

THURSDAY, OCTOBER 3 2:00 p.m.

Session I—Synergy

Paper #1

Hand Surgeons & Rheumatologists: A National Survey of Physicians' Attitudes toward Surgery for the Rheumatoid Hand

Amy K. Alderman, MD, MPH, Ann Arbor, MI

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Sandra V. Spilson, MPH, Ann Arbor, MI

Peter A. Uble, MD, Ann Arbor, MI

PURPOSE Over 1.4 million Americans with rheumatoid arthritis (RA) have some form of hand disability. However, the surgical management of this disease is controversial, demonstrated by large national variations in the surgical rates of RA hand procedures.¹ The source of these variations—patient preference or provider bias—is unknown. Our objective is to conduct a national survey evaluating potential differences in physicians' attitudes towards the management of RA hand deformities.

METHODS We performed a national cross-sectional survey using a self-administered, mailed questionnaire to 500 rheumatologists and 500 hand surgeons. The questionnaire was designed through a process involving literature reviews, interviews with physicians and patients, and extensive pilot testing. The physicians are a random sample from the 2001 registry of the American College of Rheumatology and American Society for Surgery of the Hand. The responses are based on ordered categories, and Wilcoxon rank sum test is used for the analyses.

RESULTS Of the rheumatologists, only 15% believe that quality information exists regarding rheumatoid hand surgery, and 70% consider hand surgeons deficient in knowledge pertaining to the medical options for rheumatism. Surgeons are equally critical, as 64% perceive rheumatologists as being too pas-

sive in managing RA hand deformities, and 79% find the timing of rheumatologists' referrals inappropriate. When asked to evaluate the benefit of RA hand procedures, major differences between the providers are highlighted. Metacarpophalangeal joint arthroplasty is believed to improve hand function by only 45% of rheumatologists compared to 89% of surgeons ($p < 0.0001$); extensor tenosynovectomy is believed to prevent tendon rupture by only 46% of rheumatologists compared to 92% of surgeons ($p < 0.0001$); and small joint synovectomy is believed to delay joint destruction by only 8% of rheumatologists compared to 60% of surgeons ($p < 0.0001$).

CONCLUSIONS Rheumatologists and hand surgeons significantly disagree on the effectiveness of hand surgery in the RA population. These survey responses explain the wide national variation in surgical practice patterns for rheumatoid disease. This study accentuates the need to develop consensus among physicians caring for RA patients. Further research should be aimed at improving communication between the specialties, coordinating research efforts, and developing an optimal treatment strategy for this common disease.

1. Alderman, A, Chung, K, DeMonner, S., Spilson, S., Hayward, R. Large area variations in the surgical management of the rheumatoid hand. *Surgical Forum* LII: 479-481, 2001.

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Session I—Synergy

Paper #2

A Random Placebo Controlled Double Blind Dose Study of Injectable Collagenase for Dupuytren's Disease

Marie A. Badalamente, PhD, Stony Brook, NY

Lawrence C. Hurst, MD, Stony Brook, NY

Vincent R. Hentz, MD, Palo Alto, CA

PURPOSE Our prior Phase 2 clinical trials of injectable collagenase for Dupuytren's disease have shown clinical safety and efficacy as a non operative treatment. The purpose of this study was to determine a minimum safe and effective dose of collagenase for injection in a random, placebo controlled, double blind dose study.

METHODS Eighty patients entered the study, 64 males and 16 females, mean age 64 years. Fifty-five patients had MP joint contractures (mean contracture=50 degrees) and 25 had isolated PIP contractures (mean contracture=49 degrees). Patients were randomized to receive either saline/calcium placebo or 2,500, 5,000 or 10,000 unit collagenase injection. Patients were evaluated at 1, 7, 14 and 30 days. If patients did not respond with cord rupture to 0-5 degrees of extension by day 30, repeat, open label 10,000 unit collagenase injections, up to a total of 5, could be given, either to the initial target joint or other involved joints. Patients were further followed at 2, 3, 6, 9 and 12 months post injection. Serial IgE testing was also done to monitor potential allergic response.

RESULTS Seventeen patients received placebo, 18 patients received 2,500 units, 22 patients received 5,000 units and 23 patients received 10,000 units collagenase. There was no response to placebo injections in any patient. The 10,000 unit dose was the most effective in inducing cord rupture. The statistical success rate (hazard function) in returning patients to 0-5 degrees of extension at 30 days was 90% for MP joints and 70% for PIP joints at the 10,000 unit collagenase dose. These results were sustained for 12 months. Other involved joints of the same finger/hand or contralateral hand, treated open label with repeat 10,000 unit collagenase injections responded in the same statistical manner. These included 13 MP joints and 25 PIP joints. The success rate for the lower doses in both MP and PIP joints were approximately 40%. There were no adverse immune effects to any collagenase injections.

CONCLUSIONS This study has shown that the minimum, safe and effective dose of injectable collagenase for Dupuytren's disease patients to restore normal hand extension is 10,000 units. This therapy has shown clear merit as a safe and effective alternative to surgical fasciectomy.

THURSDAY, OCTOBER 3 2:18 P.M.

Session I—Synergy

Paper #3

Arthroscopic Assisted Fixation of Scaphoid Nonunions Without Bone Grafting

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Joseph F. Slade, III, MD, Guilford, CT

A nonunion of the scaphoid has traditionally been managed by open reduction, internal fixation with bone grafting. Open reduction and bone grafting of a scaphoid nonunion through a volar approach potentially affects the vascularity of the fracture fragments, while division of the important radioscaphocapitate ligament may result in instability. The purpose of this study was to evaluate the healing rate of selected scaphoid nonunions managed by arthroscopic assisted fixation alone without supplemental bone grafting. Fifteen patients underwent arthroscopic assisted fixation of a scaphoid nonunion without bone grafting. There were 14 males and 1 female in the study. Average age was 20 years (range 17–28 years). A history of a scaphoid nonunion was present an average of 8 months prior to fixation (range 4–15 months). The lunate was neutral on pre-operative radiographs without carpal collapse to be included in the study. There were 12 horizontal oblique fractures involving the middle third, 1 transverse and 2 proximal third fractures. A guide wire is placed under fluoroscopic guidance and anatomic reduction of the fracture was assessed arthroscopically from the midcarpal space. The fracture reduction was “fine-tuned” with joysticks as viewed from the midcarpal

space as necessary. A headless cannulated compression screw is then placed dorsal to volar. No patient underwent bone grafting. Fracture union was evaluated by CT scan and plain radiographs. All patients healed their fractures. Average time to union was twelve weeks (range 8–18 weeks). Average wrist extension was 50°, flexion 60°, radial deviation 20°, and ulnar deviation 25°. Utilizing the Mayo Modified Wrist Score, there were 12 excellent and 3 good results. Bone grafting may not be required in all patients with scaphoid nonunion. Arthroscopic assisted fixation of selected scaphoid nonunions without bone grafting yielded a 100% union rate in this series with minimal morbidity. Placement of a cannulated screw under arthroscopic guidance avoids soft tissue stripping, preserves the blood supply to the fracture fragments and yields an excellent range of motion in this series. The patients in the study were relatively young, which may have influenced the results. This technique would not be recommended in patients with a “humpback” deformity or signs of carpal collapse where bone grafting is required to correct the flexion deformity of the scaphoid.

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Session I—Synergy

Paper #4

A Randomized Controlled Trial of Indirect Reduction and Percutaneous Fixation versus Open Reduction and Internal Fixation for Displaced Intra-Articular Distal Radius Fractures

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Hans J. Kreder, MD, Toronto, ON Canada

Julie Agel, MA, Minneapolis, MN

Thomas E. Trumble, MD, Seattle, WA

OBJECTIVE To compare indirect reduction and percutaneous fixation versus open reduction and internal fixation for displaced intra-articular distal radius fractures in a multi-center randomized clinical trial.

METHODS 179 skeletally mature patients 16–75 with displaced intra-articular distal radius fractures received either indirect percutaneous reduction and external fixation (N=88) or ORIF (N=91). Each fracture was reduced to a standard of acceptable radiographic parameters. Patients were evaluated at 6 weeks, 6 months, 1 and 2 years. Function was measured using the upper extremity module of the Musculoskeletal Function Assessment representing the primary endpoint. Pain, Jebsen Taylor functional testing, ROM, grip and pinch strength were secondary outcomes. Repeated measures analysis of variance was used to compare outcome between the two study groups over time.

RESULTS Primary and secondary outcome measures improved significantly the first year. By two years the mean Jebsen Taylor and pain scores were within 1/2 standard deviation of the control population scores for both study groups. Upper extremity function improved more rapidly after indirect reduction as compared with ORIF; a 13 point score difference was noted in favor of indirect reduction at the six month evaluation ($p=0.037$). After adjusting for repeated measures over the two year study period, indirect reduction resulted in significantly better upper

extremity function as compared with ORIF ($p=0.014$). Pinch strength was also significantly better after indirect reduction ($p=0.020$), with similar trends for grip strength ($p=0.448$) and Jebsen Taylor scores ($p=0.059$). There was no statistically significant difference in the radiographic restoration of anatomic parameters ($p>0.05$). Twelve patients (14%) healed with residual intra-articular step deformity in the indirect reduction group compared with thirteen patients (14%) in the open reduction group ($p=1.0$). Only three patients (3%) in the indirect group and two patients (2%) in the ORIF group had step deformity of more than 2 mm at union ($p=0.679$). Residual step and gap deformity were associated with radiographic arthritis development and also with poor function scores ($p<0.05$).

Indirect reduction and percutaneous fixation results in more rapid return to function and superior functional outcome within two years from injury as compared with ORIF for displaced intra-articular distal radius fracture provided that intra-articular step and gap deformity is minimized.

CLINICAL IMPLICATIONS This is the first study showing that ORIF of intraarticular distal radius fractures should be preceded by attempts at closed reduction, percutaneous stabilization and external fixation. Only if the reduction cannot be obtained with closed percutaneous methods should the fracture be opened and internally secured.

FRIDAY, OCTOBER 4 8:00 A.M.

Session IIA—Imaging

Paper #5A

Comparison of CT and Plain Radiography in the Assessment of Scaphoid Fracture Healing

Charles Cassidy, MD, Boston, MA

Roderick J. Bruno, MD, Boston, MA

Leonard K. Ruby, MD, Boston, MA

Bryan Klepper, MD, Boston, MA

PURPOSE The reliability of plain radiographs to assess union following scaphoid fractures has been questioned. However, a “gold standard” for imaging the healing scaphoid has not been established. The purpose of this study is to evaluate the inter- and intra-observer reliability of CT compared with plain radiographs to assess scaphoid union.

METHODS Twelve patients with scaphoid fractures underwent scaphoid CT and plain radiographs (scaphoid series) at an average of 7 weeks (range: 6–11) following injury or surgery. Mean patient age was 32 years (17–67); all were male. The studies were evaluated on two separate occasions by three orthopaedic hand surgeons who were blinded to patient identity. For each study, three questions were answered: 1) is the fracture united; 2) are there trabeculae crossing the fracture line; and 3) is there sclerosis at the fracture site. Five possible answers included definitely no/yes, probably no/yes, and inconclusive. Following the second assessment, the observers were given the matched Xray/CT pair for a third review, and responded as to whether the CT would make a difference in the management of the

fracture. The data were analyzed and expressed in terms of intra- and inter-observer agreement in pairs, and weighted Kappa statistics were applied.

RESULTS For assessing union, the average inter-observer correlation was slight ($k=0.147$) with plain radiographs, and substantial ($k=0.62$) with CT. The average intra-observer correlation was fair ($k=0.397$) with plain radiographs, and substantial ($k=0.777$) with CT. For both types of imaging, there was a substantial correlation between bridging trabeculae and union, but a poor correlation between sclerosis and union. Fifteen percent of the fractures appeared less healed by CT than plain Xray, while 65 percent appeared to be more healed on CT. In 67 percent of cases, the observers concluded that the CT results would make a difference as to how the fracture would be treated.

DISCUSSION Both the intra- and inter-observer reliability of scaphoid CT appears to be far superior to plain Xray in assessing scaphoid healing. CT is probably unnecessary when plain radiographs show definite evidence of union, but is of value in assessing the degree of healing in equivocal cases.

FRIDAY, OCTOBER 4 8:06 A.M.

Session IIA—Imaging

Paper #6A

The Lichtman Classification of Kienböck's Disease: A Radiographic Evaluation of Stage 3A and 3B

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Richard H. Gelberman, MD, St. Louis, MO

Martin I. Boyer, St. Louis, MO

The present study was undertaken to assess the reliability of the Lichtman classification for Kienböck's disease with specific attention paid to distinguishing Stages 3A from 3B. Posteroanterior and lateral wrist radiographs from thirty-nine patients with previously diagnosed Kienböck's disease were studied. Four reviewers evaluated each radiograph set. Radiographs were graded according to Lichtman classification; additionally, scapholunate angle (SL), radiolunate angle, capitulate angle, scaphocapitate angle, and radioscapoid angle (RS) were measured. The presence of a scaphoid cortical ring sign, the modified carpal height ratio and the Stahl ratio were all assessed. Data were analyzed using kappa values, Wilcoxon-Mann-Whitney and Fisher Exact tests. Whereas interobserver reliability of the Lichtman classification was found to be substantial with a kappa coefficient of 0.63, only the modified carpal height ratio and the Stahl index correlated positively with Lichtman stage. Measures of carpal height were not correlated with pathologic flexion of

the scaphoid. The Stahl ratio, the SL angle, and the RS angle were found have a high degree of interobserver reliability. Several conclusions may be drawn from these findings: 1) While the Lichtman classification is reliable as evidenced by the moderate kappa value, differentiation between stages 3A and 3B is difficult. 2) Presence of a scaphoid cortical ring sign does not correlate with increased SL or RS angles, or with decreased carpal height ratio and Stahl index; it is therefore not a reliable sign of carpal collapse or of disease progression. 3) Pathologic scaphoid flexion, as can be reliably measured by RS angle, is a known precursor to wrist arthritis and has been previously correlated with worsening clinical outcomes in patients with Kienböck's disease. Radiographs with a RS angle greater than 60 degrees should be classified as Lichtman Stage 3B without consideration of carpal height. This modification of the Lichtman Classification will improve reliability, will assist with treatment planning, and clarify outcomes expectations.

FRIDAY, OCTOBER 4 8:15 A.M.

Session IIA—Imaging

Paper #7A

Radiocarpal MR Arthrography of the Wrist: Capabilities and Pitfalls

Mark Skirgaudas, MD, San Francisco, CA

Lisa Lattanza, MD, San Francisco, CA

Edward Diao, MD, San Francisco, CA

Lynne Steinbach, MD, San Francisco, CA

BACKGROUND Although significant advances in MR technique have allowed detailed evaluation of radiocarpal anatomy, the differentiation and confident diagnosis of pathology involving the triangular fibrocartilage and the intrinsic and extrinsic ligaments of the wrist have continued to provide a challenge. Several techniques combining arthrography with MRI have evolved in order to improve diagnostic accuracy. Previous reports have discussed the utility of three compartment MR arthrography in order to diagnose and characterize triangular fibrocartilage and intrinsic carpal ligament injuries. In this study, the utility of single compartment MR arthrography is discussed as a practical and accurate method for diagnosing injuries of the wrist.

