

Chin, KR, **Kharrazi, FD,** Miller, BS, Mankin, HJ, Gebhardt, MC. Osteochondromas of the Distal Aspect of the Tibia or Fibula. Natural History and Treatment. *J. Bone Joint Surg Am.* 2000 Sept; 82(9) :1269-78.

Kharrazi, FD, Vince, KG, Subvastus Surgical Approach for Total Knee Arthroplasty. Techniques in Knee Surgery by C.D. Anvner, K.G. Vince, F.H. Fu., Lippincott Williams & Williams, 2001.

Miller, CM, Tibone, JE, Hewitt, M, **Kharrazi, FD,** Elattrache, NS. Interference Screw Divergence in Femoral Tunnel Fixation during Endoscopic Anterior

Cruciate Ligament Reconstruction using Hamstring Grafts. *Arthroscopy.* 2002 May-Jun; 18(5):510-4.

Enad, JG, **Kharrazi, FD**, ElAttrache, NS, Yocum, LA. Electrothermal Capsulorrhaphy in Glenohumeral Instability without Bankart Tear. *Arthroscopy.* 2003 Sep; 19 (7):740-5.

Charlton, WP, **Kharazzi, FD**, Alpert, S, Glousman, RE, Chandler, RW. Unstable Nonunion of the Scapula: A Case Report. *J Shoulder Elbow Surg.* 2003 Sep-Oct; 12(5): 517-9.

Sethi, PM, Mirzayan, R, and **Kharrazi, FD**. Microfracture technique. Cartilage Injury in the Athlete [edited by] Raffy Mirzayan. New York: Thieme, c2006.

Temple JD, Sethi PM, **Kharrazi FD**, Elattrache NS. Direct biceps tendon and supraspinatus contact as an indicator of rotator cuff tear during shoulder arthroscopy in the lateral decubitus position. *J Shoulder Elbow Surg.* 2007 May-June; 16(3):327-9.

Kharrazi, FD, Busfield, BT, Khorshad, DS. Acromioclavicular Joint Reoperation After Arthroscopic Subacromial Decompression With and Without Concomitant Acromioclavicular Surgery. *Arthroscopy: The Journal of Arthroscopic and Related Surgery,* Vol 23, No. 8 (August 2007): 804-808.

Kharrazi, FD, Busfield, BT, Khorshad DS, Hornicek, FJ, Manikin, HJ. Osteoarticular and total elbow allograft reconstruction with severe bone loss. *Clin Orthop Relat Res. Jan 2008; 466 (1) : 205-9*

Kharrazi, FD, Hornicek, FJ, Mankin, HJ. Severe Metallosis due to Late Failure of a Metal Backed Patellar Component Presenting as a Knee Mass: The "Metal Line" Sign Revisited. Accepted for Publication.

PRESENTATIONS:

Orthopedic Trauma Association, September 5, 1995. Tampa, Florida. Rodgers, WB, **Kharrazi, FD,** Waters, PM, Kennedy, JG, McKee, MD, Lhowe, DW. The Use of Intraosseous Suture Anchors in the Treatment of Severe, Complicated Elbow Dislocations.

International society of Limb Salvage, 1997 Annual Meeting. Hornicek, FJ, Wolf, M, Gebhardt, MC, **Kharrazi, FD,** Mankin, HJ. P-glycoprotein levels predict poor outcome in Osteosarcoma.

Thesis Day. Harvard combined Orthropaedic Surgery Residency Program. June 1997. **Kharrazi, FD,** Hornicek, FJ, Gebhardt, MC, Mankin, HJ, Long-Term Results of Osteoarticular Allograft Recontruction of the Elbow.

American Academy of Orthopaedic Surgeons, 1997 Annual Meeting. New Orleans, Louisiana. Hornicek, FJ, Wolfe, M, Gebhardt, MC, **Kharrazi, FD,** Mankin, HJ. P-glycoprotein levels predict poor outcome in Osteosarcoma.

The American Orthopaedic Association, 111th Annual Meeting, June 1998. Asheville, North Carolina. **Kharrazi, FD,** Hornicek, FJ, Gebhardt, MC, Mankin, HJ. Long-Term results of Osteoarticular Allograft Reconstruction of the Elbow.

The American Association of Hip and Knee Surgeons, 8th Annual Meeting, 1998. Dallas, Texas. Spitzer, AI, **Kharrazi, FD,** Vince, KGD, Mayekawa, D. Evaluation of the Cement Mantle in Impaction Allograft Using Spiral CT Canning.

Societe Internationale de Chirurgie Orthopedique et de Traumatologie (SICOT) 21st Triennial World Congress, April 1999. Sydney, Australia. **Kharrazi, FD,** Vermillion, DA, Spitzer, AI, Vince, KGD. Evaluation of Femoral Component Rotation im Failed Total Knee Arthroplasty Using Computerized Tomography.

Societe Internationale de Chirurgie Orthopedique et de Traumatologie (SICOT) 21st Triennial World Congress, April, 1999. Sydney, Australia. **Kharrazi, FD,** Spitzer, AI, Vince, Mayekawa, D. Evaluation of

the Cement mantle in Impaction Allografting Using Spiral CT Scanning.

Societe Internationale de Chirurgie Orthopedique et de Traumatologie (SICOT) 21st Triennial World Congress, April 1999. Sydney, Australia. **Kharrazi, FD,** Spitzer, Al, Vince, KGD. Offset and Limb Length in Total Hip Arthroplasty: Optimizing Outcome with Careful Preoperative Planning and Use of a Proximally Modular Cementless Stem.

Kerlan-Jobe Orthopaedic Clinic, Fellows Day, July 1999, Los Angeles, CA. **Kharrazi, FD,** Vermillion, DA, Reinhart, GA, Chandler, RW, Tibone, JE. Treatment of Displaced Complex Proximal Humerus Fractures Using a Proximally Locked Humeral Nail.

Arthroscopy Association of North America, April 2000, Miami Beach, Florida. Re-operation on the Acromio Clavicular Joint following Arthroscopic Subacromial Decompression.

1: J Shoulder Elbow Surg. 2008 Jul 24. [Epub ahead of print]

ELSEVIER FULL TEXT ARTICLE

Subacromial pain pump use with arthroscopic shoulder surgery: A short-term prospective study of complications in 583 patients.

Busfield BT, Lee GH, Carrillo M, Ortega R, Kharrazi FD.

Arthritis, Orthopedic and Sports (AOS) Medical Center, Glendale, CA.

Pain pumps containing local anesthetics, with or without opioids, can be used for perioperative analgesia after arthroscopic shoulder surgery to reduce pain. Although several smaller studies have demonstrated the analgesic properties, no large series to date has reported the short-term complication rate of subacromial pain pumps. We prospectively studied (2005 to 2007) 583 patients who underwent arthroscopic shoulder surgery at a single outpatient surgery center and had intraoperative placement of a pain pump catheter into the subacromial space. Patients had at least 1 month of follow-up. No patient received perioperative brachial plexus regional anesthesia. There were no cases of infection, internal catheter breakage, pump failure, or hospital admission for pain control. The only complication was external catheter breakage that occurred when a patient attempted to remove the pump without removing the tape fastening the catheter at the skin. Subacromial pain pumps used for arthroscopic shoulder procedures are safe in the short-term.

PMID: 18657448 [PubMed - as supplied by publisher]

Knee mass from severe metallosis after failure of a metal-backed patellar component total knee arthroplasty.

Kharrazi FD, **Busfield BT**, **Khorshad DS**, **Hornicek FJ**, **Mankin HJ**.

Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California 90045, USA.

Publication Types:
- Case Reports

PMID: 18401493 [PubMed - indexed for MEDLINE]

☐ **3:** Clin Orthop Relat Res. 2008 Jan;466(1):205-9. Epub 2008 Jan 3.

Related Articles, Links

SpringerLink

Osteoarticular and total elbow allograft reconstruction with severe bone loss.

Kharrazi FD, **Busfield BT**, **Khorshad DS**, **Hornicek FJ**, **Mankin HJ**.

Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace Dr, Los Angeles, CA 90045, USA. fdkharrazi@aol.com

Osteoarticular allograft reconstruction is an option in patients with massive periarticular elbow bone loss secondary to tumor surgery or trauma. Our consecutive series consisted of 18 patients with tumors and one patient with trauma. Reconstruction consisted of 16 hemiarticular allografts and three total elbow osteoarticular allografts; patients had a minimum followup of 2 years (mean, 9.9 years; range, 2-12 years). For patients who had hemiarticular allografts, 14 of 16 were able to return to their preoperative level of occupational function, with one patient experiencing failure of the allograft from infection. For the three patients who had total elbow allograft reconstructions, all had degenerative changes develop after surgery and two of the allografts failed. Complications occurred in six of 19 patients. Hemiarticular elbow allograft reconstruction is useful for limb salvage with massive bone loss. Total elbow allograft reconstructions have a high failure rate in the mid-term. LEVEL OF EVIDENCE: Level IV, therapeutic study.

PMID: 18196394 [PubMed - indexed for MEDLINE]

☐ 4. Arthroscopy. 2007 Aug;23(8):894.e1-

 Links

Acromioclavicular joint reoperation after arthroscopic subacromial decompression with and without concomitant acromioclavicular surgery.

Kharrazi FD, **Busfield BT**, **Khorshad DS**.

Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California 90045, USA. fdkharrazi@aol.com <fdkharrazi@aol.com>

PURPOSE: The purpose of this study was to examine the reoperation rate on the acromioclavicular (AC) joint after arthroscopic subacromial decompression (ASAD) with and without concomitant AC joint surgery and to identify factors related to continued AC joint symptoms. METHODS: We conducted a retrospective review of 1,482 cases without concomitant shoulder pathology that were followed up by physical examination, phone interview, questionnaire, or chart review. Group A, patients who underwent ASAD alone, consisted of 1,091 cases. Group B, patients who underwent ASAD with concomitant AC joint surgery consisting of either co-planing or arthroscopic distal clavicle resection (ADCR), consisted of 391 cases. RESULTS: A total of 22 patients underwent reoperation on the AC joint. The overall reoperation rate was 1.5%, or 22 of 1,482 patients. The index procedure failed in 16 patients from the ASAD group (group A), yielding a reoperation rate of 1.5%. The index procedure failed in 6 patients from the group undergoing ASAD with concomitant AC joint surgery (group B), for a reoperation rate of 1.5%. Reoperation occurred at a mean of 22 months and 8 months for group A and group B, respectively. Overall, 17 of 22 patients (77%) who required AC joint reoperation were either Workers' Compensation (WC) or litigation cases. The reoperation rate was 2.4% for WC patients and 0.8% for non-WC patients. WC status was found to be a statistically significant factor in the rate of reoperation for AC joint symptoms ($P < .05$). Of the 22 patients, 10 continued to have pain at a mean of 25.9 months (range, 9 to 53 months) after reoperation. Given the similar rates of reoperation, routine AC joint violation by co-planing or ADCR is not recommended during ASAD. Reoperation for continued AC joint symptoms was associated with a nearly 50% rate of continued symptoms. CONCLUSIONS: The results of the study show that the incidence of reoperation on the AC joint after ASAD with or without concomitant AC joint surgery is small for both groups with a 1.5% rate of reoperation for each group. The incidence of reoperation is lower, at 0.8%, for non-WC cases. In addition, there was a high rate of continued symptoms, with 45% of patients having continued pain after reoperation. Violation of the AC joint during the initial surgery by co-planing or ADCR did not alter the reoperation rate for AC joint symptoms. LEVEL OF EVIDENCE: Level IV, therapeutic case series.