MATERIALS AND METHODS We performed single compartment MR arthrography on 10 patients (ages 23–52) who presented with wrist pain and/or weakness. The pre-operative MR diagnosis was compared to findings at surgery. Three of the ten patients had both pre- and post-operative MR arthrograms. MRI of the wrist was performed using coronal and axial T1 weighted sequences with and without fat saturation, thin-section gradient echo coronal, FSE T2 coronal and axial images with fat saturation. These

sequences were performed after single compartment arthrography using fluoroscopic guidance and an injection of dilute gadolinium in normal saline and iodinated contrast.

RESULTS A total of 4 triangular fibrocartilage tears, 2 lunato-triquetral ligament tears, and 5 scapho-lunate ligament tears were identified. In addition focal cartilage defects, focal marrow abnormalities, and abnormalities of the extrinsic ligaments of the wrist were identified. These findings were compared to findings at surgery.

DISCUSSION Single compartment MR arthrography provides a distinct advantage over previously described three compartment techniques in that the injection of only one compartment saves considerable time and is technically less challenging. It is our belief that single compartment injection provides adequate detail and allows confident diagnosis of tears of the triangular fibrocartilage, scapho-lunate, and lunato-triquetral ligaments. The post-arthrogram images give excellent visualization of the intrinsic ligaments allowing differentiation of partial from complete tears. Limitations of this study include a small patient population and the lack of a direct comparison to standard non-invasive MR techniques.

FRIDAY, OCTOBER 4 8:21 A.M.

Session IIA—Imaging

Paper #8A

The Effect of Rotational Malalignment on Radiographs of the Wrist

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Ken Accousti, MD, Newark, NJ

PURPOSE To evaluate the effect of rotational malposition of the wrist on the measurement of typical radiographic parameters of the distal radius and carpus.

METHODS Seven wrists from four young (age 25–38) healthy volunteers were imaged in varying degrees of rotation. The wrists were placed in a custom, calibrated jig and images were taken in 5-degree increments to a maximum pronation and supination of 20 degrees. Radiographs were obtained and printed using a mini-fluoroscopy machine. The images were digitally scanned and angles were calculated using a custom software package. The following measurements were made: scapho-lunate (S-L) angle, radio-scaphoid (R-S) angle, radial-ulnar overlap, radio-lunate (R-L) angle and volar tilt. Radial-ulnar overlap was defined as the distance between the dorsal cortex of the radius and ulna, with a positive value representing dorsal displacement of the ulna.

RESULTS The results demonstrate the following trends: a steady decrease in the S-L angle with extremes of pronation and supination; an increase in volar tilt with supination and a decrease with pronation; no consistent change in the R-L or R-S angle with rotation, and an average 6.3 mm change in ulnar displacement with each 10 degrees of rotation.

DISCUSSION This is the first study to quantify the effect of wrist rotational mal-position on common intercarpal and distal radial measurements. These results demonstrate how malrotation in x-ray positioning can have a significant effect on the apparent alignment of the distal radius and carpal bones. Measurements taken from these poor x-rays typically fall outside of the normal range and could adversely effect treatment decisions.

(degrees)	20pro	15pro	10pro	5pro	Neut	5sup	10sup	15sup	20sup
Scap-lun	41.8	45.8	50.0	53.5	54.0	47.5	40.5	30.0	26.0
Rad-scap	49.3	51.5	50.8	56.3	57.0	63.3	50.3	37.0	39.5
Vol-tilt	1.7	2.8	4.5	8.8	10.5	11.4	14.1	16.2	19.3
Rad-lun	7.5	6.0	-8.2	1.5	3.3	5.3	11.0	7.3	13.3
Rad-Uln Ovrlp(mm)	9.8	7.3	1.3	0.5	-3.5	-6.0	-9.8	-12.5	-14.5

FRIDAY, OCTOBER 4 8:30 A.M.

Session IIA—Imaging

Paper #9A

Computer Assisted Distal Radius Osteotomy: Long-Term Outcomes of a Clinical Feasibility Study

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David R. Pichora, MD, Kingston, ON, Canada

Randy E. Ellis, PhD, Kingston, ON, Canada

Carolyn F. Small, PhD, Kingston, ON, Canada

INTRODUCTION Traditional corrective osteotomy for distal radius malunion is a technically challenging procedure. A fixation-based three-dimensional pre-surgical planner and intraoperative guidance system has been developed which, in in vitro tests, has displayed significant reductions in both maximum error of correction and the standard deviation of the correction error. Intraoperative registration and guidance utilizes an optical tracking system, reducing or eliminating the use of fluoroscopy. Six clinical cases have been performed with this computer-assisted distal radius osteotomy (CA-DRO) technique. The presented work is a postoperative study of outcomes.

CLINICAL RELEVANCE The purpose of this single-cohort study was to validate the technique and to determine the long-term outcomes of computer assisted corrective osteotomy for post-traumatic deformity of the distal radius.

METHODS Six patients with malunion following distal radius fractures (4 dorsal and 2 volar malunions) underwent computer-assisted distal radius osteotomy and were available for follow-up evaluation of range of motion, grip strength, radiographic parameters and with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire. Pre- and post-osteotomy CT based 3D isosurface models were constructed and visually assessed for correction of deformity.

RESULTS At an average of 25 months (range, 15 to 36 months) after computer-assisted surgery the average grip strength measured with a Jamar dynamometer was 30 kilograms compared with 38 kilograms in the contra-lateral hand. Post-operative range of motion measured 87% of the motion of the contra-lateral limb. DASH results averaged 14.0; range, 3.3-53.3. Radiographic measures improved in all three planes. Radial inclination improved from 12° pre-operatively to 21° post-operatively (normally 22°), ulnar variance improved from +7.5mm pre-operatively to +1.9mm post-operatively (contralateral mean +1.5mm), and volar tilt improved from -30° for dorsal malunions and +20° for volar malunions pre-operatively to 9° post-operatively (normally 11°). Axial malalignment, not seen on plain radiographs, was identified and corrected in all cases. An average of 15° of supination was required as part of the correction in dorsal malunions.

CONCLUSIONS CA-DRO improves objective radiographic measurements and provides outcomes, as measured by clinical examination and functional questionnaires, comparable or superior to published results for conventional techniques. CA-DRO allows the surgeon to accurately and reliably correct multi-planar deformities with reduced radiation exposure to patients and OR staff.

FRIDAY, OCTOBER 4 8:36 A.M.

Session IIA—Imaging

Paper #10A

The Correlation Between Physical Examination and Glenohumeral Joint Deformity after Obstetrical Brachial Plexus Palsy

Scott H. Kozin, MD, Philadelphia, PA

INTRODUCTION A common sequelae after obstetrical brachial plexus palsy is glenohumeral joint deformity. This purpose of this study is to determine if the physical examination findings correlate with the severity of glenohumeral joint dysplasia.

METHODS Thirty children between the ages of 1.3 and 9.3 years (average=4.8 years) with residual brachial plexopathy underwent MR imaging of both shoulders using high-resolution 3-millimeter thick axial gradient-recalled echo images. The glenoscapular angle (the degrees of version) was measured and the percent of humeral head anterior to the middle of the glenoid fossa (PHHA) was calculated on both sides. The physical examination findings were recorded including the active and passive motions about the shoulder. The external rotation of the glenohumeral joint was measured during firm stabilization of the scapulothoracic joint. The data was analyzed using analysis of variance and Pearson product correlation coefficients.

RESULTS The uninvolved shoulders averaged minus 6° (range: -15 to 0°) of version and PHHA averaged 50% (range: 41 to 60%). The involved shoulders averaged minus 26° (range: -75 to -4) of version and PHHA averaged 34% (range: 5 to 52%). Both version

and subluxation were significantly different ($p < .001$) between uninvolved and involved shoulders. There was a significant correlation between version and subluxation ($r = .9$, $p < .001$). External rotation was limited on the involved side averaging minus 3° (range: -45 to 35°). There was a significant correlation between external rotation, version ($r = .5$, $p = .01$), as well as PHHA ($r = .7$, $p < .001$). Progressive loss of external rotation beyond neutral was associated with increased angles of retroversion and diminished humeral head anterior to the middle of the glenoid fossa. Abduction or age did not correlate with the amount of deformity.

DISCUSSION Normal shoulder development appears to require a complete range of motion between the humeral head and glenoid. Residual obstetrical brachial plexus palsy often results in a persistent deficiency of external rotation and creates a constant position of internal rotation, which promotes glenoid retroversion and humeral head subluxation. The clinical loss of glenohumeral external rotation beyond neutral correlates with the underlying glenohumeral dysplasia and should be regarded as an indicator of shoulder malformation.

FRIDAY, OCTOBER 4 8:00 A.M.

Session IIB—Congenital

Paper #5B

Toe Transfers to Improve Gripping Ability in Children

Simo K.Vilkki, MD, PhD, Tampere, Finland

Seventy-two microneurovascular toe-to-hand transplantations were done for 66 pediatric patients between 1979 and 2001. For this study we selected those toe-to-hand transfers in which the indication was to improve the gripping ability of the defective hand. Both posttraumatic and congenital cases were included. Joint transfers were excluded. The studied material consists of 52 transfers for 49 defective hands.

POSTTRAUMATIC SERIES There were 16 patients. The age of the patients ranged from 3 to 14 years. Mean age was 9.4 years. A thumb was reconstructed in 13 hands and a finger(s) in 3 hands. The transferred toe consisted of all three joints in 8 cases, two joints in 7 cases and a second toe wrap-around a flap was used for one thumb reconstruction.

CONGENITAL SERIES There were 32 patients and 36 toe-transfer operations were done. Age ranged from 1 to 14 years. The mean age was 4.9 years. There were 33 adactylic or acheiric hands with a major defect in hand function. The main indication (30 hands) was the lack of gripping or pinching ability. A monodactylous symbrachydactyly was indication in 21 and acheiria in 5 hands. Two extreme cleft hands with single ulnar digit were treated with toe transfers. The thumb was reconstructed in 11 operations and an ulnar finger reconstruction was performed in 25

cases. Three hands were operated twice for further grasp improvement. The transplanted toe included all three joints in 30 transfers and two joints in 5 transfers and only a proximal phalanx in one case. A non-vascularised free phalanx transfer was combined to improve the function in 6 cases.

RESULTS The microsurgical success rate was 96%. In posttraumatic series, no failures were recorded. In the congenital series, there were 2 complete vascular failures. Both failures occurred in the age group below 2 years. The pinching ability was restored in all posttraumatic hands and in 29/33 congenital hands. The new grip was considered very useful in all but one congenital hand after successful transfers. The donor feet had no problems at follow-up.

CONCLUSION AND SIGNIFICANCE A defective hand can be reconstructed successfully using microneurovascular toe-to-hand transplantation in children. It is a very effective means of improving the gripping ability after posttraumatic thumb defects and especially in monodactylous symbrachydactyly type of adactyly in congenital hands. The recommended age in congenital cases is from 3 to 5 years of age. A cosmetic improvement was better achieved in posttraumatic group while the overall hypoplastic appearance of the hand will remain in congenitally severely defective hands.

FRIDAY, OCTOBER 4 8:06 A.M.

Session IIB—Congenital

Paper #6B

Ollier's Disease of the Hand in Children

Didier Moukoko, MD, St. Gely du Fesc, France

In Ollier's disease the short tubular bones of the hand are most frequently involved with multiple enchondromas, but little has been written on upper extremity issues. Only a few cases have been reported, one series of 10 patients describes specific hand lesions, whereas treatment of multiple enchondromas is occasionally reported with their solitary counterparts in mixed series. We report a retrospective study of 22 children followed up through growth for hand multiple enchondromatosis. We recorded 246 localizations on short tubular bones presenting usually painless finger masses and radio-lucent lesions. Half the patients presented unilateral lesions while bilateral involvement was correlated with a more severe and generalized form of the disease. 14 patients have reached skeletal maturity with a stable condition. 7 patients averaging 9 years 3 months are currently being followed up. 1 patient suffering from Maffucci's syndrome died aged at 6+3 from angiosarcomatous degeneration of a leg soft tissue lesion. Average age at diagnosis was 6 years 9 months. Pain and pathological fractures were a very unusual symptom encountered in only 3 patients. Function generally remained adequate. However 14 patients were operated on; 3 for forearm lesions and 11 for symptomatic increase of hand tumor volume, at an average age of

8+8. Of the latter, 5 were operated twice, and 1 patient 3 times, totaling 18 surgical procedures. There were 37 tubular bones operated with 51 surgical interventions. Curettage alone was performed in 21 cases, and associated with autologous cancellous bone grafting in the remaining 30. One ray was amputated. At a shortest post-operative follow up of 19 months, residual radio-lucent lesions were common averaging 62%, of which 43% required re-operation. In general, disabling forms are rare, function remains adequate without surgery and pathological fractures are exceptional. Cosmetic issues indicate surgery in most cases. The goal for surgery is to decrease bulk and prominence to improve cosmesis rather than eradication of the lesion which is difficult to obtain by surgery. At skeletal maturity the disease stabilizes. Pain, swelling or pathological fractures are highly suspect of malignant changes. No secondary chondrosarcomas were observed in our series of young patients. However, with increasing age, the risk of their development increases. This occurrence should lead to carcinological excision, posing the problem of choice of resection margin. The behavior and aggressiveness of multiple enchondromas of the hand makes these lesions separate entities from their solitary counterparts and deserve specific discussion.

FRIDAY, OCTOBER 4 8:15 A.M.

Session IIB—Congenital

Paper #7B

Anatomical Description of an Anomalous Muscle in Thrombocytopenia Absent Radius (TAR) Syndrome and Discussion of Its Clinical Significance

Peter Carter, MD, Dallas, TX

Janith Mills, PA-C, Dallas, TX

Marybeth Ezaki, MD, Dallas, TX

INTRODUCTION AND PURPOSE A heretofore undescribed muscle is consistently noted in children with Thrombocytopenia Absent Radius (TAR) Syndrome. This muscle contributes to the persistence, and or recurrence, of the radial club hand deformity. We attempt to better describe and characterize this anatomic finding.

MATERIALS AND METHODS A retrospective review of all cases of TAR syndrome seen at our institution was made. There were 15 patients with 29 arms with a Bayne Type IV totally absent radius. Operative records and radiographs and intra operative photographs were examined. To serve as a control, the radiographs of 13 cases of radial dysplasia not associated with Thrombocytopenia Absent Radius (TAR) Syndrome were examined.

RESULTS In all 29 limbs with Type IV totally absent radius in association with the TAR syndrome, the

anomalous muscle was clearly demonstrated on the radiograph and originates high on the humerus at the level of the deltoid muscle insertion. All cases that we have explored for this muscle, it has presented as a broad, substantial muscle that spans the elbow and wrist joint and attaches to the deficient carpus. In 12 cases reviewed with Type IV radial dysplasia not associated with TAR syndrome, the muscle was not seen.