PMID: 17681199 [PubMed - indexed for MEDLINE]

ELSEVIER
FULL-TEXT ARTICLE

Direct biceps tendon and supraspinatus contact as an indicator of rotator cuff tear during shoulder arthroscopy in the lateral decubitus position.

Temple JD, **Sethi PM**, **Kharrazi FD**, **Elattrache NS**.

Kerlan-Jobe Orthopaedic Clinic, Los Angeles, CA, USA.

The purpose of this study was to evaluate consecutive shoulder arthroscopies for the presence or absence of a space between the biceps tendon and the supraspinatus as an indicator of a full-thickness rotator cuff tear. We performed 588 consecutive shoulder arthroscopies in the lateral decubitus position, and the presence or absence of a space between the rotator cuff (supraspinatus) and the biceps tendon was recorded immediately upon entering and insufflating the joint. Of the 588 patients, 174 (30%) were found to have full-thickness rotator cuff tears. Of these 174 patients, 171 had absence of the space between the biceps and the supraspinatus, for a sensitivity of 98%. Of the 414 patients in whom no full-thickness tear was present, 4 had absence of the space, for a specificity of 99%. The 4 patients with a false-negative result had adhesive capsulitis. During shoulder arthroscopy, a normal interval exists between the supraspinatus and biceps tendons as a result of joint insufflation. Loss of this interval is both highly sensitive (98%) and specific (99%) for a full-thickness rotator cuff tear. The space between the rotator cuff and the biceps tendon can be a reliable adjunct for verification of a full-thickness rotator cuff tear immediately upon entering the shoulder joint but should not be used in place of a full arthroscopic evaluation of the cuff.

Publication Types:
- Comparative Study

PMID: 17321153 [PubMed - indexed for MEDLINE]

☐ **6:** Arthroscopy. 2003 Sep;19(7):740-5.

Related Articles, Links

ELSEVIER
FULL-TEXT ARTICLE

Electrothermal capsulorrhaphy in glenohumeral instability without Bankart tear.

Enad JG, **Kharrazi FD**, **ElAttrache NS**, **Yocum LA**.

Bone and Joint/Sports Medicine Institute, Naval Medical Center, Portsmouth, Virginia 23708, USA. jgenad@mar.med.navy.mil

PURPOSE: The purpose of this study is to review the clinical results of electrothermal capsulorrhaphy (ETC) performed on 23 patients for the treatment of glenohumeral instability at an minimum follow-up of 2 years. TYPE OF STUDY: Retrospective case series. METHODS: Twenty-six patients with symptomatic unidirectional or multidirectional glenohumeral instability without Bankart tear were treated with ETC using a radiofrequency probe. No labral repairs were performed. A standard postoperative rehabilitation protocol was followed. Patients were evaluated with respect to motion, direction of instability, need for repeat surgery, return to overhand sports, and symptoms of pain and instability using various scores. Results: Twenty-three patients were available for follow-up evaluation at an average of 30 months. The overall average ASES and Rowe scores were 84.2 and 79.3, respectively. Recurrent instability requiring an open stabilization procedure occurred in 4 patients (17%), 2 with anterior and 2 with multidirectional instability. Seven of 14 overhead athletes (50%) reported inability to return to their previous level. According to Rowe scores, overall results were 11 excellent, 5 good, 4 fair, and 3 poor. No postoperative nerve complications occurred. CONCLUSIONS: The ETC procedure was safely performed to treat glenohumeral instability without Bankart lesions. The recurrence rate is similar to that for other arthroscopic procedures but higher than for open surgery. In the absence of Bankart tear, patients with multidirectional instability and overhand athletes may require something other than an isolated ETC procedure to address instability. Long-term results of ETC are needed to better define its surgical indications.

Publication Types:
- Review

PMID: 12966382 [PubMed - indexed for MEDLINE]

☐ **7:** Arthroscopy. 2002 May-Jun;18(5):510-4.

Related Articles, Links

ELSEVIER FULL-TEXT ARTICLE

Interference screw divergence in femoral tunnel fixation during endoscopic anterior cruciate ligament reconstruction using hamstring grafts.

Miller CM, **Tibone JE**, **Hewitt M**, **Kharrazi FD**, **Elattrache NS**.

Kerlan Jobe Orthopaedic Clinic and the Kerlan Jobe Orthopaedic Foundation, Los Angeles, California, USA.

PURPOSE:To compare the divergence angles between bioabsorbable interference screws inserted into the femoral tunnel with the screwdriver placed through the anteromedial portal to those inserted with the

screwdriver placed through the tibial tunnel and to examine the effect of the femoral tunnel interference screws' divergence angles on fixation strength of hamstring grafts after anterior cruciate ligament (ACL) reconstruction using hamstring grafts. TYPE OF STUDY:Cadaveric biomechanical pullout study. METHODS:ACL reconstruction was performed in 8 pairs of fresh-frozen human cadaveric knees using hamstring grafts fixed within the femoral tunnels using bioabsorbable interference screws. Within matched pairs, 1 screw was placed into the femoral tunnel using a screwdriver placed through the tibial tunnel (group 1), and in the other knee it was placed into the femoral tunnel using a screwdriver placed through the anteromedial portal (group 2). Radiographs were taken to measure the degree of divergence between the interference screw and the femoral tunnel. After disarticulation, pullout strength was then measured using a cyclic-loading model. RESULTS:In group 2, there was significantly more divergence between the screw and the femoral tunnel compared with group 1, particularly in the sagittal plane (average 14.4 degrees compared with 3.4 degrees, P =.00014). With the number of specimens available for comparison, no significant difference was detected between the 2 groups with regard to 3 mm and 5 mm of pullout when cyclically loaded (P =.77 and.74, respectively). CONCLUSIONS: The increased technical difficulty, combined with the potential risks of tibial tunnel widening and graft damage, with placement of the screwdriver through the tibial tunnel for the purpose of decreasing femoral interference screw divergence in ACL reconstruction using hamstring grafts may not be justified.

Publication Types:

- Comparative Study
- In Vitro

PMID: 11987062 [PubMed - indexed for MEDLINE]

☐ **8:** J Bone Joint Surg Am. 2000 Sep;82(9):1269-78.

Related Articles, Links

Osteochondromas of the distal aspect of the tibia or fibula. Natural history and treatment.

Chin KR, **Kharrazi FD**, **Miller BS**, **Mankin HJ**, **Gebhardt MC**.

Orthopaedic Oncology Service, Massachusetts General Hospital, Harvard Medical School, Boston 02114-2696, USA. kchin@partners.org

BACKGROUND: There is little information on the natural history or treatment of osteochondromas arising from the distal aspect of either the

ankle if these exostoses are left untreated or if the physis or neurovascular structures are injured during operative intervention. METHODS: We reviewed the records of twenty-three patients who had been treated for osteochondroma of the distal aspect of the tibia or fibula between 1980 and 1996. Four of the patients had hereditary multiple cartilaginous exostoses. There were seventeen male and six female patients, and the average age at the time of presentation was sixteen years (range, eight to forty-eight years). RESULTS: Preoperative radiographs showed evidence of plastic deformation of the fibula in eleven patients who had a large osteochondroma. Four patients elected not to have an operation. The tumor was excised in nineteen patients. Postoperatively, all nineteen patients had a Musculoskeletal Tumor Society score of 100 percent for function of the lower extremity with pain-free symmetrical and unrestricted motion of the ankle at the latest follow-up examination. Partial remodeling of the tibia and fibula gradually diminished the asymmetry of the ankles in all nineteen operatively managed patients; however, the remodeling was most complete in the younger patients. Pronation deformities of the ankle did not change after excision of the tumor. Complications of operative treatment included four recurrences (only three of which were symptomatic), one sural neuroma, one superficial wound infection, and one instance of growth arrest of the distal aspects of the tibia and fibula. CONCLUSIONS: Osteochondromas of the distal and lateral aspects of the tibia were more often symptomatic than those of the distal aspect of the fibula; they most commonly occurred in the second decade of life with ankle pain, a palpable mass, and unrestricted ankle motion. Untreated or partially excised lesions in skeletally immature patients may become larger and cause plastic deformation of the tibia and fibula and a pronation deformity of the ankle. Ideally, operative intervention should be delayed until skeletal maturity, but, in symptomatic patients, partial excision preserving the physis may be necessary for the relief of symptoms and the prevention of progressive ankle deformity. However, partial excision is associated with a high rate of recurrence, so a close follow-up is required. Skeletally mature patients who are symptomatic may require excision of the tumor.

PMID: 11005518 [PubMed - indexed for MEDLINE]

☐ **9:** Clin Orthop Relat Res. 2000 Apr;(373):11-7.

Related Articles, Links

Wolters Kluwer | Lippincott Williams & Wilkins

P-glycoprotein levels predict poor outcome in patients with osteosarcoma.

Hornicek FJ, Gebhardt MC, Wolfe MW, Kharrazi FD, Takeshita H, Parekh SG, Zurakowski D, Mankin HJ.

Orthopaedic Oncology Unit, Massachusetts General Hospital, Boston 02114, USA.

To evaluate the relationship between the expression of P-glycoprotein by osteosarcomas and the rate of metastasis and death, a retrospective review of 172 patients who were diagnosed with osteosarcoma between 1987 and 1992 was performed. Forty patients had P-glycoprotein levels available. The majority of the osteosarcomas were Stage II-B (33 patients), with the remaining seven being Stage III. Tumor sites included 25 femurs, seven humeri, five tibias, and one each of pelvis, radius, and fibula. The patients with Stage III disease at presentation were treated differently from the time of diagnosis and therefore, these seven patients with Stage III osteosarcoma were excluded from additional analyses. The expression of P-glycoprotein by cultured tumor cells from biopsy specimens was determined using immunofluorescent microscopy. In the 33 patients with Stage IIB osteosarcoma with detectable P-glycoprotein, 67% (10 of 15) had metastases develop as compared with 28% (five of 18) of patients with undetectable P-glycoprotein. Similarly, 53% (eight of 15) of patients with tumors expressing P-glycoprotein died of disease compared with 11% (two of 18) with no detectable P-glycoprotein. Expression of P-glycoprotein by tumor cells seems to be associated with an estimated ninefold increase in the odds of death and a fivefold increase in the odds of metastases in patients with Stage IIB osteosarcoma. Kaplan-Meier survivorship analysis revealed that patients with detectable P-glycoprotein fared worse in terms of survival time and metastasis-free survival. Adjusting for covariates in the Cox proportional hazards model, expression of P-glycoprotein and its level were significantly predictive of time to death in patients with Stage IIB osteosarcoma.

PMID: 10810457 [PubMed - indexed for MEDLINE]

☐ **10:** J Pediatr Orthop. 1997 Nov-Dec;17(6):762-5.