DISCUSSION The anomalous muscle appears to be a homologue of the normal brachioradialis muscle but is more proximal in its origin and more distal in its insertion but usually is more fan shaped. During the reconstructive procedure to treat the radial club hand deformity associated with TAR syndrome, both proximal and distal release and/or resection of this muscle has appeared to play an important role in improved outcomes. Surgeons treating these children should be aware of its clinical significance.

FRIDAY, OCTOBER 4 8:21 A.M.

Session IIB—Congenital

Paper #8B

Ulnar Growth Patterns in Radial Longitudinal Deficiency

Anthony Sestero, MD, Minneapolis, MN

Ann E. Van Heest, MD, Minneapolis, MN

Julie Agel, MA, Minneapolis, MN

OBJECTIVE To determine the effect of centralization on the longitudinal growth of the ulna in radial longitudinal deficiency and whether the technique of centralization can alter this effect.

METHODS AND MATERIALS Charts were reviewed on 90 patients with 124 affected limbs. Thirty-four (38%) of the patients were affected bilaterally and 56 (62%) were affected unilaterally. In the unilateral patients the right side was affected in 29 (52%) of the patients and the left side in 27 (48%) of the patients. Using the Bayne and Klug classification there were 5 type I, 3 type II, 9 type III, and 107 type IV deformities. Deficiency in the thumb was found in 113 (91%) of these limbs. Eleven of the thumbs were normal, 59 (47%) were hypoplastic, 43 (35%) were aplastic, and 11 (9%) had deficiencies of digits in addition to the thumb. Fifty (56%) of the patients had an associated syndrome or deformity. All available radiographs were measured for ulnar length, ulnar angulation, hand-forearm axis, and distal metaphyseal width and depth. Seventy-three limbs (59%) had available radiographs. Of the measured radiographs 46 (63%) had undergone a centralization, 4 (5%) had an alternative procedure, and 23 (32%) had non-operative treat-

ment. The patients undergoing a centralization were subclassified into a "notched" centralization, if any portion of the carpus or ulna was resected, or a "non-notched" centralization, if neither the carpus nor the ulna had been resected.

RESULTS Ulnar length for the non-operative, non-notched centralization, and notched centralization groups were compared to normative data for ulnar length. The non-operative group attained 64% normal length, while the non-notched centralization group attained 58% and the notched centralization group attained 48% of normal ulnar length. When compared to the non-operative group, the expected difference in ulnar length at skeletal maturity was 1.6 cm less for the non-notched centralization group and 4.7 cm less for the notched centralization group.

CONCLUSION Patients with radial longitudinal deficiency can be expected to attain 64% of normal forearm length. When treated with a centralization procedure some of their ulnar growth potential will be lost. A non-notched centralization will preserve more of the ulnar growth potential than a notched centralization.

FRIDAY, OCTOBER 4 8:30 A.M.

Session IIB—Congenital

Paper #9B

Effect of Osteochondromatosis Location on Forearm Deformity in Patients with Multiple Hereditary Osteochondromatosis

Yumiko Kanauchi, MD, Maywood, IL

Terry R. Light, MD, Maywood, IL

Michael S. Bednar, MD, Maywood, IL

PURPOSE Deformities of the forearm in patients with multiple hereditary osteochondromatosis may result in functional impairment and cosmetic deformity of the extremity. We evaluated the natural history to determine predictors of deformity.

MATERIAL AND METHOD The records of 102 patients who had forearm deformities associated with multiple hereditary osteochondromatosis were reviewed. Anteroposterior and lateral radiographs of the forearms were available for forty-eight patients; a total of seventy-six forearms were studied. Clinical cases were divided into 6 types according to osteochondromatosis location. Type 1: The main osteochondroma formation is in the distal portion of the ulna: 30 forearms. Type 2: Distal ulna and radius: 23 forearms. Type 3: Distal radius: 9 forearms. Type 4: Diaphysis of the ulna: 7 forearms. Type 5: Proximal radius or ulna: 2 forearms. Type 6: Radial head dislocation at initial evaluation: 5 forearms. Radiographic determinations included 1) Ulnar bow- the maximal distance between posterior border of the ulnar diaphysis and ulnar axis divided by the length of the linear axis of forearm, 2) Ratio of proximal point of osteochondroma (RPO) - the distance from the proximal osteochondroma to distal radial physeal plate divided by the length of the linear axis of the forearm, 3) Ulnar variance, 4) Radial articular angle (RAA), 5)

Radial bow, 6) Radial and ulnar length. The effects of each measure were statistically evaluated with the use of linear regression and correlation analysis in each Type.

RESULTS Radial and ulnar lengths were highly correlated linearly in all Types (Type 1: $r^2=0.72$; $p<0.0001$, Type 2: 0.94, Type 3: 0.99, Type 4: 0.99). In Type 1, correlation was shown between RAA and radial bow ($r^2=0.633$), RAA and radial lengths ($r^2=0.656$), radial bow and radial length ($r^2=0.568$), ulnar bow and ulnar length ($r^2=0.61$), ulnar bow and radial length ($r^2=0.58$), ulnar bow and RPO ($r^2=0.59$), RPO and ulnar length ($r^2=0.58$), ulnar variance and ulnar length ($r^2=0.58$).

DISCUSSION Because the natural history of multiple hereditary osteochondromatosis remains ill defined, the role and timing of surgical treatment of the forearm remains controversial. Our observations demonstrated that Type 1 forearms are most likely to develop excessive bowing of the radius and ulna. The five Type 6 forearms appeared to have initially demonstrated Type 1 appearance. Moreover 7 of the 30 Type 1 forearms developed subsequent radial head dislocation, while only one of the others, 41 forearms, a Type 2 forearm, developed radial head dislocation. This review suggests that Type 1 forearms are most at risk to develop secondary deformity.

FRIDAY, OCTOBER 4 8:36 A.M.

Session IIB—Congenital

Paper #10B

Neonatal Brachial Plexus Palsy: Results of Treatment of Shoulder Dislocation in Infancy

Marybeth Ezaki, MD, Dallas, TX

Peter Carter, MD, Dallas, TX

Randall Alexander, MD, Dallas, TX

Richard Chang, MD, Dallas, TX

INTRODUCTION AND PURPOSE The most common residual weakness in neonatal brachial plexus palsies (NBPP) involves the shoulder. Glenoid dysplasia and shoulder subluxation, dislocation and stiffness are known complications for patients with NBPP. The incidence of posterior shoulder dislocations in infants with neonatal brachial plexus palsies is about 8% at our institution. We present here our treatment algorithms, operative indications, surgical procedures, and results of our care of shoulder subluxations and dislocations in infants with NBPP.

MATERIALS AND METHODS 38 patients with NBPP and posterior shoulder subluxations or dislocations underwent surgical procedures on the shoulder. Average age at time of operation was 12.9 months (range 3–27 months). There were 20 females and 19 male patients. Procedures included intraoperative arthrograms, closed and open reductions, soft-tissue releases, capsulorrhaphies, muscle and tendon transfers. Two patients underwent concomitant brachial

plexus explorations and neurolyses. Preoperative and postoperative shoulder range of motion was recorded and imaging studies were compared.

RESULTS Mean follow-up time was 16 months (range 6–40 months). One shoulder required a second open reduction. Glenoid development has not been normal in any child. Range of motion improved in active abduction by an average of 18 degrees.

DISCUSSION The onset of posterior shoulder subluxation or dislocation in patients with NBPP can occur earlier and more suddenly than has generally been appreciated. We report here our surgical approach to 39 patients who underwent open or closed reductions on the shoulder with concomitant soft-tissue releases, capsulorrhaphies, and tendon transfers. Our results indicate that active range of motion, particularly in abduction, improved in these patients and suggest that longer-term follow-up may reveal improved functional results.

FRIDAY, OCTOBER 4 1:00 P.M.

Session IIIA—Arthritis

Paper #11A

A Prospective Outcomes Study of Swanson Metacarpophalangeal Joint Arthroplasty for the Rheumatoid Hand

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Amy K. Alderman, MD, MPH, Ann Arbor, MI

INTRODUCTION Swanson Metacarpophalangeal Joint Arthroplasty (SMPA) has been widely used for correction of ulnar subluxation of the fingers in the rheumatoid hand. However, a prospective outcomes study has been lacking to demonstrate the effectiveness of this procedure in improving health-related quality of life in the rheumatoid population. The purpose of this study is to prospectively evaluate a series of patients undergoing SMPA using a validated outcomes questionnaire and objective hand function tests.

METHODS Over a two-year period, we prospectively enrolled a group of rheumatoid patients undergoing SMPA who have Stage 3 or 4 disease at the metacarpophalangeal (MCP) joints. Patients are eligible if they require SMPA on all four MCP joints, with and without thumb MCP fusion. Preoperative evaluations include the Michigan Hand Outcomes Questionnaire (MHQ), Jebsen-Taylor test, grip/pinch strength, degree of ulnar deviation of the fingers, and finger range of motion. Patients are followed at six-month,

one year, two year, and three year intervals with these same tests. Results: We have enrolled 17 patients into this study, and the six-month data is presented. There is no statistically significant difference in the functional outcomes, as shown in Table 1. Ulnar drift improves from 29 to 6 degrees ($p=0.03$), while MCP joint range of motion does not change significantly (45 to 47 degrees ($p=0.83$)). However, Table 2 indicates that the most important improvements occur in the MHQ domains. Huge effect sizes are seen in the ADL, aesthetics, satisfaction, and overall hand function domains, while large effect sizes are seen in the work and pain domains.

CONCLUSION At six-month follow-up, SMPA significantly improves health-related quality of life in rheumatoid patients, while the biomechanical parameters are not changed. This study highlights the importance of using validated quality of life measures in the study of rheumatoid patients. SMPA is highly effective in the short term in improving hand function. Our ongoing study will determine whether the salutary outcomes are maintained over the long term.

TABLE 1

Test	Pre-Operative Mean	Post-Operative Mean	p-Value	Effect Size
Grip Strength (kg)	7.2	6.4	0.40	0.3
Key (Lateral) Pinch (kg)	2.8	3.1	0.40	0.3
2-Point (Tip) Pinch (kg)	1.5	2.0	0.15	0.6
Three Jaw (Palmar) Pinch (kg)	2.0	2.7	0.14	0.6
Jebsen-Taylor (sec)	42.8	35.3	0.16	0.6

TABLE 2

MHQ Scale	Pre-Operative Mean	Post-Operative Mean	p-Value	Effect Size
Function	36.88	71.25	<0.01	1.7
ADL	30.43	78.70	<0.01	3.1
Work	23.75	55.0	<0.01	1.4
Pain	73.75	34.38	<0.01	2.0
Aesthetics	22.66	94.53	<0.01	3.9
Satisfaction	18.23	76.04	<0.01	4.0

FRIDAY, OCTOBER 4 1:06 P.M.

Session IIIA—Arthritis

Paper #12A

Isolated Silicone Replacement Arthroplasty for Post-Traumatic and Primary Osteoarthritis of the Metacarpophlangeal Joint

Brian M. Jurbala, MD, Pittsburgh, PA

Kodi K. Azari, MD, Pittsburgh, PA

Glen A. Butterbaugh, MD, Wexford, PA

Joseph E. Imbriglia, MD, Wexford, PA

PURPOSE Silicone replacement arthroplasty has proven to be an effective procedure for relief of pain and improvement in range of motion in select patients with rheumatoid arthritis (RA). We know of no large published series that has examined the results of isolated metacarpophlangeal (MCP) arthroplasty for osteoarthritis. The purpose of this study was to review the senior author's technique and results of silicone replacement arthroplasty for isolated MCP post-traumatic and primary osteoarthritis (OA) and to identify factors associated with a poor outcome.

METHODS Twenty-four patients with isolated MCP posttraumatic OA and primary OA underwent silicone replacement arthroplasty. Average age at operation was 49 years (range 24–74 years). 16 cases involved middle, 4 index, 2 ring and 2 small MCP joints. Two patients had a history of Diabetes Mellitus. All patients were evaluated preoperatively in the office. 9 patients had primary OA with the remainder having arthritis associated with a history of trauma. The primary indications for operation were pain unresponsive to conservative treatment, loss of range of motion and X-ray findings consistent with degenerative arthritis. Length of follow up averaged 43 months.

TECHNIQUE The operative technique for isolated MCP arthroplasty, as opposed to multiple arthroplasties, involved an axial rather than transverse skin incision. In contrast to the technique we use for rheumatoid patients, we resected the metacarpal head just distal to the origin of the collateral ligaments rather than proximal. This allows more stability, preserves length and leads to more physiologic motion.

RESULTS Good pain relief at the MCP joint was obtained in 21 of 24 patients. The average postoperative range of motion was 68 degrees. Major complications included infection in two patients requiring removal of the prosthesis. Patients with primary OA had the best results with some patients obtaining an 85 degree arc of motion. The postoperative range of motion was proportional to the preoperative range of motion in the postraumatic cases.

CONCLUSION Patients with the best overall results were those with primary isolated MCP OA. Patients with posttraumatic OA, major concomitant soft tissue injuries and stiffness involving other digits had the poorest results.

FRIDAY, OCTOBER 4 1:15 P.M.

Session IIIA—Arthritis

Paper #13A

Resection of the Distal Scaphoid for Treatment of Scaphotrapezial Trapezoid Arthritis

Nash H. Naam, MD, Effingham, IL

INTRODUCTION Isolated osteoarthritis of the scaphotrapezial trapezoid (STT) joint accounts for approximately 15 % of osteoarthritis of the wrist. Patients who fail conservative treatment may need surgical intervention, in the form of either STT fusion or silicone arthroplasty. Both options are associated with relatively high complication rates. Resection of the distal scaphoid has been proposed as a surgical alternative.

MATERIALS AND METHODS Between 1994 and 1999, 23 patients underwent distal scaphoid resection for isolated STT arthritis. There were 14 males and 9 females, with an average age of 63 years. Patients were symptomatic for an average of 19 months. The distal 1/4 of the scaphoid was resected through a dorsoradial approach under regional anesthesia on outpatient basis. The plane of resection was made perpendicular to the long axis of the forearm rather than the axis of the scaphoid. Dorsal capsulodesis was performed in 8 patients because of preoperative dorsal intercalated segmental instability (DISI) tendency. Postoperatively, patients were placed in short arm splint for three weeks, followed by active range of motion (AROM) exercises.

RESULTS Post operative follow-up ranged from 2-7 years with an average of 3 1/2 years. Relief of pain was excellent in 61%, good in 30%, fair in 4% and poor in 4%. AROM and grip strength averaged 85% and 79% of the contralateral side respectively. According to Mayo wrist scoring system: excellent results were achieved in 57% of the patients, good in 35%, fair in 4%, and poor in 4%. All patients eventually returned to their original work activities. All patients exhibited some postoperative increase of the radiolunate angle which was less in patients who underwent capsulodesis. The degree of DISI deformity did not change with time. One patient developed significant increase in the degree of DISI deformity. That patient continued to complain of pain and limited extension. He underwent further surgical procedure for removal of the scaphoid and 4-corner bone fusion. 92% of the patients were very satisfied with the operation.