Related Articles, Links

Increasing lordosis of the occipitocervical junction after arthrodesis in young children: the occipitocervical crankshaft phenomenon.

Rodgers WB, **Coran DL**, **Kharrazi FD**, **Hall JE**, **Emans JB**.

Children's Hospital and Harvard Medical School, Boston, Massachusetts, USA.

Five children were treated before age 6 years with occipitocervical fusion for occipitocervical instability. Long-term (average, 11.8 years; range, 8.4-14.5 years) follow-up revealed increasing lordosis across the fused

segment in four of the patients, a finding we here refer to as the occipitocervical crankshaft phenomenon. On average, occipitocervical lordosis increased 1.06 degrees per level fused per year until skeletal maturity. Although such a progression might be expected, to our knowledge this is the first report of its occurrence. Compensatory subaxial motion was able to overcome this increase in all of the patients. We recommend occipitocervical fusion in a neutral or slightly flexed position in the very young child to account for this predictable increase in lordosis.

PMID: 9591978 [PubMed - indexed for MEDLINE]

☐ **11:** Am J Orthop. 1997 Oct;26(10):689-91.

Related Articles, Links

Protrusio acetabuli and bilateral basicervical femoral neck fractures in a patient with Marfan syndrome.

Kharrazi FD, **Rodgers WB**, **Coran DL**, **Kasser JR**, **Hall JE**.

Orthopaedic Trauma Service, Massachusetts General Hospital, Boston, Massachusetts, USA.

A 22-year-old man with Marfan syndrome and bilateral protrusio acetabuli presented with bilateral femoral neck stress fractures after vigorous stretching exercises for hip "stiffness." Fifteen years later, his fractures, which were treated with internal fixation, have healed, his acetabular protrusion has not worsened, and his perceived hip "stiffness" persists. This case demonstrates a rare manifestation of Marfan syndrome, protrusio acetabuli, and a possible side effect of vigorous stretching in the face of abnormal joint mechanics.

Publication Types:
- Case Reports

PMID: 9349891 [PubMed - indexed for MEDLINE]

☐ **12:** J Orthop Trauma. 1997 May;11(4):277-81; discussion 281-2.

Related Articles, Links

Erratum in:
- J Orthop Trauma 1997 Oct;11(7):543.

Parturition-induced pelvic dislocation: a report of four cases.

Kharrazi FD, **Rodgers WB**, **Kennedy JG**, **Lhowe DW**.

Orthopaedic Trauma Service, Massachusetts General Hospital, Boston, Massachusetts 02114, USA.

OBJECTIVE: To describe our experience with four cases of severe pelvic dislocation associated with difficult parturition. DESIGN: Retrospective case series. PATIENTS: Four patients, each with rupture of the symphysis pubis and sacroiliac joints during labor. All injuries were associated with significant initial pain and disability. All developed persistent symptoms related to the sacroiliac disruption. INTERVENTIONS: The three patients who had presented acutely were freated with closed reduction and application of a pelvic binder. Two underwent closed reduction of their pelvic dislocation while anesthetized with a general anesthetic. One patient (N.A.), who presented late, had not been treated with a binder. RESULTS: All four patients had persistent posterior pelvic (sacroiliac) pain. In two patients a postpartum neuropathy persisted. CONCLUSIONS: Severe pelvic dislocations are rare during labor, with conservative treatment reported to be successful in most cases. The persistence of symptoms in our patients emphasizes the need for careful examination and follow-up of these rare injuries. Because the outcome in our patients was poor and results in the literature are equivocal, we suggest the consideration of an operative approach to treatment in patients with symphyseal diastasis of > 4.0 cm.

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Related Articles, Links

The use of osseous suture anchors in the treatment of severe, complicated elbow dislocations.

Rodgers WB, **Kharrazi FD**, **Waters PM**, **Kennedy JG**, **McKee MD**, **Lhowe DW**.

Capital Region Medical Center, Jefferson City, Missouri, USA.

Seventeen patients who sustained severe trauma resulting in dislocation or fracture-dislocation of the elbow were treated using osseous suture anchors to repair the soft-tissue constraints of the elbow. In 15 of these patients, the medial collateral ligament and flexor-pronator origin were repaired. Ten patients underwent repair of the lateral collateral ligament using anchors. Five patients were also treated with a hinged external

of the patients had stable elbows at follow-up. Elbow flexion averaged 127 degrees; an average 19 degrees extension loss was noted. The arc of forearm rotation averaged 156 degrees. The aggressive approach detailed in this report is applicable only to severe injuries to the elbow, not routine dislocations. These cases demonstrate the reliability of the osseous suture anchor in the operative treatment of massive trauma to the elbow.

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Related Articles, Links

Dislocation of the elbow complicated by arterial injury. Reconstructive strategy and functional outcome.

Kharrazi FD, **Rodgers WB**, **Waters PM**, **Koris MJ**.

Harvard Combined Orthopaedic Surgery Residency Program, Boston, Massachusetts, USA.

Four cases of arterial injury complicating posterior dislocation of the elbow are described. All of these patients were treated by emergent revascularization; reconstruction of the soft-tissue constraints of the elbow joint was performed by using osseous suture anchors. Despite prompt treatment of the vascular injury and successful restoration of elbow articulation and stability, all of the patients had residual functional disability. The previous literature has not discussed the functional results of these reconstructions. This report underscores the severity of these injuries, details our reconstructive strategy, and analyzes the functional outcome of these badly traumatized extremities.

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Acromioclavicular Joint Reoperation After Arthroscopic Subacromial Decompression With and Without Concomitant Acromioclavicular Surgery

F. Daniel Kharrazi, M.D., Benjamin T. Busfield, M.D., and Daniel S. Khorshad

Purpose: The purpose of this study was to examine the reoperation rate on the acromioclavicular (AC) joint after arthroscopic subacromial decompression (ASAD) with and without concomitant AC joint surgery and to identify factors related to continued AC joint symptoms. **Methods:** We conducted a retrospective review of 1,482 cases without concomitant shoulder pathology that were followed up by physical examination, phone interview, questionnaire, or chart review. Group A, patients who underwent ASAD alone, consisted of 1,091 cases. Group B, patients who underwent ASAD with concomitant AC joint surgery consisting of either co-planing or arthroscopic distal clavicle resection (ADCR), consisted of 391 cases. **Results:** A total of 22 patients underwent reoperation on the AC joint. The overall reoperation rate was 1.5%, or 22 of 1,482 patients. The index procedure failed in 16 patients from the ASAD group (group A), yielding a reoperation rate of 1.5%. The index procedure failed in 6 patients from the group undergoing ASAD with concomitant AC joint surgery (group B), for a reoperation rate of 1.5%. Reoperation occurred at a mean of 22 months and 8 months for group A and group B, respectively. Overall, 17 of 22 patients (77%) who required AC joint reoperation were either Workers' Compensation (WC) or litigation cases. The reoperation rate was 2.4% for WC patients and 0.8% for non-WC patients. WC status was found to be a statistically significant factor in the rate of reoperation for AC joint symptoms ($P < .05$). Of the 22 patients, 10 continued to have pain at a mean of 25.9 months (range, 9 to 53 months) after reoperation. Given the similar rates of reoperation, routine AC joint violation by co-planing or ADCR is not recommended during ASAD. Reoperation for continued AC joint symptoms was associated with a nearly 50% rate of continued symptoms. **Conclusions:** The results of the study show that the incidence of reoperation on the AC joint after ASAD with or without concomitant AC joint surgery is small for both groups with a 1.5% rate of reoperation for each group. The incidence of reoperation is lower, at 0.8%, for non-WC cases. In addition, there was a high rate of continued symptoms, with 45% of patients having continued pain after reoperation. Violation of the AC joint during the initial surgery by co-planing or ADCR did not alter the reoperation rate for AC joint symptoms. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Shoulder—Acromioclavicular joint—Subacromial decompression—Distal clavicle resection.

Current shoulder arthroscopic surgical techniques allow results from decompression of subacromial impingement and resection of the distal clavicle for acromioclavicular (AC) arthrosis to be comparable to open surgery. Neer[1] originally described the 1-stage anterior acromioplasty for treatment of shoulder impingement, in 1972. A modification of this technique included resection of the inferior AC spurs. Ellman[2] described an arthroscopic technique and reported similar results to open acromioplasty. Arthroscopic decompression is advantageous because of earlier func-

From the Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California, U.S.A.

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Address correspondence and reprint requests to F. Daniel Kharrazi, M.D., Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace Dr, Los Angeles, CA 90045, U.S.A. E-mail: fdkharrazi@aol.com

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tional recovery.[3] Regardless of the technique used to decompress the subacromial space, the AC joint remains a source of controversy and a potential source of pain and surgical failure. It remains controversial whether violation of the inferior AC joint capsule during decompression leads to instability and deterioration of the AC joint. Multiple studies have reported conflicting results regarding this issue.[4-10] This has prompted some surgeons to recommend an "all-or-none approach" to the AC joint during arthroscopic subacromial decompression (ASAD) whereas others recommend resection of the inferior AC osteophytes or "co-planing" to adequately decompress the subacromial space without the need for routine arthroscopic distal clavicle resection (ADCR) in the asymptomatic patient.[4,6-10] The rate of failure as a result of AC joint complaints as defined by the need for reoperation is poorly defined. To our knowledge, no large published clinical series has reported on the rate of reoperation on the AC joint after ASAD with or without concomitant AC joint surgery.

The purpose of this study was to establish the overall rate of reoperation on the AC joint in cases of isolated impingement treated with ASAD in a large series of patients at 1 institution. In addition, factors related to failure of the index procedure with subsequent reoperation on the AC joint after ASAD with or without concomitant AC joint surgery were identified.

METHODS

A retrospective review was performed at the Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California, to identify patients who underwent ASAD with and without ADCR. Between 1991 and 1998, a total of 2,371 patients were identified. The cases were individually reviewed to identify the number and characteristics of patients who required reoperation on the AC joint. A total of 883 patients with concurrent combined operative procedures or previous shoulder surgery were excluded. Exclusion criteria included any other pathology found during the arthroscopic examination such as rotator cuff, labrum, capsule, or biceps pathology. Furthermore, cases were excluded if any additional surgical procedures were performed other than a subacromial decompression with or without AC joint surgery. The 6 patients with preoperative AC joint symptoms who did not have an ADCR at the time of the index ASAD because of a preoperative diagnostic error were also excluded from the study. Of the remaining 1,482 patients included in the study, we obtained follow-up data for 1,236 patients (83%). Attempts were made to obtain direct follow-up from each patient by physical examination at our clinic. If the patient was unable to return for follow-up, a phone interview or survey was performed. Questions were asked regarding current shoulder function, satisfaction with the surgery, any subsequent surgeries, and any continued AC joint symptoms. Patients who could not be followed up by examination or survey were evaluated by chart review. After this algorithm was used to determine which patients required reoperation for continued AC joint symptoms, follow-up consisted of physical examination (661 patients), questionnaire (330 patients), or phone interview (245 patients). The remaining 246 patients were followed up by chart review at a mean of 11 months. The 661 patients followed up by physical examination by the senior author were seen at a mean follow-up of 26 months. There were no trends regarding patient reoperation failures and the method of follow-up. After identification of the patients who elected to undergo reoperation for continued AC joint symptoms, each was individually evaluated in our clinic. A total of 1,482 patients were included in the study and divided into two groups. Group A, patients who underwent ASAD alone, consisted of 1,091 cases. Group B, patients who underwent ASAD with concomitant AC joint surgery, consisted of 391 cases. Student t tests were used for comparison between groups of patients.