CONCLUSION Resection of the distal scaphoid is a viable option for treatment of isolated scaphotrapezial trapezoid arthritis. Capsulodesis may prevent further progression of DISI deformity. Patients with a significant degree of preoperative DISI deformity may be better treated with STT fusion.

FRIDAY, OCTOBER 4 1:21 P.M.

Session IIIA—Arthritis

Paper #14A

Tendon Suspension and Interposition Arthroplasty of the Wrist

Yoshitaka Minamikawa, MD, Osaka, Japan

Masaya Nakamura, MD, Moriguchi, Japan

Naoya Ichioka, MD, Osaka, Japan

Ko Nakatani, MD, Kochi, Japan

Total wrist replacement and silicone implant have been used for rheumatoid patients. Despite the early enthusiastic applications, long term results with these arthroplasties are disappointing. Radio-lunate fusion is an excellent procedure when the mid carpal joint is preserved. Palmar shelf arthroplasty and fibrous-union combined with dorsal stabilization are other historical techniques for more advanced destruction; but, total arthrodesis is probably the most established choice for the advanced conditions. Our experience, however, makes us believe that total arthrodesis can be avoided even for failed arthroplasty if bone resection is limited to a minimum. We report new surgical procedure for wrists with destruction in both radiocarpal and mid carpal joints. Tendon suspension and interposition arthroplasty (TSIA) of the wrist was designed to create a space by joint debridement and proximal row carpectomy; to stabilize the wrist (using wrist tendons), and interpose these tendons into the space. One wrist extensor (ECRB or ECRL) and one flexor (FCR or FCU) are incised proximally, kept attached distally and used as suspension interposition between capitate and radius. The wrist flexor is passed from volar to dorsal via a hole made at the distal radius (volar to dorsal stabilization); half of the extensor is passed from cap-

itate to radius through bony holes made in the center of the joint (central stabilization); the other half of the extensor is passed through a dorsal hole in the radius (dorsal stabilization). Each tendon slip is then anchored around the tendon that is located in the center of the joints. Twenty-two wrists (20:RA, 2:OA) in 21 patients aged 29 to 68 were operated in past 6 years, with minimum follow up of 18 months (average, 36.6 months). Mean postoperative flexion/extension arc was 36 degrees active and 64 degrees passive. Grip strength doubled on average compared to pre-operation in 17, no change in 3, decreased in 2. Pain relief and patients' satisfaction were excellent except for 3. There was one delayed wound healing and two ulnar nerve palsies and no infections. The two patients with palsy underwent nerve release, and one recovered completely but the other developed RSD. Joint space created by this operation decreased within 6 months, however no ankylosis was observed. Advantages of this operation include use of no foreign materials, preservation of minimum motion and excellent pain relief. Although further follow up and more cases are required, this operation has proven to be a good alternative to total joint replacement or total fusion.

FRIDAY, OCTOBER 4 1:30 P.M.

Session IIIA—Arthritis

Paper #15A

Biaxial Total Wrist Arthroplasty: Results Using a Modified (Long) Metacarpal Stem

Marco Rizzo, MD, Rochester, MN

Robert D. Beckenbaugh, MD, Rochester, MN

The biaxial total wrist arthroplasty (TWA) has offered good pain relief and adequate range of motion to many patients. One concern regarding the implant is survivorship, especially with failure of the distal component. Previous studies have noted approximate 20% failure rate by six years. A long revision distal stem was developed in 1993. The purpose of this study is to evaluate the results of primary TWA with this longer stem. Seventeen wrists in fourteen patients underwent primary TWA using the modified distal component between 1993 and 1997. The diagnoses included eleven patients with rheumatoid arthritis (RA), one patient with juvenile RA, and two with osteoarthritis. The mean age at surgery was 58.6 years. The mean follow-up period is 73.9 months (range 49–102 months). Pain is reported as none in 15 (88%) and mild in 2 (12%), whereas all patients had significant pain pre-operatively. The average wrist range of motion at follow-up was 26° flexion, 35° extension, 9° radial deviation, and 22° ulnar deviation. The average grip strength improved from 5.6 kg (pre-operatively) to 9.8 kg. To date no prosthesis has failed. One prosthesis demonstrated mild erosion into the dorsal cortex of the third metacarpal that stabilized with no clinical relevance to date. In this case,

initial placement of the distal component was dorsal within the metacarpal. Two cases of intra-operative non-displaced metacarpal fractures have been noted. Both cases went on to heal uneventfully. At most recent follow-up four cases (23%) demonstrate some degree of lucency about the cement mantle. Two patients had an isolated lucency in zone 3, and one in zones 1 and 5. A final patient demonstrated diffuse lucencies in zones 2 and 3. The bony changes have not proven clinically relevant and no radiographic evidence of basilar settling or loosening of the prosthesis has been noted. No cases of dislocation or infection have occurred. No proximal component loosening or settling has occurred. The results of this study are equal to or better than previous studies examining the biaxial TWA. Historically, the major site of failure has been secondary to distal component loosening. Early data using the longer stem is very encouraging. No failures at a greater than 6-year average (4-year minimum) follow-up have been noted. All of the patients were satisfied with their surgery. Intra-operative complications such as fracture and technical challenges of placement of a longer metacarpal stem were encountered but did not affect the outcomes.

FRIDAY, OCTOBER 4 1:36 P.M.

Session IIIA—Arthritis

Paper #16A

Multi-Center Outcome Study of the Universal Total Wrist Prosthesis

Brian D. Adams, MD, Iowa City, IA

INTRODUCTION The Universal wrist prosthesis has several features designed to improve the performance and longevity of total wrist arthroplasty. This report presents the radiographic and clinical outcomes of a multicenter, prospective study involving six surgeons using the prosthesis for the treatment of rheumatoid arthritis.

METHODS A consecutive series of patients from the practices of six surgeons who are participating in an ongoing, prospective, multicenter study of the prosthesis were reviewed. All patients suffered from longstanding inflammatory arthritis with stage 3 or 4 radiographic findings. 85 wrists in 82 patients were reviewed, with follow-up ranging from 1 to 6 years. The information collected included the DASH outcome questionnaire, and assessments of wrist and forearm motion, grip strength, wrist balance and prosthetic stability. Radiographs were obtained preoperatively and at specified postoperative intervals to assess the severity of arthritis, operative technique, and implant loosening.

RESULTS DASH scores improved on average 28 points. With the exception of those patients having a complication, all patients believed the operation met their expectations and claimed they would have the

procedure again. Average postoperative wrist motions were: 40° flexion, 32° extension, 11° radial deviation, and 17° ulnar deviation. Pronation averaged 86° and supination 79°. Grip strength improved 118%. Radiographs showed no implant loosening of either the carpal or radial component. Two patients developed mild ulnar deviation imbalance but it did not noticeably impact function. The resected distal ulna did not cause symptoms. There were no deep infections. Complications were more common in each surgeon's early experience and in patients with severe disease. Prosthetic instability was more problematic in patients with severe deformity, preoperative joint laxity and active synovitis. Dislocations occurred in six such patients; four responded to further treatment and retained their implants and two were eventually converted to an arthrodesis.

DISCUSSION The clinical and radiographic outcomes of multiple surgeons were favorable in the treatment of patients with rheumatoid arthritis. The design of the carpal component provides consistent and secure fixation, and the prosthesis affords good wrist balance and motion. In properly selected patients, the Universal prosthesis provides a functional wrist and high patient satisfaction.

FRIDAY, OCTOBER 4 1:45 P.M.

Session IIIA—Arthritis

Paper #17A

The Ulnar Head Prosthesis—Radiological and Clinical Results

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 Karl-Josef Prommersberger, MD, Bad Neustadt, Germany
 Steffen C. Froehner, MD, Bad Neustadt, Germany
 Timothy Herbert, MD, Mons Var, France

The ulnar head prosthesis (UHP) has been advocated for the salvage of painful instability of the distal ulna following resection arthroplasties of the distal radioulnar joint (DRUJ). Being a hemiarthroplasty, direct contact between the head of the prosthesis and the sigmoid notch as well as the surrounding soft tissues is given. Stabilization of the shaft of the prosthesis shall be achieved by osseointegration into the ulnar shaft. The aim of this prospective, longitudinal study was to evaluate the effects of the UHP against the sigmoid notch, the carpal bones and the surrounding soft tissues as well as the clinical performance. From 1996 to 2001 the UHP has been in 14 patients. All patients were clinically and radiologically followed up in yearly intervals. One patient was excluded from the study as the prosthesis was removed due to a deep infection. Patients, age averaged 44 (28–57) years, follow up 46 (6–69) months. Preoperative clinical examination included pain and satisfaction scoring using a visual analog scale (0–10), grip strength and forearm rotation. Radiographic investigations included p.a., lateral and transverse loading views. At the latest examination the DASH score was applied next to a full clinical examination. Radiologically, standard radiographs, MRI- and CT-

investigations were performed. Pronation increased from 73° preoperatively to 80° postoperatively, supination from 65° to 78°. Grip strength improved from 41% to 84% compared to the unaffected extremity. Pain decreased from 9 to 3 and patients satisfaction improved from 2 to 8 on the visual analogue scale. The DASH score measured from 12 to 82 but seems to be highly influenced by additional wrist pathology (arthrodesis). Radiologically an average ulna-minus situation of 2.06 (+0.5 to -4) mm was achieved. CT-scans demonstrated osteointegration in all patients. A bone resorption at the distal end of the ulna proximal to the neck of the prosthesis was evident in 10 patients with an average of 1.17 (0–3) mm. Osteophytic bone adaptations at the edges of the sigmoid notch were found in 4 patients. MRI demonstrated in only one patient bone edema at the ulnar aspect of the lunate due to ulna impaction syndrome. Synovitis around the head of the prosthesis was evident in one patient. The UHP significantly improves the clinical symptoms in these patients. Osteointegration is achieved, pressure overload of the radius is not evident. Bony reactions at the sigmoid notch or the distal ulna do not show progress over time.

FRIDAY, OCTOBER 4 1:51 P.M.

Session IIIA—Arthritis

Paper #18A

Arthroscopic Synovectomy of the Rheumatoid Wrist

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Jin Hwan Ahn, MD, Seoul, South Korea

Jin Seok Kang, MD, Seoul, South Korea

Synovectomy is usually employed to relieve pain and preserve the function of wrists affected by rheumatoid arthritis. The use of arthroscopic technique has advantages over the conventional open procedures in avoiding major surgical trauma to the joints. The purpose of this study is to evaluate the therapeutic effectiveness of arthroscopic synovectomy for the patients with rheumatoid wrists. 19 wrists in 18 patients (4 males and 14 females, average age 49.2 years) who had not responded to anti-rheumatic medications, were treated with arthroscopic synovectomy. Patients who had tenosynovitis or severe radiographic involvement were not included. Arthroscopic synovectomy was performed using a 2.4-mm or 4.0-mm diameter arthroscope and a motorized shaver system. In addition to standard portals, extra portals were employed to gain access to all the areas of the radiocarpal and midcarpal joints. The distal radioulnar joints were accessed through the perforated triangular fibrocartilage. Immediate mobilization was allowed postoperatively. Patients' subjective symptoms were evaluated by the visual analogue scales for pain and satisfaction. Range of motion was measured. Standard posteroanterior radiographs taken preoperatively and at the final follow up were analyzed by the modified Larsen/Rau score system (normal, 0; total destruction,

40). The average follow up period was 28.2 months (range from 24 to 45 months). Postoperatively, all patients experienced reduction in pain. Two patients required repeated arthroscopic synovectomy due to recurrence of symptoms. The mean preoperative pain score was 8.6 and decreased to 3.6 at one year after the operation. It increased to 6.3 at the final follow-up, suggesting tendency of pain aggravation with time. The average satisfaction score at the final follow up was 6.3(10 points is the maximum satisfaction). The average flexion-extension arc was increased from 81 degree preoperatively to 92 degree at the final follow-up. The mean modified Larsen/Rau score was 11.9 preoperatively and increased to 16.5 at the final radiographs, demonstrating slow progression of degenerative changes. The severity of joint degeneration showed no correlation with the postoperative results. There was no complication, such as postoperative stiffness and infection. The arthroscopic synovectomy of the rheumatoid wrists results in effective reduction of pain and high satisfaction. It provides a short period of rehabilitation with no risk of postoperative stiffness. The effectiveness of arthroscopic synovectomy is comparable with the conventional surgical synovectomy, however prolonged benefit should be observed with long term follow-up.

FRIDAY, OCTOBER 4 1:00 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #11B

Comparison of Growth and Function after Conventional Non-Vascularized Toe Phalangeal Bone Grafting and Microsurgical Toe-to-Hand Reconstruction of Congenital Transverse and Longitudinal Hand Deficiencies

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 James Chang, MD, Stanford, CA
 Prosper Benhaim, MD, Los Angeles, CA
 John F. Lawrence, MD, Los Angeles, CA

PURPOSE Children born with congenital absence of the digits due to transverse or longitudinal deficiencies or constriction ring syndrome have conventionally been reconstructed using non-vascularized toe phalangeal bone grafts, but more recently, microsurgical toe-to-hand transfers have been advocated. The purpose of this study was to compare the conventional technique of non-vascularized toe phalangeal bone grafting with microsurgical reconstruction using toe-to-hand transfers by analysis of growth of the transferred bone and hand function.

METHODS 17 children who had undergone non-vascularized toe phalangeal bone grafting were compared with 17 children who had undergone microsurgical toe-to-hand transfers. Radiographic analysis of growth was evaluated by the appearance of open epiphyseal plates, phalangeal growth over time and comparison of the transferred toe phalanges with the contralateral foot. The parents subjectively evaluated the improvement in their child's hand function.

RESULTS 29 non-vascularized toe phalangeal bone grafts harvested extra-periosteally from the second, third or fourth toes were transferred in 17 children. Mean age at operation was 1.8 years, and mean radiographic follow-up was 4.5 years. 36% of growth

plates remained open, but no growth of the transferred proximal phalanges was observed over time. Only 3 parents (18%) felt that hand function had improved after toe phalangeal bone grafting. 21 microsurgical toe transfers were performed in 17 children at a mean age of 4.6 years with a mean follow-up of 2.5 years. 96% epiphyseal plates remained open and progressive growth of the phalanges over time was seen in 90%. In those children in whom it was possible to compare radiographs of the contralateral foot, there was equal growth in the transferred toe phalanges. All parents (100%) felt that microsurgical toe transfers had improved both pinch and grasp function.

CONCLUSIONS Despite meticulous extra-periosteal dissection, conventional reconstruction by non-vascularized toe phalangeal bone grafts does not seem to provide any bone growth over time. Conversely, with microsurgical toe-to-hand transfers, growth potential is preserved and is comparable to the corresponding toe on the contralateral foot. Little improvement in hand function is seen after conventional reconstruction, except in those children in whom the toe phalangeal bone grafts are placed distal to the PIP joints. Microsurgical toe transfers into the thumb or ulnar border digit position improves both pinch and grasp function.

FRIDAY, OCTOBER 4 1:06 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #12B

Long-Term Results of Free Vascularized Joint Transfers to the Finger PIP Joints

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Takae Yoshizu, MD, Niigata, Japan

Yutaka Maki, MD, Niigata, Japan

PURPOSE We have indicated vascularized toe PIP joint transfer for reconstruction of severely damaged finger PIP joints since 1979. Early clinical results of free vascularized joint transfers previously reported from some centers showed almost satisfactory motion and stability, but long-term results reports were very few. We reviewed the long-term results of our cases and examined the problems of this operation.

MATERIALS AND METHODS Eleven joints in ten cases were reviewed 10 to 22 years after the operation (average 14 years). There were 1 female and 9 male patients, with an average age at the operation of 32 years (range 9–53 years). Operated fingers were index-1, long-7, ring-2, and little-1. Evaluation of the cases included direct interview, physical examination, and x-ray film.

RESULTS An average ROM was 47 degrees (ext. -41-flex. 87 degrees). An average ROM decreased comparing with the early results, average 52 degrees (ext. -28-flex. 80 degrees). Grip power in all cases was maintained at about 80 percent of non-affected side. No cases complained finger and toe pain, and gait disturbance. Two patients complained of lack of

extension and three patients complained lack of flexion. Ten cases were satisfied with the functional and cosmetic results except one. X-ray showed that all the cases kept joint spaces, but three cases had osteophytes at the insertion of central slip and volar cartilage plate, and one case, followed for 22 years, had mild arthritis change. We saw no Charcot-like change.

DISCUSSION Long-term results of our free vascularized joint transfers were almost satisfied. But all cases had some extension lag and flexion contracture. This lack of extension increased gradually with the lapse of time. We speculate that the preoperative damages of extensor mechanism and the natural flexed habitus of the toe PIP joint caused the lack of extension. As the toe PIP joint which had narrow ROM (an average 42 degrees, ext. -9-flex. 51 degrees in our cases) received the strong force of finger flexion after the transfer, the ROM was shifted to flexion side. We thought that the flexion force to the transferred joint made the osteophyte as mentioned above. It is important to prevent the extension lag and maintain the extension mechanism with tight central slip suture of the transferred joint and meticulous postoperative care.

FRIDAY, OCTOBER 4 1:15 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #13B

Short Term Immunosuppression Following Microvascular Transplantation of Epiphyseal Plate Allografts

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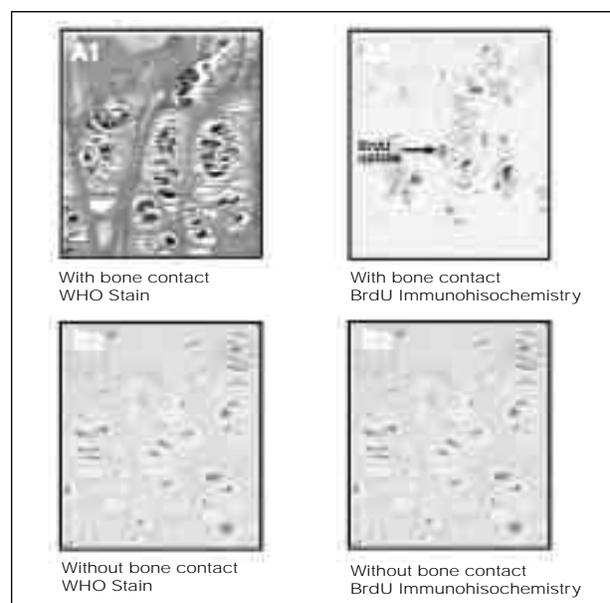
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Loss of epiphyseal plate viability following successful vascularized allograft transplantation occurs due to rejection of the vascular supply. This study investigated the effect of immunosuppression withdrawal on epiphyseal plate viability after bony healing to the recipient site. Our objective was to determine whether or not vascularized epiphyseal plate allograft transplants remain viable after the withdrawal of short-term CyclosporineA (CsA) immunosuppression using a validated model for the heterotopic microvascular transplantation of rabbit proximal tibial epiphyseal plate allografts. Our hypothesis was that vascularized allografts would survive following immunosuppression withdrawal only if bony healing, and therefore epiphyseal and metaphyseal vascular continuity, had occurred between the transplanted epiphyseal plate and recipient bone. Female New Zealand White rabbits at 12 weeks of age were used as both donors and recipients. The proximal tibial epiphyseal plate was isolated on the popliteal vessels, and harvested from the donor animal. The graft was transferred to the recipient allogeneic animal into a cancellous defect created in the iliac crest. Microvascular anastomoses were performed to recipient vessels to restore graft circulation. The short-term immunosuppression regimen consisted of CsA 10 mg/kg/day SC administered for 6 weeks, followed by a withdrawal of immunosuppression for 4 weeks. Sacrifice was at ten weeks post-operatively. CsA levels were monitored weekly, and fluorochromes were administered prior to sacrifice. Two experimental and two control groups were evaluated. Group I (n=12) consisted of grafts transferred with bony contact between the transplanted graft and the iliac crest recipient site, whereas group II (n=12) consisted of allografts transplanted without bony contact (grafts were transferred into a soft tissue pocket.) Control groups had identical surgical procedures done but were not immunosuppressed post-operatively. Longitudinal growth and bony union were assessed by fine-detail radiography. Post-mortem specimens were evaluated for fluorochrome uptake and histological features. A cellular

viability index was calculated by immunohistochemical quantification of bromodeoxyuridine uptake and analyzed statistically by 2-way ANOVA to compare epiphyseal plate viability between groups. Following withdrawal of short-term immunosuppression, the viability index of epiphyseal plate grafts with bone contact was significantly greater than those without bone contact (16.0 ± 2.9 vs. 0.0 ± 0.0 ; $p < 0.05$). All control growth plates transferred without immunosuppression were non-viable. These results suggest that the viability of epiphyseal plate allograft transplants is preserved following withdrawal of short-term immunosuppression, provided that graft design and recipient site preparation allow for epiphyseal and metaphyseal neovascularization via bony healing between graft and recipient.

FIGURE 4—Serial photomicrographs of transplanted epiphyseal plates with short-term immunosuppression (6 weeks with, 4 weeks without) with and without bone contact. Only grafts with bone contact were viable, and were positive for BrdU detection by immunohistochemistry.



FRIDAY, OCTOBER 4 1:21 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #14B

Follow-Up on the First Bilateral Hand Transplant Patient

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PURPOSE The 21 months follow-up of the first bilateral hand transplant is presented.

METHODS The operation was performed on January 14th, 2000 in a 33 year-old male who had lost both hands in an explosion injury 4 years ago. The level of amputation was the same in both upper limbs, i.e. at the distal forearm level. Both hand transplantations were performed simultaneously in the Edouard Herriot Transplantation Unit by two hand surgeon teams. Five HLA-A, -B, and -DR mismatches were present with the donor; T and B cell cross-match was negative. Immunosuppressive protocol included tacrolimus, prednisone, mycophenolate mofetil and, for induction, antithymocyte globulins and then CD 25 monoclonal antibody. Follow-up included immunological tests, skin biopsies, repeated clinical and x-rays evaluations, electromyography, functional MRI and an intensive rehabilitation program.

RESULTS AND DISCUSSION Neither anti-HLA antibodies nor chimerism in peripheral blood were shown. Two episodes of acute rejection with cutaneous lesions occurred on day 53 and 82 after transplantation. Both were reversed by topical clobetasol and increased systemic corticosteroid therapy. Side-

effects related to treatment were reversible serum sickness and hyperglycemia. No infectious complications and no signs of graft-versus-host disease occurred. At 21 months follow-up, immunosuppressive treatment was well tolerated. General condition and function were similar in both hands although function was better in the right dominant hand. Median and ulnar nerves showed signs of recovery in both hands. General appearance and vascularity were satisfactory; satisfactory nail growth was observed. Active wrist and fingers motion reached about 30% of normal; this was mainly due to extrinsic muscle activity but there was also some definite clinical and electromyographic intrinsic muscle activity in both hands. Good protective sensation was observed; monofilament # 4.56 was felt at index and fifth finger pulps in both hands. However, there was no static two-point discrimination. Comparison of pre and post functional MRI showed progressive cortical reorganization. The result was fair according to Chen's score. Despite this fact, the result in this particular patient was interesting because of good tolerance of the immunosuppressive treatment and because both hands were used in many activities of daily living. However, hand transplantation is still an experimental procedure. The latest follow-up will be presented.

FRIDAY, OCTOBER 4 1:30 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #15B

Post-Operative Motion Does Not Affect Results of Digital Nerve Repair

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O. Alton Barron, MD, New York, NY

Steven Z. Glickel, M, D, New York, NY

INTRODUCTION Following primary repair of digital nerve lacerations, casting for three to four weeks has been the accepted protocol at least since Miller's recommendation in 1921, theoretically to keep tension off the nerve repair as it heals. This could, however, compromise range of motion in the injured digit. In contrast, combined digital nerve and flexor tendon repairs are rehabilitated with a protocol of immediate post-operative range of motion. To our knowledge, no previous studies have evaluated the effects of immediate motion on the results of digital nerve repair in these two common, yet different, clinical situations. The purpose of this study was to compare the results of primary nerve repair in isolated digital nerve lacerations immobilized post-operatively, with nerve repairs combined with flexor tendon repairs which are mobilized immediately post-operatively.

MATERIALS AND METHODS We retrospectively reviewed patients who had undergone surgical repair of isolated digital nerve lacerations or combined digital nerve and flexor tendon lacerations. Demographics obtained included age, hand dominance, injured digit, and time to mobilization. Follow-up data included range of motion at the MCP, PIP, DIP, and wrist joints, grip and pinch strength, static 2-point discrimination, Semmes-Weinstein monofilament testing, and subjective satisfaction. Between group comparisons were based on t-tests for continuous

measures and chi-squared tests for categorical measures. Paired t-tests were used for within group comparisons. All comparisons were based on two-tailed 0.05 level tests.

RESULTS Fifteen patients (17 digits) with isolated digital nerve repairs (Group I) and 12 patients (13 digits) with combined digital nerve and flexor tendon repairs (Group II) were seen in follow-up. The average age and duration at follow-up were similar in the two groups. The average time to mobilization, however, was 21 days in Group I and 4 days in Group II. Injuries occurred equally in dominant and non-dominant hands. Good range of motion returned in all joints with one exception. There was a significantly decreased arc of motion in the MCP joint of the injured digits of Group I. We found comparable return of grip and pinch strengths in both groups. In addition, there was no significant difference in final 2-point discrimination ($p=0.67$) and Semmes-Weinstein testing ($p=0.09$) between Group I and Group II.

CONCLUSIONS Our data showed statistically significant stiffness in the metacarpophalangeal joint after isolated digital nerve repairs immobilized post-operatively. The difference in sensibility, however was not found to be statistically significant between the two groups. This data challenges the long-held belief that digital nerve repairs should be immobilized post-operatively.

FRIDAY, OCTOBER 4 1:36 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #16B

A Ten Year Experience with Vascularized Bone Grafts for the Treatment of Kienböck's Disease

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William P. Cooney, MD, Rochester, MN

Allen T. Bishop, MD, Rochester, MN

Over a ten year period (1991–2001), 49 pedicled vascularized bone grafts (VBG) were performed as treatment for lunate avascular necrosis (Kienböck's disease). Average patient age was 30 (16–59). At the time of surgery, one patient was classified as Lichtman Grade I, 19 grade II, 20 grade IIIA and 8 grade IIIB. 80% of patients underwent a reverse-flow pedicled VBG from the distal radius, based upon the described anatomy¹. The vascular pedicles used included the 1,2 intracompartmental supra-retinacular artery (ICSRA) (1), 2,3 ICSRA (3), 4th extensor compartmental artery (ECA) (5), 5th ECA (2), 4+5 ECA pedicle (27) and palmar metaphyseal arch (1). Several early cases used VBG harvested from the radial diaphysis (3), ulnar shaft (3) and 2nd metacarpal (4). Concomitant unloading procedures were used in 90% of cases. These included temporary wrist external fixation (23 patients) or midcarpal joint pinning (14). Permanent unloading was used in 15 instances, including 4 scaphocapitate fusions, 10 radial shortening and one ulnar lengthening procedure. Mean follow-up was 22 months. Post-operative evaluation included range of motion, grip strength, pain evaluation, Lichtman outcome score, carpal height and post-operative MRI. Prior to surgery, the flexion-extension arc of the involved wrist was 66% of the unaffected side. Radioulnar deviation was 64%,

and grip strength was 57% of unaffected hand. Post-operatively, there was no significant change in flexion-extension arc motion. Wrist deviation improved to 79% of the unaffected side, however, and grip strength improved to 89%. 98% of patients had significant improvement in pain. Satisfactory results were seen in 88% of patients, using the Lichtman score 2. 83% showed no further collapse at and average of 22 months post-operatively. 18 of the 49 patients had follow up MRIs at a mean of 18 months post-operatively. 89% (16/18) showed evidence for revascularization, with improvement in T2 and/or T1 signal. Complications occurred in 14% of patients. Most were related to fixation, including 4 pin tract infections, and 1 EPL rupture. Others included delayed union at a radial shortening site (1) and scapho-lunate dissociation from further lunate fragmentation (1). Vascularized pedicle bone grafts provide improved grip strength and wrist range of motion, as well as MRI evidence of revascularization when used for the treatment of Kienböck's disease. The current procedure utilizing the 4 + 5 ECA pedicled graft allows graft harvest and lunate revascularization through a single dorsal wrist incision. Overall complications are low and pain relief quite reliable.

1. Sheetz, KK, et al., J. Hand Surg., 1995; 20: 902–14.
2. Lichtman DM, et al., J. Hand Surg. 1982; 7: 343–7.

FRIDAY, OCTOBER 4 1:45 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #17B

Ulnar Nerve Entrapment in Pediatric Midshaft Forearm Fractures: A Clinical and Anatomic Study

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James M. Calandruccio, MD, Germantown, TN

Dennis P. DeVito, MD, Atlanta, GA

Scott H. Kozin, MD, Philadelphia, PA

INTRODUCTION Both bone forearm fractures (BBFFs) are prevalent in children. Treatment depends upon displacement, angulation, and soft tissue injuries. Neurovascular injury is uncommon, although a potential problem in widely displaced fractures. This report details the clinical history and treatment of 7 patients with a BBFF and concomitant ulnar nerve injury. This injury pattern was reproduced in a series of cadavers.

MATERIALS AND METHODS Five males and 2 females with an average age of 6.2 years were evaluated following a displaced BBFF and concomitant ulnar nerve injury. Four injuries were Grade I open and three were closed. All children had similar fracture patterns with midshaft volar angulation and prominent proximal ulna spike. The ulnar nerve deficit was noted prior to reduction (5) or during immobilization (2). Follow-up averaged 3.2 years (range: 1.5 to 5.4 years). Impact loading was used to recreate midshaft BBFFs in 6 cadavers. X-ray was used to verify the fracture and closed reduction performed. Specimens were dissected to assess the vulnerability of the ulnar nerve.