RESULTS

Of the 1,482 patients who underwent ASAD with or without concomitant AC joint surgery, 22 had residual AC joint pain after the index procedure and elected to undergo reoperation on the AC joint. Of the 22 failures requiring reoperation, 16 were from group A and 6 were from group B. The failure rates for group A and group B were both 1.5%, as was the overall failure rate for all patients. The mean time to reoperation was 22 months and 8 months for group A and group B, respectively. The mean time to reoperation for the overall study group was 17 months. The difference in time to reoperation for the AC joint was statistically significant ($P < .05$).

The 22 patients who required reoperation for the AC joint consisted of 17 men and 5 women. The mean age was 46.4 years (range, 31 to 70 years) at the time of reoperation. Right and left shoulders were involved in 19 and 3 patients, respectively. Of the group B patients in whom failure occurred, 10 had co-planing performed and 6 had a complete ADCR combined with ASAD confirmed by postoperative radiographs.

We could not reliably determine from review of operative reports the number of patients in group B with no subsequent AC joint surgery in which the surgeon performed co-planing during the index procedure. Although 62% of the group B failures involved co-planing, we could not quantify this technique as an overall risk factor for group B.

Of the 22 patients with reoperation on the AC joint, 17 (77%) were either Workers' Compensation (WC) cases (n = 15) or litigation cases (n = 2). When distinguished by WC status, the rate of reoperation on the AC joint was 2.4% for WC cases versus 0.8% for non-WC cases. Furthermore, when distinguished by WC status within each subgroup, the rate of reoperation for WC cases versus non-WC cases was 2.28% versus 0.91% in group A and 2.7% versus 0.5% in group B. Overall, WC status was found to be a statistically significant factor in the rate of reoperation ($P < .05$). Of the 22 patients who underwent reoperation after the index procedure, 10 (45%) continued to have AC joint symptoms. Only 1 of the 10 cases with continued AC joint symptoms was not a WC (n = 7) or litigation (n = 2) case.

DISCUSSION

Symptomatic AC joint arthritis can occur in isolation or in conjunction with subacromial impingement. It is well recognized that spurs on the undersurface of the AC joint can contribute to mechanical abrasion of the supraspinatus. As popularized by Neer,[1] adequate subacromial decompression frequently requires resection of AC joint spurs. Routine resection of inferior AC joint spurs impinging on the supraspinatus has also been recommended for ASAD.[2,3,6,8] Routine ADCR in the presence of degenerative changes of the AC joint and absence of pain and tenderness is not recommended. Although AC joint degenerative changes can be a normal part of aging and are frequently asymptomatic, some authors recommend routine ADCR during ASAD to avoid the possibility of progression to symptomatic AC arthrosis after ASAD.[11,12] Stubbs et al.[12] observed a 10% reoperation rate in patients undergoing isolated ASAD and no reoperations in patients when a concomitant ADCR was performed.

Many authors argue that an adequate ASAD requires decompression medially to the medial acromial facet. This medial extension may violate the inferior AC joint capsule and may cause instability. Recently, there has also been concern regarding the contribution of co-planing, or resection of a small portion of the inferior clavicle, to AC joint symptoms. Fischer et al.[7] reported an incidence of symptomatic AC joints after ASAD with co-planing of 39% (14 patients). Only 8 of 14 patients required additional surgery. Patients in whom there was no violation of the AC joint or who had complete ADCR had no sequelae related to the AC joint in their series. Given these findings, the authors recommend an "all-or-none approach" to the AC joint when performing ASAD.[7] Several biomechanical studies show postoperative AC joint instability and suggest it to be a possible cause of pain. Although the testing conditions in the cadaveric studies have varied, co-planing has been found to cause a statistically significant increase of less than 1.5 mm between mean values for anteroposterior and superior compliance.[13] Rotation, superior translation, and anteroposterior motion were found have a statistically significant increase of less than 2.6 mm after co-planing of 25% of the AC joint.[14] A 3-mm posterior translation and increased coracoclavicular ligament forces with anterior loading have been shown in a cadaveric study after ASAD without co-planing.[15] Although these biomechanical data are statistically significant, it is unclear whether the increased translation is clinically significant. A cadaveric study comparing ASAD and ASAD with co-planing showed an increase in superior translation of 53% and an increase in anterior translation of 19%.[16] In a clinical study with stress radiographs after ASAD without co-planing, 12 patients (38%) showed 2 to 3 mm of superior translation.[14] Of the 31 patients in the study, 9 had AC joint tenderness and instability on stress radiographs.[14] In contrast, other authors have shown a high rate of successful results with ASAD that included co-planing.[3,17-19] Weber[19] reviewed the results of ASAD that included co-planing in 1,259 patients and found that only 3 patients (0.2%) required reoperation for ADCR. In our larger series of 1,482 patients, we found a similar low overall reoperation rate of 1.5% in both groups A and B, which contrasts significantly with the 10% reported by Stubbs et al.[12] (without ADCR) and the 39% reported by Fischer et al.[7] (with co-planing).

Analysis of failure after traditional open acromioplasty has also been reported.[20] AC arthritis was considered to be responsible for a total of 24 of 255 failures in published reports, with an incidence ranging from 0% to 19.6%.[20] WC cases were associated with less improved outcomes.[21,22] Patients with WC cases have been recognized previously as having higher rates of failure with open acromioplasty, as well as with ASAD.[3,21,23] The results of revision sur-

gery in this group have shown a high rate of poor results, similar to the finding in our study.[21]

The rate of reoperation for the AC joint after ASAD is poorly defined. The 0.2% rate of revision surgery for AC joint problems in non-WC patients reported by Weber[19] is similar to the 0.8% in this study. With WC cases included, an overall incidence of reoperation of 1.5% in our study is significantly less than the rates reported by Fischer et al.[7] and Stubbs et al.[12]

Hawkins et al.[23] reported on 19 patients who underwent open acromioplasty after failed ASAD. One patient required distal clavicle resection at the time of the index surgery. A 42% failure rate was reported in WC cases, with only 2 of 8 patients improving after revision surgery.[23] In our study 55% of patients had improvement after reoperation. Of 10 patients with persistent symptoms after reoperation, 7 were WC cases.

Recently, the results of ASAD combined with ADCR have been reported. Martin et al.[24] reported universal patient satisfaction and a high rate of return to playing sports. No WC cases were mentioned in the study. A high rate of success is possible in properly selected patients.

Adequate ASAD may require resection to the medial acromial facet, which may violate the inferior AC joint capsule attachment. If further co-planing of the distal clavicle is performed for decompression, the resection may further compromise the stability of the joint. Although small amounts of instability have been identified in multiple biomechanical studies and a clinical study, the contribution to pain is poorly identified.[9,13-16] Clinical data have correlated advanced AC arthritis and lack of instability after ASAD.[14] Of the 22 cases in which failure occurred in group B, 10 were associated with co-planing. Perhaps resection of a portion of the AC joint leads to an increase in joint contact pressures in nonarthritic joints or increased motion in an early arthritic joint that leads to pain. Our institution promotes ADCR whenever more than 25% of the AC joint is violated during the ASAD; thus our rate of ADCR was 26% in this series. Buford et al.[17] recommend co-planing as long as it involves less than 20% to 25% of the AC joint, whereas Fischer et al.[7] recommend against any violation of the AC joint. The task of performing an adequate ASAD without violation of the AC joint may be difficult in patients with significant spurring of the medial acromial facet.

This study reviews a large case series of ASAD with and without concomitant AC joint surgery. This review of failures appears to be the largest series to date. Limitations of our study include the retrospective nature and lack of outcome scores. Our rate of patients lost to follow-up, 17%, is acceptable, given the large number of patients in this study. In our attempt to include a larger number of patients and avoid biasing selection to patients who were easily able to return to the clinic for follow-up by physical examination, we used several means of obtaining follow-up. Although many patients were examined or questioned by the senior author, some were studied by chart review. By relying on chart review for follow-up and for details regarding the index surgery, our conclusions are subject to the accuracy of the surgeon's clinical and operative notes. Reliably determining cases of ASAD involving co-planing was difficult, given the lack of a specific definition for the term. Each surgeon's definition may vary from strict extra-articular resection of infraclavicular osteophytes to a variable amount of AC joint resection, thus the difficulty in drawing conclusions from our co-planing data. If the operative report mentioned any violation of the AC joint during the ASAD, the patient was assigned to group B. Although 62% of ASAD failures in group B involved co-planing, definitive conclusions are difficult to make. Given our lack of outcome scores, we relied on reoperation as the end point of a failed result. This definition of failure likely underestimates the clinical failure rate by an outcome score, because not all patients with poor outcomes necessarily elect to have revision surgery. In the study of Fischer et al.,[7] 57% of patients (8/14) with symptomatic AC joints underwent subsequent AC joint surgery after co-planing in the initial surgery. There are a number of reasons why patients may not elect to have a reoperation despite a poor surgical outcome, including financial and time constraints. A prospective study with a validated outcome measure would be an ideal study model, but this would be difficult to apply to such a large series. Our minimum overall mean follow-up of 11 months in the chart review group is reasonable to reliably determine postoperative failures requiring reoperation for continued AC joint symptoms. Our purpose was not to report clinical outcomes after ASAD, which has been documented in the literature. By focusing on the subset of patients, we sought to define the rate of reoperation for the AC joint and associated patient characteristics.

CONCLUSIONS

We observed a very low rate of reoperation on the AC joint overall in our large series of patients. There was an overall failure rate, as determined by reopera-

tion for continued AC joint symptoms, of 1.5% in both group A and B patients. The incidence of reoperation was 0.8% with the exclusion of WC cases, very similar to the 0.2% reoperation rate in the study of Weber.[19] The incidence of reoperation was statistically higher in WC cases ($P < .05$). Even after reoperation, WC patients had a high failure rate with continued AC joint symptoms despite ADCR. It is difficult to extrapolate a specific reason for this trend in WC cases. Generalizing to a diverse group of patients with a wide variety of injuries, preinjury work capacity, and work demands simply based on a common payment system may be erroneous. Possible explanations for a higher rate of reoperation for the AC joint could include secondary gain issues but may also be a result of a lack of financial and time constraints given the fixed income from the WC system. The high rate of concomitant AC joint surgery in our series may explain our low 1.5% incidence of reoperation on the AC joint. On the basis of this study and the similar reoperation rates in groups A and B, routine co-planing or ADCR is not recommended.