RESULTS Surgery was performed in 6 cases and refused in one patient. Findings included entrapment of the ulnar nerve in callus (4) or interposition of the

nerve between the fractured ends (2). Treatment consisted of neurolysis (3), direct neuroorrhaphy (2), or nerve grafting (1). Follow-up revealed complete ulnar nerve function in 4 and partial recovery in 2. Sensibility exceeded motor recovery in instances of partial recovery. All fractures healed, although the x-rays in 2 patients revealed a notch indicative of nerve entrapment. Cadaver dissection revealed ulnar nerve vulnerability within the mid to distal third of the forearm. The nerve is confined between the shaft, flexor digitorum profundus, and flexor carpi ulnaris. A BBFF with an apex volar angulation of the ulna intrudes this area and can injure the nerve by impact or entrapment between the bone ends.

DISCUSSION BBFFs require assessment of the neurovascular status at presentation and following reduction. Considerable displacement with volar angulation can injure the nerve, which resides in a precarious position in the mid third of the forearm. Open injuries should heighten the clinical suspicion of nerve injury. A block to reduction in a closed injury warrants early exploration to ensure the ulnar nerve is not interposed between the fractured bone ends. An open injury should include debridement with wide exposure to identify entrapment of the ulnar nerve. In a subacute presentation MRI could confirm entrapment.

FRIDAY, OCTOBER 4 1:51 P.M.

Session IIIB—Microsurgery and Nerve Injury

Paper #18B

Radial Nerve Palsy Associated with Humeral Shaft Fracture: Should High-Energy Injuries Be Explored?

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Kingsley Chin, MD, Boston, MA

INTRODUCTION The management of radial nerve palsy associated with fracture of the humeral diaphysis is disputed. Some recent data suggest that high-energy closed fractures merit exploration.

METHODS Twenty-nine patients with fracture of the diaphyseal humerus and radial nerve palsy were reviewed retrospectively. Twenty-five patients (17 men and 7 women; average age 25 years) were injured in high-energy accidents and four patients (all older-aged women) were injured in simple falls. Ten fractures were open (Gustilo Type 2 in 5 and Type 3 in 5). Six were associated with a massive upper extremity injury (multiple open fractures or multiple neurovascular injuries), 3 part of a floating elbow injury, and 7 one of multiple traumatic injuries. Thirteen fractures were isolated injuries. Nerve exploration was performed in all patients with open wounds, none of the patients with closed injuries.

RESULTS All five patients with transected nerves had open humerus fractures as part of a massive upper extremity injury. None of the nerves recovered after

repair. Among the twenty-four nerves treated closed or found to be intact at operation, all but one recovered—a patient treated with closed IM rod fixation and noted to have nerve transection at a later surgery for nonunion (whether the nerve was transected by the injury or the placement of the rod is not known). Twenty-two of the twenty-three nerves recovered within 12 months of injury (average 5 months). One nerve required 21 months for complete recovery.

DISCUSSION Transection of the radial nerve is associated with open fractures of the humerus that are part of a massive upper extremity injury. The results of nerve repair in this circumstance are dismal, limiting the value of exploration and repair. Exploration of the radial nerve is not necessary for closed fractures, even those that are part of a high-energy injury, as transection is unusual. Early tendon transfers should be considered if the nerve is lacerated, but tendon transfers should be delayed at least one year in patients with closed injuries or intact nerves as complete or near complete recovery are the rule.

SATURDAY, OCTOBER 5 9:00 A.M.

Session IVA—Wrist Fractures

Paper #19A

Treatment of Scaphoid Nonunion by Dowel Bone Grafting

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Michael J. Sandow, FRACS, Adelaide, Australia

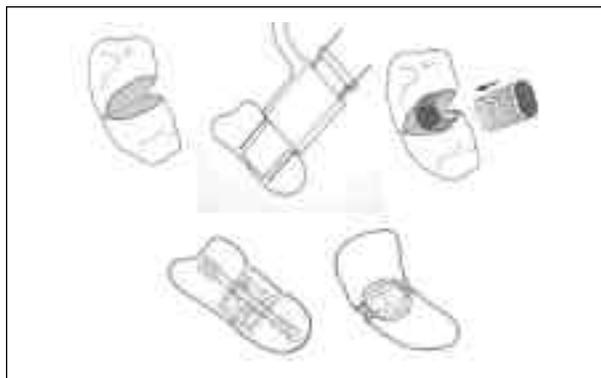
INTRODUCTION Carpal collapse and progressive degenerative change characterize the natural history of scaphoid nonunion. Various grafting techniques can be technically challenging due to difficulties with graft sculpting, alignment correction and stability. We present our results of a technique used since 1989 that places a size-matched iliac crest dowel bone graft in transverse orientation across the scaphoid nonunion, with stability usually augmented by a Herbert screw.

MATERIALS AND METHODS Ninety-eight consecutive patients with scaphoid non-union (100 wrists) underwent dowel bone grafting and internal fixation, with 26 fractures involving the proximal pole. The patients were assessed prospectively with a consistent technique by a single surgeon. Average time from injury to surgery was 38 months. 96% follow up was achieved at an average of 11 months.

RESULTS An overall union rate of 88% (proximal pole 71%, waist 94%) was obtained. Grip strength improved from 68% to 83% ($p < 0.01$) of the contralateral wrist and wrist flexion-extension arc improved from 114 degrees to 118 degrees. Using a modified Green and O'Brien wrist score the average preoperative rating improved from 66 to 81 postoperatively ($p < 0.01$). There were 11 nonunions (four waist frac-

tures and seven proximal pole fractures). Seven went on to successful costo-osteochondral (rib) autografts, one was treated with an arthrodesis and three had mild symptoms not requiring operative intervention. Apart from three patients requiring hardware removal, there were no other complications.

DISCUSSION Dowel bone grafting for scaphoid non-union has technical advantages over alternate bone sculpting methods, and achieves a high union rate with low donor site morbidity. The technique is technically straightforward and allows correction of scaphoid angulation and displacement, and was universally applicable in a wide range of scaphoid non-unions.



SATURDAY, OCTOBER 5 9:06 A.M.

Session IVA—Wrist Fractures

Paper #20A

Trans-Scaphoid Dorsal Perilunate Fracture-Dislocations: Review of 14 Cases at an Average 8.5 Years Follow-up

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PURPOSE Trans-scaphoid dorsal perilunate fracture-dislocations (TS-dorsal PLFD) are the most frequent type of perilunate dislocations. However few studies consider this group as a specific entity. The purpose of this study was to focus on the long-term results of a series of TS-dorsal PLFD surgically treated at the acute or subacute stage.

METHODS 14 patients (14 wrists) with TS-dorsal PLFD were retrospectively reviewed. All were male. Their average age was 24 (range 17 to 45). The delay between injury and surgery averaged 6 days (range 0 to 21 days). In seven wrists the lunate and proximal scaphoid fragment maintained their relationships with the radius (stage I): all were treated by ORIF (single dorsal approach in 6 wrists, combined carpal tunnel and dorsal approaches in 1 wrist). In five wrists the lunate and proximal scaphoid were volarly dislocated with a rotation arc of less than 90° (stage II A) : all were treated by ORIF through a single dorsal approach. Two wrists in which lunate and proximal scaphoid were volarly dislocated with a rotation arc of more than 90° (stage II B) were treated by 1 ORIF and 1 proximal row carpectomy (PRC) through combined carpal tunnel and dorsal approaches. Each patient was clinically and radiologically evaluated by an independent observer

(modified Mayo wrist score, standard PA and lateral x-rays) at an average 8.5 years follow-up (range 3 to 13 years).

RESULTS Among 13 wrists treated by ORIF, there were 4 excellent, 7 good and 2 poor clinical results. All fixed scaphoids healed. Carpal alignment measurements were within normal limits in all cases. No lunate or proximal scaphoid necrosis with collapse were observed. However, degenerative changes were observed at the midcarpal level in 12/13 case and at the radio-carpal level in 9/13 wrists. The two poor clinical results displayed an osteochondral fracture of the head of the capitate at the time of surgery. The patient having sustained PRC had a good result at 13 years follow-up.

DISCUSSION Early surgical treatment of TS-dorsal PLFD led to satisfactory long-term clinical results in 85% of the cases in this series. Fixation of scaphoid fracture through a dorsal approach was effective. However, late degenerative changes at mid and radiocarpal levels were almost constant. The negative effect of an associated osteochondral fracture of the head of the capitate on the clinical result was striking in this series; its prognosis value has to be confirmed at a larger scale.

SATURDAY, OCTOBER 5 9:15 A.M.

Session IVA—Wrist Fractures

Paper #21A

Kinematic and Torque-Related Effects of Dorsally Angulated Distal Radius Fractures on the DRUJ

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 Yu-Te Lin, MD, Rochester, MN
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PURPOSE Dorsal angulation of the distal radius post-fracture is known to affect the constraints of the distal radioulnar joint (DRUJ). The purpose of this study was to examine the torque required to achieve a full range of motion with increasing dorsal angulation.

METHOD Nine normal human cadaveric forearm specimens were dissected, leaving the soft tissue of the wrist, elbow, and IOM intact. PQ, PT, FCR, Supinator, Biceps, ECRL and ECRB tendons were prepared and loaded. Unloaded and resistive muscle loading conditions were simulated throughout a complete pronation-supination motion on a forearm simulator. A torque cell was used to measure the torque required to create and resist motion of the DRUJ. The torque required to achieve a prescribed full range of motion was measured. Data was collected in the intact state, and after increasing degrees of distal radial fracture realignment: 0°, 10°, 20°, 30°, and 40° dorsal tilt. After measurements of torque with ligaments intact, the TFCC was sectioned and the distal radius angulation sequence was repeated. Dynamic loading data was reduced to 4 static points in the full range of motion to facilitate data analysis. Data were compared to normal using ANOVA.

RESULTS The torque to complete motion was affected by the degree of simulated malunion, TFCC presence, and muscle loading. With muscles unloaded, for both the TFCC intact and disrupted, there was statistically increased torque at the DRUJ with greater than 30° malunion (Fig. 1). With resistive loading and the TFCC intact, increased torque was necessary to achieve a full range of motion with greater than 40° angulation in pronation, and 30° angulation in supination (Fig. 2).

CONCLUSION Dorsal angulation of the distal radius, as may occur following Colles fractures, is associated with increased resisted torque at the DRUJ. With a malunion of more than 30° dorsal angulation, the torque across the joint is increased even with the muscles unloaded. With active load in supination, more than 30° dorsal malunion and more than 40° in pronation produced increased torque at the DRUJ. Although not statistically significant, results indicate torque changes with as little as 10° malunion. This suggests that a correction osteotomy may be indicated with lesser degrees of malunion if the full range of motion of the wrist is particularly important for a patient.

FIGURE 1—UNLOADED CONDITION WITH INTACT TFCC

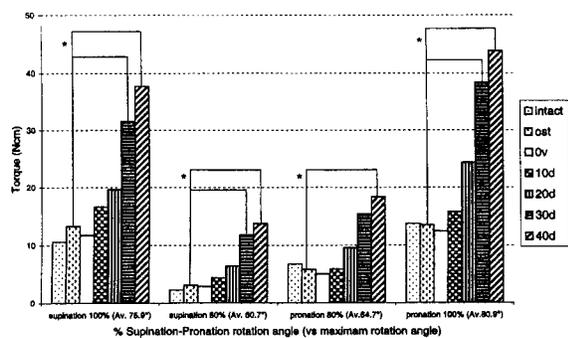
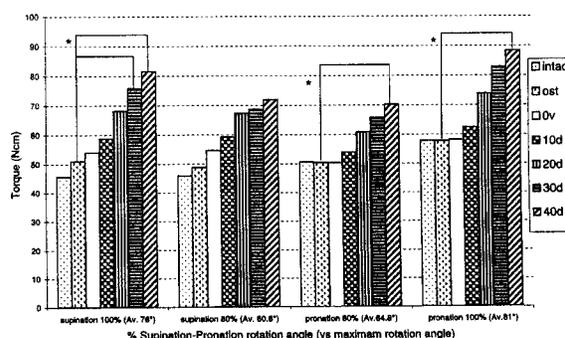


FIGURE 2—RESISTIVE LOADING CONDITION WITH INTACT TFCC



SATURDAY, OCTOBER 5 9:21 A.M.

Session IVA—Wrist Fractures

Paper #22A

Rotational Deformity in Malunited Fractures of the Distal Radius

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Ulrich B. Lanz, MD, Bad Neustadt, Germany

INTRODUCTION Common types of malunion of the distal radius include shortening and angulation deformity in the sagittal and frontal plane. In addition, a certain rotational deformity of the distal fragment with respect to the diaphysis may exist. While angulation deformity and shortening and their effects on the biomechanics of the wrist are well-known, little is known about rotational deformity of the distal fragment.

PURPOSE The aim of this study was to analyze malunions of the distal radius with respect to rotational deformity of the distal fragment and its effect on forearm rotation.

MATERIAL AND METHODS 25 patients with a dorsally and 12 patients with a volarly tilted malunion of the distal radius, which were referred to us for the treatment of a symptomatic malunion, had computer tomography of both wrists to determine rotational deformity of the distal fragment with respect to the diaphysis according to the method outlined by Frahm. Radius tilt, ulnar inclination and ulnar variance were assessed on plain radiographs.

RESULTS Dorsally angulated malunions: 11 patients (44%) had no rotational deformity, 8 (32%) had pronation and 6 (24%) supination deformity. The average on pronation deformity was 10° (range, 3 to 22°). The average on supination deformity was also

10° (range, 4 to 18°). Volarly angulated malunions: 3 (25%) patients had no rotational deformity, 6 (50%) had pronation and 3 (25%) had supination deformity. The average on pronation deformity was 13° (range, 3 to 28°) and 14° (range, 10 to 19°) on supination deformity. Whilst there was no significant differences between dorsally and volarly tilted malunions in regard to forearm pronation, forearm supination was significantly more decreased in volarly tilted malunions with an average of 48° as in dorsally tilted malunions averaging 68° ($p=.04$). Surprisingly volarly tilted malunions with a rotational deformity less than 10° had the smallest amount of forearm supination averaging 43° compared to volarly angulated malunions with a rotational deformity greater than 10° (average, 53°), dorsal malunion with a rotational deformity less than 10° (average, 71°) or more than 10° (average, 62°). Multivariate regression analysis showed, that forearm supination is affected more by the radius tilt ($p=.036$) than by rotational deformity or ulnar variance.

CONCLUSION Rotational deformity is very common in malunited fractures of the distal radius, especially in volarly angulated malunions. However, in this clinical study rotational deformity had less effect on forearm rotation as dorsal or palmar angulation of the distal radius.

SATURDAY, OCTOBER 5 9:30 A.M.

Session IVA—Wrist Fractures

Paper #23A

A Randomized Controlled Trial of Closed Reduction and Casting versus Closed Reduction and External Fixation for Distal Radius Fractures with Metaphyseal Displacement but without Joint Incongruity

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Julie Agel, MA, Minneapolis, MN

Michael D. McKee, MD, Toronto, ON, Canada

OBJECTIVE To compare closed reduction and casting with closed reduction and external fixation for distal radius fractures with metaphyseal displacement but without joint incongruity.