REFERENCES

1. Neer CS II. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: A preliminary report. *J Bone Joint Surg Am* 1972;54:41-50.
2. Ellman H. Arthroscopic subacromial decompression: Analysis of one- to three-year results. *Arthroscopy* 1987;3:173-181.
3. Sachs RA, Stone ML, Devine S. Open versus arthroscopic acromioplasty: A prospective, randomized study. *Arthroscopy* 1994;10:248-254.
4. Bigliani LU, Kimmel J, McCann PD, Wolfe I. Repair of rotator cuff tears in tennis players. *Am J Sports Med* 1992;20: 112-117.
5. Burns TP, Turba JE. Arthroscopic treatment of shoulder impingement in athletes. *Am J Sports Med* 1992;20:13-16.
6. Caspari RB, Thal R. A technique for arthroscopic subacromial decompression. *Arthroscopy* 1992;8:23-30.
7. Fischer BW, Gross RM, McCarthy JA, Arroyo JS. Incidence of acromioclavicular joint complications after arthroscopic subacromial decompression. *Arthroscopy* 1999;15:241-248.
8. Paulos LE, Franklin JL. Arthroscopic shoulder decompression development and application: A five year experience. *Am J Sports Med* 1990;18:235-244.
9. Roberts MR, Tasto JP, Hazel M. The effects of acromioclavicular joint stability after arthroscopic co-planing. Presented at Specialty Day, Shoulder and Elbow Society, San Francisco, CA, February 1997.
10. Ryu RKN. Arthroscopic subacromial decompression: A clinical review. *Arthroscopy* 1992;8:141-147.
11. Neviaser TJ, Neviaser RJ, Neviaser JS, Neviaser JS. The four-in-one arthroplasty for the painful arc syndrome. *Clin Orthop Relat Res* 1982:107-112.
12. Stubbs MJ, Field LD, Savoie FH. The role of distal clavicle resection in the treatment of impingement syndrome. Presented at the 18th Annual Meeting of the Arthroscopy Association of North America, Vancouver, British Columbia, Canada, April 1999.
13. Deshmukh AV, Perlmutter GS, Zilberfarb JL, Wilson DR. Effect of subacromial decompression on laxity of the acromioclavicular joint: Biomechanical testing in a cadaveric model. *J Shoulder Elbow Surg* 2004;13:338-343.
14. Kuster MS, Hales PF, Davis SJ. The effects of arthroscopic acromioplasty on the acromioclavicular joint. *J Shoulder Elbow Surg* 1998;7:140-143.
15. Debski RE, Fenwick JA, Vangura A, Fu FH, Woo SL, Rodosky MW. Effect of arthroscopic procedures on the acromioclavicular joint. *Clin Orthop Relat Res* 2003:89-96.
16. Edwards SG. Acromioclavicular stability: A biomechanical comparison of acromioplasty to acromioplasty with complaining of the distal clavicle. *Arthroscopy* 2003;19:1079-1084.
17. Buford D, Mologne T, McGrath S, Heinen G, Snyder S. Midterm results of arthroscopic co-planing of the acromioclavicular joint. *J Shoulder Elbow Surg* 2000;9:498-501.
18. Patel VR, Singh D, Calvert PT, Bayley JIL. Arthroscopic subacromial decompression: Results and factor affecting outcome. *J Shoulder Elbow Surg* 1999;8:231-237.
19. Weber SC. Co-planing the AC joint at the time of acromioplasty: A long term study. Presented at the 18th Annual Meeting of the Arthroscopy Association of North America, Vancouver, British Columbia, Canada, April 1999.
20. Seltzer DG, Wirth MA, Rockwood CA. Complications and failures of open and arthroscopic acromioplasties. *Oper Tech Sports Med* 1994;2:136-151.
21. Hawkins RJ, Chris T, Bokor D, Kiefer G. Failed anterior acromioplasty. *Clin Orthop Relat Res* 1989:106-111.
22. Ogilvie-Harris DJ, Wiley AM. Failed acromioplasty for impingement syndrome. *J Bone Joint Surg Br* 1990;72:1070-1072.
23. Hawkins RJ, Saddemi SR, Mor JT. Analysis of failed arthroscopic subacromial decompression. *Arthroscopy* 1991;7:315-316.
24. Martin SD, Baumgarten TE, Andrews JR. Arthroscopic resection of the distal aspect of the clavicle with concomitant subacromial decompression. *J Bone Joint Surg Am* 2001;83: 328-335.

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ORIGINAL ARTICLE

Osteoarticular and Total Elbow Allograft Reconstruction With Severe Bone Loss

F. Daniel Kharrazi MD, Benjamin T. Busfield MS, MD, Daniel S. Khorshad, Francis J. Hornicek MD, PhD, Henry J. Mankin MD

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Abstract Osteoarticular allograft reconstruction is an option in patients with massive periarticular elbow bone loss secondary to tumor surgery or trauma. Our consecutive series consisted of 18 patients with tumors and one patient with trauma. Reconstruction consisted of 16 hemiarticular allografts and three total elbow osteoarticular allografts; patients had a minimum followup of 2 years (mean, 9.9 years; range, 2–12 years). For patients who had hemiarticular allografts, 14 of 16 were able to return to their preoperative level of occupational function, with one patient experiencing failure of the allograft from infection. For the three patients who had total elbow allograft reconstructions, all had degenerative changes develop after surgery and two of the allografts failed. Complications occurred in six of 19 patients. Hemiarticular elbow allograft reconstruction is useful for limb salvage with massive bone loss. Total elbow allograft reconstructions have a high failure rate in the mid-term.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

After effective local control by wide surgical resection of a bone tumor, restoration of function of the limb is a primary goal of limb salvage surgery. Limb salvage after successful reconstruction frequently results in a more satisfactory outcome than amputation of the upper extremity. Massive allograft transplantation has become a potential reconstructive option in the management of large skeletal defects after wide resection of locally aggressive and malignant tumors of bone [2, 7, 9–11, 16, 17, 23–26, 28, 29]. To salvage the limb for function, allografts have been used for intercalary or osteoarticular reconstruction. As experience with allograft implantation has advanced during the past 25 years, it has become clear the results of allograft transplants depend on a multitude of factors [5, 7, 9, 14, 16, 22–26, 28, 29]. These factors include not only the type of allograft implanted (osteoarticular versus intercalary versus total joint transplantation) but also the particular joint reconstructed [6, 8, 14, 17, 20, 23–26].

Tumors affecting the distal humerus or proximal ulna, although rare, present a particularly challenging reconstructive dilemma. Because above-elbow amputation would be required in these cases, functional limb salvage reconstruction is an attractive approach. Reconstructive options include endoprosthetics, resection arthroplasty, interposition arthroplasty, arthrodesis, allograft reconstruction, or allograft-prosthesis composite arthroplasty [3, 11–13, 18, 21, 24, 27, 30–32]. Arthrodesis and endoprosthetic elbow reconstructions are made difficult by the

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F. D. Kharrazi (✉), B. T. Busfield, D. S. Khorshad
Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace Dr, Los Angeles, CA 90045, USA
e-mail: fdkharrazi@aol.com

F. J. Hornicek, H. J. Mankin
Department of Orthopedic Surgery, Orthopedic Oncology Unit, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

extent of the skeletal defects created by wide resection of these tumors. Patients with these tumors can be quite young and are not ideal candidates for elbow arthroplasty [8]. Arthrodesis, if possible, does not provide the same functional outcome as reconstruction [21]. For these reasons, osteoarticular allograft reconstruction of the elbow is an appealing alternative.

Although multiple case series of elbow allograft reconstructions used in the salvage for posttraumatic elbow injuries have been reported [2, 6, 10, 11, 17, 35, 36], a review of the literature failed to reveal a series specifically devoted to elbow osteoarticular allograft reconstruction after tumor resection. One series reported on two similar reconstructions of the distal humerus in 20 patients with nonunions of the distal humerus, whereas another reported on two series of complete elbow allograft reconstruction for salvage after failed total elbow arthroplasties [1, 15, 19]. These isolated reports with variable followups have not addressed the long-term outcomes in patients undergoing allograft elbow reconstruction after tumor resection.

We ascertained the functional results and complications of partial and complete osteoarticular allograft elbow reconstructions.

Materials and Methods

We retrospectively reviewed 19 patients who underwent osteoarticular allograft elbow reconstruction between 1976 and 1996. We included all patients who had osteoarticular allograft reconstruction of the elbow, including hemiarticular or total elbow. Eighteen patients had aggressive benign or malignant tumors about the elbow. The only patient included who did not have a tumor sustained a traumatic elbow injury with massive bone loss from an open fracture. Given the focus on functional outcome after elbow allograft reconstruction rather than tumor treatment, the patient was included in the study. Tumors included six giant cell bone tumors, five chondrosarcomas, a fibrosarcoma, a malignant myxoid epithelial tumor, a malignant fibrous histiocytoma of bone, a Ewing's sarcoma, a lymphoma, a chondromyxoid fibroma, and a metastatic renal cell carcinoma. Reconstruction consisted of 11 distal humerus only, five proximal ulna only, and three complete elbow osteoarticular allografts. Seven were left-sided and 12 were right-sided elbow surgeries. There were 10 female and nine male patients with an average age of 32 years (range, 14–66 years). Eight reconstructions were performed as the index procedure. Eleven reconstructions were performed as a salvage operation with an average of 1.5 previous surgeries (range, 1–4 procedures). Nine patients had a previous bone graft procedure performed. The minimum followup was 2 years (mean, 9.9 years; range, 2–12 years). One patient died at 24 months and another died at 36 months from their disease and were included in the review. Other than the patient who died 2 years after reconstruction, the minimum followup was 3 years.

The tumor operations included wide excision of the tumor involving the distal humerus, proximal ulna, or both. Patients with malignant tumors received adjuvant chemotherapy and radiation therapy based on protocols appropriate for the tumor diagnosis. The operative approach was dictated by the location and extent of the tumor, with the majority performed through a posterior approach with olecranon osteotomy as necessary. The reconstructions all were performed with frozen allografts obtained from the institution's bone bank using its harvest and processing protocols. All allografts were size-matched using orthogonal contralateral elbow radiographs. For hemiarticular allograft reconstruction, the native collateral ligaments were attached via bone tunnels to the allograft. If the patient's collateral ligaments were believed deficient intraoperatively, the collateral ligaments from the allograft were used for augmentation. For total elbow allograft reconstruction, the native ligaments on the allograft were left intact. All elbows were stable throughout a functional range of motion intraoperatively. Rigid internal fixation was used at the allograft-host junction using the standard AO technique. No total elbow or radial head arthroplasties were performed. Soft tissue coverage was adequate in each of our patients and no flaps were necessary.

Postoperatively, the patients received intravenous antibiotics while in the hospital and were discharged on a 2- to 3-month course of oral antibiotic prophylaxis. Immobilization was performed in a posterior splint for 4 to 6 weeks before beginning a supervised progressive range of motion exercise program wearing a custom-made hinged elbow brace.

All patients were followed closely with regular clinic visits and radiographs until union at the allograft-host junction. Thereafter, patients were followed with yearly clinic visits and radiographs. In a few cases in which the patients lived far away, followup was coordinated with a local orthopaedic surgeon to allow our review of the radiographs.

Functional outcome was evaluated by a system developed by Mankin et al. [26]. This system is based on a combination of factors, including survival, tumor recurrence, pain, and function. An excellent result indicates the patient is recurrence- and pain-free with normal function except for high-performance athletics. A good result indicates the patient is also recurrence- and pain-free with impairment in function that limits recreational but not occupational activities. A fair result indicates the need for aids or a brace as a result of pain or disability that may prevent return to work status. The result is considered a

failure if additional surgery is required for allograft resection, amputation, or the presence of or death from tumor recurrence. Thus, a good or excellent result by this classification indicates a return to preoperative occupational function.

Radiographic and functional outcomes were assessed by the senior author's (HJM) staff and were not blinded to the patients' procedures.

Results

Using the functional outcome criteria, 14 of 19 were able to return to their preoperative occupational function at the latest followup. For patients who had hemiarticular and total elbow allograft reconstructions, 14 of 16 and one of three returned to their preoperative occupational function. Average active range of elbow motion was flexion from 27° to 115°, pronation of 76°, and supination of 57°. Only one patient had severe limitation in his preoperative range of motion and had undergone a previous elbow contracture release. The likelihood of failure depended on the degree of allograft elbow reconstruction performed. Three patients from the entire series had failed reconstructions necessitating subsequent allograft resection. One failure occurred in a proximal ulnar hemiarticular allograft reconstruction resulting from a deep infection. All three patients who had a complete elbow allograft reconstruction had a Charcot-like joint develop 5 to 8 years after surgery. From this group, two of the three patients had unsuccessful reconstructions and ultimately required allograft excision with a residual flail elbow. The remaining patient in the complete elbow allograft reconstruction group had only a fair result. The three patients with unsuccessful reconstructions underwent allograft resection and managed the flail elbow with a brace. None elected to have an arthrodesis.

Complications occurred in six of 19 patients. Complications included two infections, a host-allograft junction nonunion, a postoperative dislocation, one unstable elbow, and two nerve palsies (one radial and one ulnar nerve). The patient with the superficial infection had the infection resolved with empirical antibiotics, as the organism was never identified. The only deep infection from Staphylococcus aureus ultimately necessitated resection of the allograft reconstruction after failed débridements and a course of antibiotics. No intraoperative cultures from the allografts were positive. The only host-allograft junction nonunion, defined as lack of bridging callus on radiographs at 6 months after surgery, occurred in a patient with metastatic renal cell carcinoma. He had two previously failed surgeries for intercalary allograft reconstruction. At his latest followup, he was pain-free with intact internal fixation. One patient underwent closed reduction for dislocation after a distal humerus allograft reconstruction after a fall 1 month after surgery. At his latest followup at 8.5 years, he has a stable and painless elbow without the need for bracing. The only patient with an unstable elbow had a fracture of her medial condyle 6 years after reconstruction. Because of instability to varus stress, she was managed with an elbow brace. One patient in this series had transient radial and ulnar nerve palsies. Although not correlated with function, degenerative changes on radiographs were common in patients followed for more than 2 years.

Discussion

In cases of elbow reconstruction after tumor resection, preservation and restoration of function are secondary goals to excision and local tumor control. Although multiple reconstruction options exist for elbow bone loss from tumor or trauma, we sought to determine the functional outcomes and likelihood of failure for hemiarticular and total elbow allograft reconstruction in 19 patients.

Our study has several limitations. The series was studied retrospectively and is a combination of partial and total elbow allograft reconstruction. The radiographic and functional outcomes were not determined by a blinded observer and the functional outcome criteria have not been formally validated as an outcome measure. However, given the rarity of this reconstructive surgery, this 19-patient series is relatively large compared with other series in the literature.

Numerous authors have reported on the techniques and results of arthroplasty of the elbow in cases with a large osseous defect by replacing the distal humerus [3, 4, 12, 13, 17, 20, 27, 31], the proximal ulna [18], or the entire elbow [2, 10, 11, 17, 36]. With less extensive bone loss, arthrodesis or resection arthroplasty may be an option [21, 31]. With massive bone loss in young patients, most surgical options are compromised and bulk allograft reconstruction becomes a viable alternative [36].

Reconstruction of the elbow with restoration of function can be challenging, particularly with large osseous defects created from tumor resection. In the largest series in the literature, results of custom endoprosthetic replacement of the humerus and elbow in 26 patients with destructive lesions of the distal humerus were reported at a mean followup of 4.5 years [31]. Three prostheses were removed for deep infection, whereas another three had aseptic loosening but were not revised. Despite these complications, endoprosthetic replacement was recommended as a limb salvage alternative. However, elbow prosthetic longevity in young patients and the postoperative restrictions are of particular concern [8].

Many authors have reported on the techniques, results, and complications of allograft reconstruction of other joints [5, 7, 14, 19, 22–26, 28, 29, 33, 34]. Regarding allograft elbow reconstruction, the literature is scarce, especially after tumor resection [1, 6, 35, 36]. With only four patients, a small series of hemiarticular posttraumatic defects treated by distal humerus allograft reconstruction were followed for an average of 5 years [6]. Despite complications occurring in half of our patients, including a deep infection and a nonunion, elbow allograft reconstruction was recommended as a surgical alternative for salvage of the posttraumatic elbow. Another small series reported on hemiarticular allograft reconstructions in two of 22 patients with distal humerus nonunions with inconclusive results [1]. In a series primarily consisting of posttraumatic patients undergoing complete allograft elbow reconstruction, nine patients had painless elbow motion but had degenerative joint changes seen on radiographs by 2 years [35]. Another series of total elbow allograft reconstruction reported a 70% complication rate in patients with six allograft resections and three patients who had conversion surgery to total elbow arthroplasty secondary to instability [10]. Instability occurred in five of six patients and three had revision to a constrained total elbow arthroplasty [11]. The allograft reconstruction was recommended as salvage only and in combination with total elbow arthroplasty, respectively [10, 11]. Despite concerns of instability in long-term followup of 5 to 7 years, only one patient in our series had instability secondary to trauma that was successfully managed with a brace.

Two small series with total elbow allograft reconstruction performed as a salvage procedure in patients with failed total elbow arthroplasty reported good initial functional results but long-term outcome is uncertain [15, 19]. In a small series of six patients treated with total elbow allograft reconstruction, radiograph degradation and lysis increased with time, although 83% had satisfactory outcomes [2]. Similarly, our radiographic findings at the latest followup confirm those of Urbaniak et al. [35, 36] in that joint function was consistently better than predicted based on radiographic appearance.

Although massive allograft reconstruction provides certain advantages, it carries with it serious potential complications [5, 22, 23, 34]. In several large series, complications included nonunion, infection, fracture, allograft resorption, and instability [5, 10, 11, 22–24, 34]. In our overall series, there were two infections (10%), one nonunion (5%), and one fracture with subsequent instability (5%). Our overall complication rates were relatively low compared with the rates in the literature, with the hemiarticular allograft reconstructions having a much lower failure rate than the total elbow allograft reconstructions. Only one allograft was removed for infection, and no amputations were performed. Despite rigid internal fixation, humeral allografts have higher nonunion rates than other sites [24, 26]. The only nonunion in our series occurred in a patient who had multiple operations for metastatic cancer. Despite the nonunion, he remained asymptomatic with good function.

Based on our study, a satisfactory functional outcome can be obtained with allograft elbow reconstruction, particularly with hemiarticular allografts. This trend was reported previously in a series with 100% (six of six) good and excellent results in hemiarticular versus one failure and one fair result in total elbow allografts [17]. The hemiarticular reconstruction subset of our series had 14 of 16 good and excellent results with one of 16 failing. The preservation of joint innervation and host bone load sharing may allow for better outcomes. All of the total elbow allograft reconstructions in our series showed radiographic degenerative changes. Our overall complication rate in approximately one third of our patients was less than that in similar reported series. Another series of posttraumatic total elbow allograft reconstructions followed for a minimum of 7 years had satisfactory outcomes in 83% of the patients [2]. Our small subset of complete elbow allograft reconstructions did not allow return to preoperative occupational function and two of three failed. Hemiarticular allograft elbow reconstruction appears superior to total elbow allograft reconstruction for functional outcome and failures. Although more failures occurred with the total elbow allograft reconstruction group, both allografts were resected 5 years after the reconstruction.

References

1. Ackerman G, Jupiter JB. Non-union of fractures of the distal end of the humerus. *J Bone Joint Surg Am.* 1988;70:75–83.
2. Allieu Y, Marck G, Chammas M, Debonnet P, Raynaud JP. Total elbow joint allograft for long term posttraumatic osteoarticular loss: follow-up results at twelve years. *Rev Chir Orthop Reparatrice Appar Mot.* 2004;90:319–328.
3. Barr JS, Eaton RG. Elbow reconstruction with a new prosthesis to replace the distal end of the humerus: a case report. *J Bone Joint Surg Am.* 1965;47:1408–1413.
4. Behrman MJ, Bigliani LU. Distal humeral replacement after failed continuous passive motion in a T-condylar fracture. *J Orthop Trauma.* 1993;7:87–89.
5. Berrey BH Jr, Lord CR, Gebhardt MC, Mankin HJ. Fractures of allografts: frequency, treatment, and end-results. *J Bone Joint Surg Am.* 1990;72:825–833.
6. Breen T, Gelberman RH, Leffert R, Botte M. Massive allograft replacement of hemiarticular traumatic defects of the elbow. *J Hand Surg Am.* 1988;13:900–907.
7. Brien EW, Terek RM, Healey JH, Lane JM. Allograft reconstruction after proximal tibial resection for bone tumors: an analysis of function and outcome comparing allograft and prosthetic reconstructions. *Clin Orthop Relat Res.* 1994;303:116–127.
8. Brumfield RH Jr, Kuschner SH, Gellman H, Redix L, Stevenson DV. Total elbow arthroplasty. *J Arthroplasty.* 1990;5:359–363.