DESIGN Multicenter randomized clinical trial.

STUDY COHORT Skeletally mature individuals 16–75 with displaced extra-articular distal radius fractures.

METHODS 113 eligible patients with distal radius fractures with metaphyseal displacement but without joint incongruity, were randomized to either closed reduction and casting (N=59) or closed reduction and external fixation (N=54). In five patients randomized to cast treatment, an open procedure was required within the first three weeks due to significant loss of correction. One patient randomized to external fixation underwent open reduction and internal fixation because of displacement of a previously undisplaced partial articular fracture. Patients were evaluated at 6 weeks, 6 months, 1 and 2 years. Upper extremity function as measured using the upper extremity module of the Musculoskeletal Function Assessment represented the primary endpoint. Pain, Jebsen Taylor functional testing, range of motion, grip and pinch strength were evaluated as secondary outcomes. Repeated measures analysis of variance was used to compare outcome between the two study groups. Results at each time interval

were compared using the student's t-test or chi squared testing.

RESULTS Upper extremity function scores, Jebsen Taylor scores, pain scores and grip strength improved significantly the first year of the study for all patients. By two years, Jebsen Taylor scores and pain scores were similar to population age and gender matched control scores in both study groups. At all evaluation time points, there was a trend for better function in the external fixation group, however this did not reach statistical significance ($p < 0.05$). The mean difference in upper extremity function scores at two years (the primary endpoint) was 5.5 in favour of external fixation (power=0.161). For 80% statistical power approximately 896 patients in total would need to be studied. There were six pin site infections in the external fixation group (14%), with one deep infection requiring curettage (2%). One patient in the external fixation group (2%) and two in the cast group (6%) developed reflex sympathetic ($p = 0.585$). There was no statistically significant difference in the radiographic restoration of anatomic parameters although there was a trend for better length and palmar tilt restoration with external fixation ($p > 0.05$).

CONCLUSIONS There was a trend for better functional, clinical and radiographic outcomes with immediate external fixation for distal radius fractures with metaphyseal displacement but with a congruous joint.

SATURDAY, OCTOBER 5 9:36 A.M.

Session IVA—Wrist Fractures

Paper #24A

Comparison of External Fixation and Percutaneous Pinning for Unstable Fractures of the Distal Radius—A Prospective Randomized Trial

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Lauren A. Beaupre, MS, PT, Edmonton, AB, Canada

Angie Scharfenberger, MD, Edmonton, AB, Canada

Don Weber, MD, FRCSC, Edmonton, AB, Canada

PURPOSE Two common techniques for treatment of unstable distal radius fractures in young adults include percutaneous pinning combined with plaster cast, and application of an external fixator, frequently with adjunctive pinning. While the simplicity of percutaneous pinning has been documented, many authors recommend external fixation to improve reduction of unstable fractures and prevent re-displacement. A higher incidence of superficial radial nerve injuries, stiff wrist joints and reflex sympathetic dystrophy (RSD) has been attributed to the use of external fixation. The objectives of this prospective randomized study were: 1. To compare the short and mid-term radiographic and clinical outcomes of these two common fixation techniques. 2. To compare the complications of the two techniques, specifically the incidence of pin tract infections, stiffness, nerve injury and RSD.

METHODS 50 adult patients (<65 years of age) with an unstable fracture of the distal radius were recruited into this study. Patients were randomized preoperatively to either percutaneous pinning or external fixation. All fractures were scored according to the AO classification. More than 75% of fractures were C2 or C3, with an equal distribution of each type in both treatment groups. All surgery was performed by one of three surgeons within 10 days of the injury. Patients were followed to one year post-surgery with

radiographs, independent clinical exam, and DASH questionnaires.

RESULTS 24 patients underwent pinning with casting, while 26 received an external fixator. The use of an external fixator did not improve the mean radiographic parameters of radial length, radial angulation or volar tilt at any time point. However, reduction of intra-articular steps was noted to be slightly improved with the use of an external fixator. No differences in mean DASH scores, total ROM or grip strength were observed, but more pin site complications were noted with the fixator group. Three patients were diagnosed with sympathetic dystrophy—all received external fixation.

DISCUSSION External fixation is a popular treatment modality for high energy fractures of the distal radius in young patients. The results of this study suggest that the limitations of this technique are significant. The reduction obtained with its use provides no clear clinical advantage over the result obtained with fracture manipulation and pinning. While it is worth noting that external fixation does not increase wrist stiffness, important factors to consider are the added cost and RSD rate with external fixation. Furthermore anatomic reduction of highly comminuted fractures is difficult to achieve, regardless of the technique employed.

SATURDAY, OCTOBER 5 9:45 A.M.

Session IVA—Wrist Fractures

Paper #25A

Minimally Invasive Treatment for Subacute and Chronic Irreducible Distal Radius Articular Fractures

Steven Beldner, MD, New York, NY

Charles P. Melone, MD, New York, NY

Ann Marie Agnes, MD, New York, NY

OBJECTIVE The goal of treatment for unstable displaced distal radius fractures is to restore and maintain radial length, palmar tilt and articular congruity. This is especially difficult to achieve with impacted fractures or when initial treatment is delayed. Ideally, this should be achieved in the least invasive manner. The purpose of this study is to assess the results of a new technique of minimally invasive open reduction of distal radius fractures, supplemented with K-wire, internal fixation, and external fixation without adjunctive bone grafting treated up to five weeks after initial injury.

CLINICAL STUDY Twenty patients (average age 51.5 years) with irreducible Melone Type IIB distal radius fractures were treated by this method. All patients required delayed management with initial treatment administered between two and five weeks after injury and all incurred relatively violent trauma resulting in major articular disruption. Ten patients demonstrated concomitant median neuropathy. Follow-up evaluation ranged from one to six years.

TECHNIQUE The reduction was performed through a limited carpal tunnel incision. A Josef elevator was inserted into the fracture beneath the contents of the flexor compartment. Utilizing fluoroscopic guidance, the fracture fragments were disengaged and reduced into anatomic position. The reduction was

maintained by a combination of percutaneous Kirschner wire internal fixation and ligamentotaxis by external fixation.

RESULTS Postoperative evaluation included the following: range of motion, strength, radiographic evaluation and patient assessment of recovery. Pre-operative dorsal tilt was 22, ulnar variance +4mm and articular step off was 2.4 mm compared to postoperative of 4 degrees volar tilt, 0.9 mm, 0.3mm respectively. Flexion/extension averaged 63/60 (84% of the opposite wrist), P/S 80/78 (98% of opposite wrist), grip was 60 lbs. (86% of opposite wrist), and pinch was 16 lbs. (83% of opposite wrist). Post-traumatic arthritis, DRUJ instability and residual nerve dysfunction was not encountered whereas a high level of patient satisfaction was the rule.

CONCLUSION This study demonstrates that this technique of minimally invasive treatment for distal radius articular fractures using a limited (carpal tunnel) incision has the capacity to restore distal radius anatomy thereby reducing the need for more extensive methods of treatment. It is consistently efficacious for patients requiring delayed management, having been successfully employed for as long as five weeks after initial injury. In such cases osteotomy and bone grafting have been avoided, while a favorable outcome has been achieved.

SATURDAY, OCTOBER 5 9:51 A.M.

Session IVA—Wrist Fractures

Paper #26A

The Use of Percutaneous Cement for Fixation of Distal Radius Fractures

Mark S. Cohen, MD, Chicago, IL

Prem Ramakrishnan, PhD, Chicago, IL

Tai-Hong Lim, PhD, Chicago, IL

PURPOSE The use of a carbonated apatite calcium phosphate cement (Norian SRS) has been shown in a multicenter study to be effective in the treatment of distal radius fractures, allowing for earlier return of motion and function without loss of reduction compared to conventional treatment. The primary technical difficulty in the use of this cement was inadequate intramedullary fill leading to fracture settling. While this led to the use of an open technique to prepare the fracture defect, it became clear that improved methods were required to optimize the post-reduction fracture void to allow adequate cement filling for fracture stabilization. This study evaluates the use of a percutaneous balloon tamp for this purpose.

METHODS Ten matched pairs of cadaveric below-elbow specimens were potted and distal radius fractures were created with a servohydraulic materials testing machine using a previously described model. Following closed reduction and provisional Kirschner wire stabilization, specimens were randomly divided into two groups: traditional open cement technique or percutaneous balloon augmentation. In the first group, through a traditional limited-open dorsal approach, the fracture defect was prepared with a series of tamps, curettes and elevators and filled with cement. In the second group, a specially designed

balloon tamp was used to percutaneously prepare the defect followed by percutaneous cement delivery. The volume of cement was recorded and fracture reduction was assessed with standard radiographic indices for each group. Specimens were then stripped of soft tissue and stability was tested to failure with the materials testing apparatus.

RESULTS Initial fracture reduction was equivalent between the two groups in all parameters measured ($P > 0.05$). Defect size and fill were significantly improved with the balloonplasty (4.4cc versus 2.3cc; $P < 0.05$). Biomechanical studies revealed improved fracture stability, both in settling and ultimate load to failure, in the percutaneously treated group using the tamp ($P < 0.01$).

DISCUSSION The use of a specially designed balloon tamp significantly improves the ability to fill the intramedullary space with calcium phosphate cement and stabilize fractures of the distal radius. This technical improvement allows percutaneous cement delivery without compromise of fracture reduction. Preliminary results have shown the described technique to be effective clinically in five patients treated to date. Laboratory and clinical results will be discussed.

SATURDAY, OCTOBER 5 10:00 A.M.

Session IVA—Wrist Fractures

Paper #27A

Internal Fixation for Unstable Distal Radius Fractures in the Elderly Patient

Jorge L. Orbay, MD, Miami, FL

Alejandro Badia, MD, Miami, FL

Roger Khouri, MD, Miami, FL

Eduardo Gonzalez-Hernandez, MD, Miami, FL

INTRODUCTION Increased incidence of falls and osteoporosis combine to make distal radius fractures a major cause of morbidity for the elderly patient. This paper presents our experience treating distal radius fractures on this population using a volar fixed angle internal fixation plate.

METHODS We reviewed retrospectively all patients >75 y/o treated between January 1998 and August 1991 at our centers, for unstable distal radius fractures using the DVR plate applied through the extended FCR approach. Postoperative management included immediate finger motion, early functional use of the hand and a wrist splint used for an average of three weeks. Standard radiographic fracture parameters were measured and final functional results were assessed by measuring digital motion, wrist motion and grip strength.

RESULTS Of 21 patients that fit the inclusion criteria, we were able to follow 18 patients with 19 unstable distal radius fractures for an average of 63 weeks. One patient died of unrelated causes and two were

lost to follow-up. Fifteen patients were treated as outpatients, all under regional anesthesia. Three were treated as inpatients; two were discharged in less than 23 hours and one patient (associated pelvic fracture) stayed 14 days in a rehabilitation unit. Final volar tilt averaged 6 deg., radial tilt 20 deg. and radial shortening averaged <1 mm. The average final dorsiflexion was 61 deg., volar flexion 56 deg., pronation 80 deg. and supination 76 deg. Grip strength was 77% of the contra-lateral side. There were no plate failures or significant loss of reduction, although there was some settling of the distal fragment in three patients (1–3 mm.).

CONCLUSION The treatment of unstable distal radius fractures in the elderly patient with a volar fixed angle plate provides stable internal fixation and allows early function. This technique minimizes morbidity in this population by successfully handling osteopenic bone, allowing early return to function, providing good final results and presenting a low complication rate.

SATURDAY, OCTOBER 5 10:06 A.M.

Session IVA—Wrist Fractures

Paper #28A

Survival Among Elderly Patients Following Fractures of the Distal Radius

Tamara D. Rozental, MD, Philadelphia, PA
Charles C. Branas, PhD, Philadelphia, PA
David J. Bozentka, MD, Philadelphia, PA
Pedro K. Beredjiklian, MD, Philadelphia, PA

INTRODUCTION Studies have documented increased mortality rates in patients sustaining hip and vertebral fractures. Distal radius fractures are common injuries among the elderly and are a significant source of disability. The purpose of this study is to analyze mortality rates in elderly patients after distal radius fractures.

METHODS The records of 325 elderly patients treated for distal radius fractures between 1992 and 1999 were reviewed and submitted to the national death registry maintained by the National Death Index and the Center for Disease Control. The mortality experience of the patient cohort was analyzed using bivariate statistical tests and multivariate regression.

RESULTS Patients included 260 women and 65 men. Average age at diagnosis: 77.37 years (range 65 to 106 years). 20.6% of patients (29.2% of men, 18.5% of women) died during the study period. At 7 years

post-fracture, the cumulative estimated survival in the cohort under study was 57% compared with an expected value of 71%, a difference of 14%. After accounting for variations in age and comorbidities, men were 2.41 times more likely to die than women (95%CI=[1.21, 4.77], $p=0.012$) and their hazard of death was 1.83 times that of women (95%CI=[1.07, 3.14], $p=0.028$). After accounting for variations in age and gender, patients with comorbidities were 5.23 times more likely to die (95%CI=1.80, 15.23, $p=0.002$) and did not survive as long as those without comorbidities ($p=0.02$).

CONCLUSIONS Survival rates following distal radius fractures were significantly lower than those expected for individuals of the same age and gender in standard populations. Men were twice as likely to die as women and did so almost twice as quickly. Distal radius fractures may be associated with increased mortality in elderly patients.

SATURDAY, OCTOBER 5 9:00 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #19B

Treatment of Unstable PIP Fracture-Dislocations Using a Hemi-Hamate Autograft

Rafael M. M. Williams, MD, Cincinnati, OH
 Peter J. Stern, MD, Cincinnati, OH
 Thomas R. Kiefhaber, MD, Cincinnati, OH
 T. Greg Sommerkamp, MD, Edgewood, KY

INTRODUCTION Despite traditional treatment of comminuted PIP volar lip fractures with osteosynthesis, volar plate arthroplasty, traction or external fixation, complications such as pain, stiffness and/or recurrent subluxation/dislocation (especially when greater than 50% of the volar lip is fractured) may occur. This study was designed to evaluate the clinical and radiographic results of a hemi-hamate autograft for the treatment of comminuted dorsal PIP fracture subluxation/dislocations.

MATERIALS AND METHODS Thirteen patients (4M: 9F), average age 29 yrs (range: 15–50 yrs), underwent hemi-hamate autograft for treatment of a dorsal PIP fracture dislocation. The technique requires debridement of the fractured middle phalangeal base and replacement of the bony defect using a size-matched portion of the dorsal/distal hamate osteo-articular surface. The autograft is secured with lag screws. Average volar lip involvement on initial injury films was 60% (range: 40–80%). The average time to surgery was 45 days (range: 2–175 days). Range of motion, stability and grip strength were measured at a mean follow-up of 6 months (range: 2–13 months). Radiographs were evaluated for union, graft incorporation and/or collapse. Subjective data [pain level as measured on a visual analog scale (0–10), sat-

isfaction, and return to work] was obtained with twelve of the thirteen patients at a mean of 10 months (range: 2–36 months).