9. Clohisy DR, Mankin HJ. Osteoarticular allografts for reconstruction after resection of a musculoskeletal tumor in the proximal end of the tibia. *J Bone Joint Surg Am.* 1994;76:549–554.
10. Dean GS, Holliger EH 4th, Urbaniak JR. Elbow allograft for reconstruction of the elbow with massive bone loss: long term results. *Clin Orthop Relat Res.* 1997;341:12–22.
11. Delloye C, Cornu O, Dubuc JE, Vincent A, Barbier O. [Elbow reconstruction with massive total osteoarticular allograft: early failure due to instability.] *Rev Chir Orthop Reparatrice Appar Mot.* 2004;90:360–364.
12. Dunn AW. A distal humeral prosthesis. *Clin Orthop Relat Res.* 1971;77:199–202.
13. Dunn AW. Eleven years' follow-up of a distal humeral prosthesis. *Clin Orthop Relat Res.* 1981;156:262–263.
14. Flynn JM, Springfield DS, Mankin HJ. Osteoarticular allografts to treat distal femoral osteonecrosis. *Clin Orthop Relat Res.* 1994;303:38–43.
15. Foulkes GD, Mitsunaga MM. Allograft salvage of failed total elbow arthroplasty: a report of two cases. *Clin Orthop Relat Res.* 1993;296:113–117.
16. Gebhardt MC, Roth YF, Mankin HJ. Osteoarticular allografts for reconstruction in the proximal part of the humerus after excision of a musculoskeletal tumor. *J Bone Joint Surg Am.* 1990;72:334–345.
17. Jaffe KA, Morris SG, Sorrell RG, Gebhardt MC, Mankin HJ. Massive bone allografts for traumatic skeletal defects. *South Med J.* 1991;84:975–982.
18. Johnson EW Jr, Schlein AP. Vitallium prosthesis for the olecranon and proximal part of the ulna: case report with thirteen-year follow-up. *J Bone Joint Surg Am.* 1970;52:721–724.
19. Kay RM, Eckardt JJ. Total elbow allograft for twice-failed total elbow arthroplasty: a case report. *Clin Orthop Relat Res.* 1994;303:135–139.
20. Kestler OC. Replacement of the distal humerus for reconstruction of the elbow joint: report of two cases with long follow-up. *Bull Hosp Joint Dis.* 1970;31:85–90.
21. Koch M, Lipscomb PR. Arthrodesis of the elbow. *Clin Orthop Relat Res.* 1967;50:151–157.
22. Lord CF, Gebhardt MC, Tomford WW, Mankin HJ. Infection in bone allografts: incidence, nature, and treatment. *J Bone Joint Surg Am.* 1988;70:369–376.
23. Mankin HJ, Doppelt S, Tomford W. Clinical experience with allograft implantation: the first ten years. *Clin Orthop Relat Res.* 1983;174:69–86.
24. Mankin HJ, Doppelt SH, Sullivan TR, Tomford WW. Osteoarticular and intercalary allograft transplantation in the management of malignant tumors of the bone. *Cancer.* 1982;50:613–630.
25. Mankin HJ, Gebhardt MC, Tomford WW. The use of frozen cadaveric allografts in the management of patients with bone tumors of the extremities. *Orthop Clin North Am.* 1987;18:275–289.
26. Mankin HJ, Springfield DS, Gebhardt MC, Tomford WW. Current status of allografting for bone tumors. *Orthopedics.* 1992;15:1147–1154.
27. Mellen RH, Phalen GS. Arthroplasty of the elbow by replacement of the distal portion of the humerus with an acrylic prosthesis. *J Bone Joint Surg.* 1947;29:348–353.
28. Ottolengi CE. Massive osteo and osteo-articular bone grafts: technic and results of 62 cases. *Clin Orthop Relat Res.* 1972;87:156–164.
29. Parrish FF. Allograft replacement of all or part of the end of a long bone following excision of a tumor: report of twenty-one cases. *J Bone Joint Surg Am.* 1973;55:1–22.
30. Rydholm A. Reconstruction after resection of the proximal ulna: report of a case of chondrosarcoma. *Acta Orthop Scand.* 1987;58:671–672.
31. Ross AC, Sneath RS, Scales JT. Endoprosthetic replacement of the humerus and elbow joint. *J Bone Joint Surg Br.* 1987;69:652–655.
32. Serra C, Delattre O, Dintimille H, Dib C, Rouvillain JL, Catonne Y. [Allograft–prosthesis composite arthroplasty for posttraumatic floating elbow.] *Rev Chir Orthop Reparatrice Appar Mot.* 2006;92:269–274.
33. Thompson RC Jr, Pickvance EA, Garry D. Fractures in large-segment allografts. *J Bone Joint Surg Am.* 1993;75:1663–1673.
34. Tomford WW, Thongphasuk J, Mankin HJ, Ferraro MJ. Frozen musculoskeletal allografts: a study of the clinical incidence and causes of infection associated with their use. *J Bone Joint Surg Am.* 1990;72:1137–1143.
35. Urbaniak JR, Aitken M. Clinical use of bone allografts in the elbow. *Orthop Clin North Am.* 1987;18:311–321.
36. Urbaniak JR, Black KE Jr. Cadaveric elbow allografts: a six-year experience. *Clin Orthop Relat Res.* 1985;197:131–140.

Knee Mass From Severe Metallosis After Failure of a Metal-Backed Patellar Component Total Knee Arthroplasty

F. Daniel Kharrazi, MD, Benjamin T. Busfield MS, MD, Daniel S. Khorshad, Francis J. Hornicek MD, PhD, and Henry J. Mankin, MD

Failure of metal-backed patellar components in total knee arthroplasty has previously been reported.[1-11] Developments in prosthetic design such as adding a third peg to the metal baseplate and the use of a mobile-bearing patella have led to lower patellar revision rates.[10,11]

Bayley and colleagues[2,3] reported on the failure of metal-backed patellar components in 25 patients after total knee arthroplasty. Mechanisms of failure included polyethylene wear, fracture, and dissociation.[2,3] Wear or dissociation of the polyethylene from the metal backing, enhanced by abnormal patellofemoral biomechanics or patellar malalignment, is followed by articulation of the patellar metal backing against the femoral component.[1,2,3,5,8] Patellar metallic wear against titanium surfaces causes much more severe abrasion and metallic debris generation in comparison with cobalt-chromium alloys.[6,7,12]

Over time, the abrasive metallic wear debris leads to synovitis.[2, 3, 12, 13] The patients generally experience any of a multitude of symptoms relating to the accompanying synovitis, including pain, limitation of motion, or crepitus with knee motion. Weissman and colleagues[9] introduced the "metal-line sign" as a preoperative aid in radiographic detection of metal-induced synovitis from failure of the metal-backed patellar components after total knee arthroplasty. Breen[14] reported on "titanium lines" as a manifestation of metallosis at the knee in the 3 patients following implantation of titanium tumor prostheses. The radiographic appearance of the titanium lines may mimic soft-tissue tumor recurrence.[14]

F. Daniel Kharrazi, MD, is Orthopedic Surgeon, Benjamin T. Busfield MS, MD, is Orthopedic Surgeon, and Daniel S. Khorshad is Research Assistant, Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California.

Francis J. Hornicek, MD, PhD, is Orthopedic Surgeon, and Henry J. Mankin, MD, is Orthopedic Surgeon, Department of Orthopaedic Surgery, Orthopaedic Oncology Unit, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts.

Address correspondence to: Benjamin Busfield, MD, Kerlan-Jobe Orthopaedic Clinic, 6801 Park Terrace Dr, Los Angeles, CA 90045 (tel, 310 665 7200; fax, 310-665-7242; e-mail, bbusfield@yahoo.com).

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Our case report details a patient referred for a knee mass 9 years after primary total knee arthroplasty with a metal-backed patellar component.

Case Report

A woman in her mid-70s with rheumatoid arthritis and knee pain was managed with a posterior cruciate ligament–preserving right Miller-Galante I total knee arthroplasty with a metal-backed patellar component (Zimmer, Warsaw, IN) in the late 1980s at an outside institution. The patient had an unremarkable postoperative course with relief of her pain. About 5 years later, she began to experience mild, progressive pain in the region of her right knee; the radiographs are shown in Figure 1. This was the last routine yearly radiograph obtained of her knee. About 4 years later, in the mid-1990s, she began having nocturnal knee pain with swelling and an anterior mass near the knee. Radiographs revealed a large radiopaque mass and failure of the metal-backed patellar component with metal-on-metal articulation of the patellofemoral components (Figure 2).

"...detecting progression to failure of total knee arthroplasty prostheses prior to metal-on-metal articulation... can make revision surgery less technically difficult."

On physical examination, the patient ambulated with an antalgic gait. Alignment of the right lower extremity was normal. Right knee motion was from full extension to 120° of flexion without any extensor lag. Pain was elicited only at the extreme of flexion. There was anterior fullness about the right knee, without tenderness to palpation. There was no demonstrable instability, and palpable crepitus was appreciated over the patellofemoral joint. Laboratory evaluation revealed normal calcium, phosphorus, and alkaline phosphatase levels with an elevated serum parathyroid hormone level of 108 pg/mL (normal, 10 to 60 pg/mL). The erythrocyte sedimentation and serum immunoelectrophoresis were normal.

Figure 1. Anteroposterior and lateral radiographs illustrating metal-backed patellar component of a total knee arthroplasty.

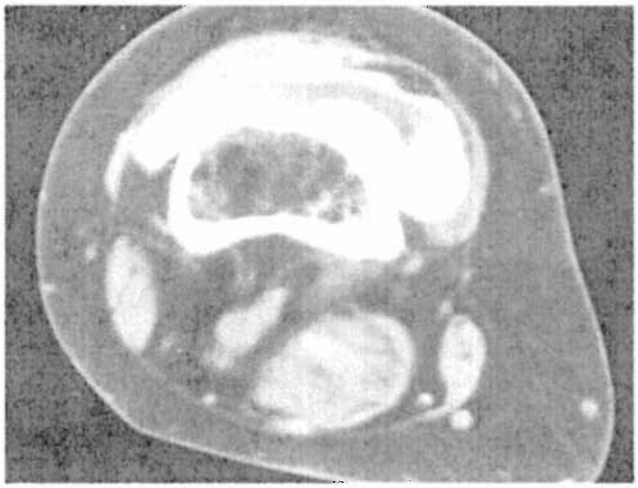

Figure 3. CT scan illustrating a nearly circumferential distal femoral knee mass displacing the quadriceps.

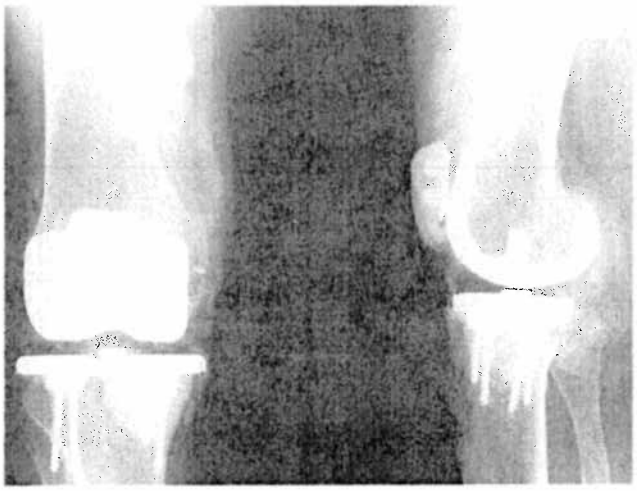

Figure 2. Anteroposterior and lateral radiographs illustrating failure of a metal-backed patellar component with metal-on-metal contact and extensive streaking of soft tissues as the "metal-line sign."

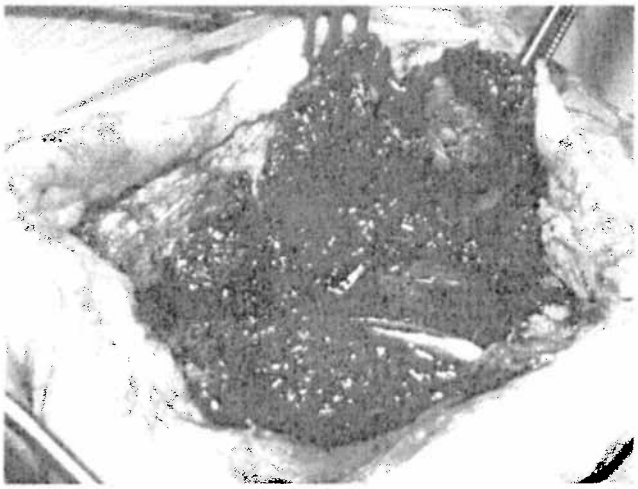

Figure 4. Intraoperative photograph documenting extensive black, metallic staining of the synovium.

A computed tomography (CT) scan showed a well-circumscribed distal femoral knee mass with displacement of the anterior thigh compartment. There was no evidence of cortical destruction or extension into the muscular compartments of the thigh (Figure 3).

Open biopsy of the mass revealed black-stained synovial fluid and synovium from metallic debris generated by the metal-on-metal articulation at the patellofemoral joint of the arthroplasty components (Figures 4 and 5). Pieces of the polyethylene fragments from the failed metal-backed patellar components were present in the joint. The patient was treated with an extensive synovectomy. Given her activity level and existing bone stock, she was treated with patellectomy rather than a revision total knee arthroplasty.

Discussion

Sarcomatous degeneration at the site of total joint arthroplasty and metallic orthopedic implants has been reported in the literature.[14-18] The potential of malignancy in the setting of metallic prostheses is quite rare given the rate of occurrence of sarcomas in the proximity of implants relative to the number of total joint arthroplasties performed annually. Metal-on-metal wear with generation of metallic debris from failure of total joint arthroplasty is more common. Although implants utilized for total joint arthroplasty are thought to be biocompatible, Rae demonstrated the toxicity of different components of metal alloys utilized for total joint prostheses by incubating human synovial fibroblasts with different preparations of metals.[19] Local metal toxicity can cause local tissue reaction, inflammation, and necrosis. Although metal toxicity may contribute to the malignant degeneration near a metallic prosthesis, the metal wear debris and tissue response causing symptoms of pain or a palpable mass near a joint prosthesis can present a diagnostic dilemma.

Bayley and colleagues[2,3] reported on the clinical presentation, radiographic findings, and mechanisms of failure in 25 patients after failure of the metal-backed patellar component in total knee arthroplasty. Clinical history and physical examination were not helpful in making the diagnosis.

Figure 5. Photograph of the tissue from synovectomy.

There was no radiographic evidence of metallic debris in the majority of patients preoperatively. Radiographs, however, revealed failure of the metal-backed patellar components when metal-on-metal articulation was evident. The average time to failure was 18 months. In the majority of patients, the clinical presentation was sudden.[2,3] The "metal-line sign" on radiographs aids in the diagnosis of metal-induced synovitis secondary to failure of joint prosthesis.[9] In a study regarding this radiographic sign, 11 of 18 patients with metallic synovitis had a "metal-line sign" on preoperative radiographs at a range from 19 months to more than 6 years after the index arthroplasty procedure.[9] For titanium total joint arthroplasties, significantly elevated serum titanium levels have been reported as a means of diagnosis of failure and metal-on-metal articulation prior to the appearance of radiographic signs.[20]

"The 'metal-line sign' on radiographs aids in the diagnosis of metal-induced synovitis secondary to failure of joint prosthesis.[9]"

Our case report demonstrates a late failure of a metal-backed patellar component in a patient 9 years following total knee arthroplasty presenting as a knee mass. The rare formation of a thigh mass and a fistula from a popliteal cyst have each been reported in the setting of failure of a total knee arthroplasty.[21,22] Our patient's presentation, with nocturnal pain and a knee mass, raised concern of a possible malignancy. Radiographic evidence of a circumscribed mass with the "metal-line sign" with a failed metal-backed patellar component and the CT scan of the mass supported the diagnosis of a metal debris–induced synovitis. The differential diagnosis included a sarcoma, heterotopic ossification, myositis ossificans, vascular malformation, and metallic synovitis. A metabolically induced mass was possible given the elevation of the parathyroid hormone. A case report by Chang and colleagues[23] describes a similar presentation in a patient with the same Miller-Gallante I knee prosthesis with a metal-backed patella. At 7 years after the index surgery, the patient developed an acutely painful calf mass with failure of the patellar implant and metal-on-metal articulation.[23] An arthrogram showed extension into a large popliteal cyst. The design of the Miller-Gallante I total knee prosthesis with a metal-backed patellar component (Zimmer, Warsaw, IN) with a thin patellar polyethylene contributed to risk of polyethylene component failure.[23] The operative finding of black-stained synovium in our case report demonstrates the utility of the "metal-line sign." Routine yearly radiographs are essential in detecting progression to failure of total knee arthroplasty prostheses prior to metal-on-metal articulation and can make revision surgery less technically difficult.

A Caution: Don't Disregard the Possibility of a Tumor

Despite the presence of a radiographic sign—the "metal-line sign"—pointing to a debris-induced synovitis, the potential toxicities associated with orthopedic metallic implants and debris make the surgeon consider a sarcoma in the differential diagnosis of this knee mass.[17] Although a cause-and-effect relationship between metal debris and carcinogenesis has not been clearly established, the diagnosis must be considered, because inappropriate treatment of a tumor by an unsuspecting surgeon may limit definitive treatment. Synovectomy or revision of the prosthesis in the setting of a sarcoma at the site of an arthroplasty can limit limb-salvage options or delay the diagnosis.

Conversely, this case report illustrates how the orthopedic oncologist should be familiar with the various pseudotumors, including metallosis and its accompanying synovitis.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Anderson HN, Ernst C, Frandsen PA. Polyethylene failure of metal-backed patellar components: 111 AGC total knees followed for 7-22 months. *Acta Orthop Scand*. 1991;62(1):1-3.
2. Bayley JC, Scott RD. Further observations on metal-backed patellar component failure. *Clin Orthop*. 1988;(236):82-87.
3. Bayley JC, Scott RD, Ewald FC, Holmes GB. Failure of metal-backed patellar component after total knee replacement. *J Bone Joint Surg Am*. 1988;70(5):668-674.
4. Buechel FF, Pappas MJ, Makris G. Evaluation of contact stress in metal-backed patellar replacement. A predictor of survivorship. *Clin Orthop*. 1991;(273):190-197.
5. Lombardi AV Jr, Engh GA, Volz RG, Albrigo JL, Brainard BJ. Fracture/dissociation of the polyethylene in metal-backed patellar components of total knee arthroplasty. *J Bone Joint Surg Am*. 1988;70(5):675-679.
6. Millano MT, Whiteside LA. Articular surface material effect on metal-

backed patellar components. A microscopic evaluation. *Clin Orthop*. 1991;(273):204-214.
7. Milliano MT, Whiteside LA, Kaiser AD, Zwirkoski PA. Evaluation of the effect of the femoral articular surface material on the wear of a metal-backed patellar component. *Clin Orthop*. 1993;(287):178-186.
8. Stuhlberg SD, Stulberg BN, Hamati Y, Tsao A. Failure mechanisms of metal-backed patellar components. *Clin Orthop*. 1988;(236):88-105.
9. Weissman BN, Scot RD, Brick GW, Corson JM. Radiographic detection of metal-induced synovitis as a complication of arthroplasty of the knee. *J Bone Joint Surg Am*. 1991;73(7):1002-1007.
10. Nasser S, Campbell PA, Kilgus D, Kossovsky N, Amstutz HC. Cementless total joint arthroplasty prostheses with titanium-alloy articular surfaces. A human retrieval analysis. *Clin Orthop*. 1990;(261):171-185.
11. Firestone TP, Teeny SM, Krackow KA, Hungerford DS. The clinical and roentgenographic results of cementless porous-coated patellar fixation. *Clin Orthop*. 1991;(273):184-189.
12. Jordan LR, Sorrells RB, Jordan LC, Olivo JL. The long-term results of a metal-backed mobile bearing patella. *Clin Orthop*. 2005;(436):111-118.
13. Matsuda Y, Yamamuro T, Kasai R, Matsusue Y, Okumura H. Severe metallosis due to abnormal abrasion of the femoral head in a dual bearing hip prosthesis. A case report. *J Arthroplasty*. 1992;7 suppl:439-445.
14. Breen DJ, Stoker DJ. Titanium lines: A manifestation of metallosis and tissue response to titatanium alloy megaprosthesis at the knee. *Clin Radiol*. 1993;47(4):272-277.
15. Bago-Granell J, Aguirre-Canyadell M, Nardi J. Malignant fibrous histiocytoma of bone at the site of a total hip arthroplasty. A case report. *J Bone Joint Surg Br*. 1984;66(1):38-40.
16. Penman HG, Ring PA. Osteosarcoma in association with total hip replacement. *J Bone Joint Surg Br*. 1984;66(5):632-634.
17. Ryu RK, Bovill EG, Skinner HB, Murray WR. Soft tissue sarcoma associated with aluminum oxide ceramic total hip arthroplasty. A case report. *Clin Orthop*. 1987;(216):207-212.
18. Swann M. Malignant soft-tissue tumor at the site of a total hip replacement. *J Bone Joint Surg Br*. 1984;66(5):620-631.
19. Rae T. The toxicity of metals used in orthopaedic prostheses. An experimental study using cultured human synovial fibroblasts. *J Bone Joint Surg Br*. 1981;63(3):435-440.
20. Leopold SS, Berger RA, Patterson L, Skipor AK, Urban RM, Jacobs JJ. Serum titanium level for diagnosis of a failed, metal-backed patellar component. *J Arthroplasty*. 2000;15(7):938-943.
21. Chavda DV, Garvin KL. Failure of a polyethylene total knee component presenting as a thigh mass. Report of a rare complication of total knee arthroplasty. *Clin Orthop*. 1994;(303):211.
22. Korovessis P, Stamatakis M, Repanti M. Fistula of a popliteal cyst caused by aggressive polyethylene granulomatosis in a cemented total knee arthroplasty. *Orthopedics*. 1997;5(1):49-52.
23. Chang FY, Tseng KF, Chen WM, Huang CK, Chen TH, Lo YH. Metal-backed patellar component failure in total knee arthroplasty presenting as a giant calf mass. *J Arthroplasty*. 2003;18(2):227-230.

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Subacromial pain pump use with arthroscopic shoulder surgery: A short-term prospective study of complications in 583 patients.

Busfield BT, **Lee GH**, **Carrillo M**, **Ortega R**, **Kharrazi FD**.

Arthritis, Orthopedic and Sports (AOS) Medical Center, Glendale, CA.

Pain pumps containing local anesthetics, with or without opioids, can be used for perioperative analgesia after arthroscopic shoulder surgery to reduce pain. Although several smaller studies have demonstrated the analgesic properties, no large series to date has reported the short-term complication rate of subacromial pain pumps. We prospectively studied (2005 to 2007) 583 patients who underwent arthroscopic shoulder surgery at a single outpatient surgery center and had intraoperative placement of a pain pump catheter into the subacromial space. Patients had at least 1 month of follow-up. No patient received perioperative brachial plexus regional anesthesia. There were no cases of infection, internal catheter breakage, pump failure, or hospital admission for pain control. The only complication was external catheter breakage that occurred when a patient attempted to remove the pump without removing the tape fastening the catheter at the skin. Subacromial pain pumps used for arthroscopic shoulder procedures are safe in the short-term.

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