RESULTS Average arc of motion at the PIP joint was 80° (10° extension / 90° flexion). MCP and DIP average motions were 0°/90° and 0°/60° respectively. None of the joints were unstable. Average grip strength was 74% of the uninjured side. Bony union was noted in all patients and none of the grafts had collapsed. Except for one patient who had transient dorsal subluxation that responded to splinting, there were no complications. Average pain level was 1.8 with only one patient noting frequent pain at both the PIP joint and the hamate harvest site. Eleven of the twelve patients were “very satisfied” with their function; the other patient was “somewhat satisfied.” All but one patient returned to their previous employment at an average of 33 days.

CONCLUSION When greater than 50% of the volar base of the middle phalanx is involved in a PIP fracture/dislocation, a hemi-hamate autograft should be considered to: 1) Reconstruct the stable cup-shaped contour of the middle phalanx articular surface; 2) Provide a stable, functional arc of motion at the PIP joint; and 3) Render minimal disability with a low rate of complications.

SATURDAY, OCTOBER 5 9:06 A.M.
Session IVB—Hand and Wrist Reconstruction

Paper #20B

Clinical Outcome and Histological Findings of Costal Osteochondral Grafts for Cartilage Defects in Finger Joints

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Takashi Sasaki, MD, PhD, Yokohama, Japan
Shinnichiro Takayama, MD, PhD, Tokyo, Japan
Yoshiyasu Ito, MD, PhD, Tatebayashi, Japan

INTRODUCTION For the purpose of achieving anatomical reduction as precisely as possible, we performed osteochondral grafting from the costo-osteochondral junction in 16 patients (17 joints) with cartilage disorders or defects in fingers due to trauma and other causes. Among them, 12 patients (13 joints) were followed up for at least two years postoperatively. In 7 of these patients (8 joints), an extremely small portion of the viable implanted cartilage was sampled with the consent of the patients at the time of pin removal and was used to prepare histological specimens (stained with H.E.). We are introducing the clinical outcome in these patients and the histological findings.

PATIENTS The sixteen patients were all men, ranging in age from 18 to 68 years (mean: 40 years). The injured joints included 3 MP joints, 6 PIP joints, 2 DIP joints, and 2 IP joint. The defect accounted for 50-100% of the entire articular surface (mean: 61%).

OPERATION The collateral ligament was preserved where possible. The graft was generally obtained from the 5th or 6th costo-osteochondral junction, trimmed to fit the defect, and fixed as firmly as possible using mini-screws or Kirschner-wires.

RESULTS Implanted cartilage remained viable in all of the patients and the mean time until bone union was 58 days. The mean range of motion was 13.6 degrees before surgery versus 60.5 degrees after surgery, with a mean increase of 46.9 degrees. Histological examination of the implanted cartilage revealed scattered chondrocytes within the matrix, and there were generally no differences from normal hyaline cartilage in all 8 joints assessed. The chondrocytes in the grafts appeared to be viable, and the reconstruction of the joint surface could be confirmed histologically.

DISCUSSION Osteochondral grafting from the costo-osteochondral junction is considered to be one of the procedures achieving the most anatomical reconstruction of the injured joint without affecting other joints. Non-invasiveness to other joints is a beneficial characteristic of this procedure. Donor sites no longer cause pain at 2 or 3 days after surgery, and raise no particular problems. This technique is particularly beneficial in the cases where it is difficult to obtain donors, as with those often observed in Japan. Although there is an article in which satisfactory clinical results of 7 reconstructed finger joints in 5 patients using this technique was reported, this is the first report on the histological features of implanted cartilage in patients.

SATURDAY, OCTOBER 5 9:15 A.M.
Session IVB—Hand and Wrist Reconstruction

Paper #21B

**Hematoma-Distraction Arthroplasty for Thumb Basal Joint Osteoarthritis:
A Prospective, Single-Surgeon Study including Outcomes Measures**

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Eric T. Emerson, MD, Gastonia, NC

Roy A. Meals, MD, Los Angeles, CA

PURPOSE Evaluate prospectively the results of trapezial excision and temporary Kirschner wire distraction/stabilization of the first metacarpal for treatment of thumb basal joint osteoarthritis.

METHODS Twenty-eight consecutive patients from one surgeon's practice entered into a prospective, single-arm study of surgical treatment for thumb basal joint osteoarthritis. Measurements taken preoperatively, and 6 and 24 months postoperatively included motion, strength, stress radiographs, and AIMS2 outcomes analysis. The surgical procedure consisted of piecemeal excision of the entire trapezium and 5-week K-wire immobilization of the first metacarpal in slight distraction and opposition. Neither tendon interposition nor ligament reconstruction was included.

RESULTS At 6-month evaluation, 26/28 thumbs adducted fully into plane of palm, and 27/28 opposed to the fifth metacarpal head. Three patients were lost to follow-up after the 6-month evaluation. At 2-year follow-up, 23 patients remained pain free and 2 reported occasional ache with forceful activities. Strength increases averaged 17.4 to 25.5 kgf for grip, 4.5 to 6.0 kgf for key pinch, and 4.0 to 4.9 kgf for tip

pinch. Radiographic scapho-metacarpal distance decreased 53% on average, and there was no correlation between metacarpal subsidence on either static or stress x-rays with strength or functional outcomes measurements. AIMS2 results indicated significant improvement in "hand and finger function" scale, "satisfaction," and "arthritis pain."

DISCUSSION Unsatisfactory results with simple trapezial excision led first to silicone implant arthroplasty and then to various interposition and suspension arthroplasties. These procedures require additional operative time and surgical exposure, often with tendon harvest, but result in more thumb stiffness and particularly less strength (See Figure 1). All surgical treatments for thumb basal joint arthritis benefit to some degree from local denervation and hematoma formation, organization and fibrosis. The question has been whether the surgeon must formally reconstruct a supporting ligament or interpose material in the trapezial void. Our results support the concept that immobilization in a slightly overcorrected position, but without formal interposition or ligament reconstruction, allows for restoration of a supple, stable, pain-free thumb that has superior strength compared to more complicated interventions.

FIGURE 1

	LRTI						Hematoma-Distraction		
	Burton '95			Weiland '98			Present Study		
	Preop	Postop (24 mo)	%	Preop	Postop (32 mo)	%	Preop	Postop (24–40 mo)	%
Grip Strength (kg)	14.6	17.6	21%	26.9	29.6	9%	17.4	25.5	47%
Key Pinch (kg)	4.8	4.4	-8%	5.2	6.2	17%	4.5	6.0	33%
Tip Pinch (kg)	2.9	3.3	14%	3.1	3.8	17%	4.0	4.9	23%

SATURDAY, OCTOBER 5 9:21 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #22B

Complications of Trapeziometacarpal Arthrodesis Utilizing Plate and Screw Stabilization

Michael J. Forseth, MD, St. Paul, MN
 Peter J. Stern, MD, Cincinnati, OH

PURPOSE The study was designed to determine the complications associated with condylar blade plate stabilization for thumb carpometacarpal arthrodesis and to compare our results with a previous study from our institution utilizing Kirschner wires for fixation.

MATERIALS Thirty-two trapeziometacarpal arthrodeses utilizing plate and screw stabilization were retrospectively reviewed. The average age was 50 years (range, 29–66) and the average follow-up was 34 months (range, 6–73 months). There were three bilateral arthrodeses. Patients were asked to rate their current level of pain on an analog scale from 0 (no pain) to 10 (severe, constant pain).

RESULTS There were a total of 25 complications in 32 arthrodeses (78%). Seven patients had no complications. Twenty-two of twenty-nine patients had a complication (76%). There were nineteen minor complications and six major complications. There were 2 (6%) nonunions and 4 (12%) delayed unions. Both nonunions were painful. Other complications included hardware malposition (8, 25%), continued

pain (7, 22%), and neuritis of the superficial sensory branch of the radial nerve (2, 6%). Nine patients (31%) in the plate and screw group required a second surgery, most commonly a hardware removal. In contrast, only 2 of 49 (4%) patients in the pin group required a second surgery. Comparing plate and screw stabilization arthrodesis with pin stabilization demonstrated the nonunion rate to be similar, 7% for pins and 6% for plate and screw fixation ($p=1.000$). The pain score averaged 1.5 for the pin group and 2.0 for the plate group. Again, this was not significant. ($p=0.0551$).

CONCLUSIONS 1. Plate and screw arthrodesis of the trapeziometacarpal joint has a high complication rate (78%) and is more likely to lead to subsequent procedures when compared to pin fixation arthrodesis (31% v. 4%, $p=0.003$). 2. Both techniques lead to similar union rates (94% v. 93%). 3. The satisfaction rate in the plate group was lower compared to the pin group (83% v. 98%, $p=0.035$). 4. We recommend pin fixation over plate and screw fixation when performing a trapeziometacarpal arthrodesis.

SATURDAY, OCTOBER 5 9:30 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #23B

The Outcome of Isolated Lunotriquetral Interosseous Ligament Tears Treated by Ulnar Shortening Osteotomy

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 Mary Kate Reinhart, CNP, Smithtown, NY

INTRODUCTION The purpose of this study is to examine isolated lunotriquetral interosseous ligament tears treated by ulnar shortening osteotomy and variables causally related to the diagnosis.

METHOD 55 patients not responding to conservative management of ulnar sided wrist pain (wrist x-rays and splinting) underwent bone scan, arthrogram and arthroscopy to confirm the presence of an isolated tear of the lunotriquetral interosseous ligament. All were treated with ulnar shortening osteotomy; in most cases, 2.5mm of ulna was removed.

RESULTS Pre-op ulnar variance was positive in 39, neutral in 12, and negative in 4. Mean pre-op grip strength increased from 53 lbs. to a mean post-op strength of 69 lbs. The mean bone healing time was 17 weeks post-osteotomy. There were no non-unions or complications. Variables having a high degree of association with LTL tears are: mechanism of injury

and positive ulnar variance. Also frequently seen was ulna sided wrist pain radiating to the ring and little fingers. A loaded dorsiflexion wrist injury was the greatest precipitating injury, commonly seen with MVA's. Follow-up was completed in 45 patients post-ulnar shortening osteotomy. Results were graded using Chun and Palmers revised grading system. There were 17 excellent, 21 good, 7 fair and no poor outcomes.

CONCLUSION This study demonstrates ulnar shortening osteotomy to be an effective form of treatment for isolated interosseous lunotriquetral ligament tears. Ulnar shortening is not effective when L-T tears are accompanied by a mid carpal instability or lunotriquetral osteoarthritis. The surgeon should maintain a high degree of suspicion for L-T ligament tears when treating patients with ulnar sided wrist pain following an MVA or dorsiflexion injury, particularly when accompanied by ulnar positive variants.

SATURDAY, OCTOBER 5 9:36 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #24B

**HALT Wrist (Hamate Arthrosis Secondary to Lunotriquetral Instability)—
 A Clinical and Biomechanical Study**

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 Frederick Werner, MME, Syracuse, NY
 S. David Boles, MD, Greeneville, TN
 Marsha Weiner, MME, Syracuse, NY

Pain on the ulnar side of the wrist continues to be an unsolved and incompletely understood problem in hand surgery. In our continuing attempt to understand this problem, a group of patients with ulnar-sided wrist pain, ulnar ligamentous injury or laxity, and associated chondromalacia of the proximal pole of the hamate was identified—(HALT wrist—Hamate arthrosis secondary to lunotriquetral instability). The occurrence of this pathological condition appears to be biomechanically analogous to degenerative arthritis on the radial aspect of the wrist secondary to scapholunate instability or nonunion/malunion of the scaphoid, i.e. SLAC or SNAC wrist (Watson et al. 1984, 1987).

METHODS AND MATERIALS A clinical review of 23 patients treated between 1991 and 2001 with ulnar-sided wrist pain who were found to have chondromalacia of the proximal pole of the hamate (hamate DJD) at the time of midcarpal arthroscopy was undertaken to assess the relationship of hamate DJD to ulnar ligamentous injuries and other arthroscopic findings, and the success of arthroscopic excision of the proximal pole of the hamate. No patients received treatment for their lunotriquetral instability although two had previously undergone treatment for LT instability (one LT fusion and one LT pinning).

BIOMECHANICAL STUDY Six fresh frozen wrists with type 2 lunates were studied, before and after proxi-

mal hamate resection to a level that completely unloaded the proximal pole of the hamate, measuring bone resection at the hamatolunate joint (x-rays) and load transfer at the triquetral-hamate joint (Fuji pressure sensitive film).

RESULTS

Clinical—15 of 23 patients were considered both subjectively and objectively to have an excellent result, 4 good and 4 poor. 18 of 23 patients were able to return to their preoperative employment or recreational status at an average of 9 weeks post surgery.

Biomechanical—Removal of 2.4 mm. of bone unloads the lunatohamate articulation without changing the force transfer at the triquetrohamate joint.

CONCLUSION Arthrosis or degenerative change of the proximal pole of the hamate is a clinical entity! This condition is most frequently seen in conjunction with laxity or tear of the lunotriquetral ligament (HALT wrist). 2+ mm. of bony resection of the proximal pole of the hamate both clinically and biomechanically unloads the lunatohamate articulation without increasing load at the triquetral-hamate articulation. Arthroscopic excision of the proximal pole of the hamate gives excellent clinical results even when lunotriquetral laxity is untreated if there is no associated radiocarpal arthritis.

SATURDAY, OCTOBER 5 9:45 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #25B

Impact of Impaired Wrist Motion on Hand and Upper Extremity Performance

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Brian D. Adams, MD, Iowa City, IA

David Murphy, BS, Iowa City, IA

Matthew McCullough, BS, Iowa City, IA

INTRODUCTION Although motion preserving procedures of the wrist are believed to provide better upper extremity function than arthrodesis, objective evidence is lacking to justify these more complex procedures associated with higher risks. The goals of this study were to: 1) further define the disability caused by impaired wrist motion using objective measurements of function, 2) quantify the performance differences between motion preserving procedures and arthrodesis, and 3) assess compensatory motions of the shoulder, elbow and forearm that are imposed by impaired wrist motion.

METHODS Twenty-one subjects without upper extremity compromise performed the Jebson's test and a series of 13 tasks taken from outcome surveys (DASH, PRWE, SF36) and pertinent literature. Tasks were performed under three conditions: 1) unrestricted wrist motion (normal), 2) fully restricted wrist motion (simulated total arthrodesis), and 3) partially restricted wrist motion (30° F and 30° E). A hinged brace was customized to each subject to restrict wrist motion. While performing the tasks, motions of the wrist, forearm, elbow, shoulder and trunk were recorded using a tracking system. The Jebson's test was timed. Subjects completed surveys (DASH, PRWE, study specific) to assess perceived difficulty under each condition.

RESULTS Compensatory motions of the shoulder, elbow and forearm were expressed as percent changes from the unrestricted wrist. Results were averaged over the 13 tasks for each condition.

Survey scores were averaged for each condition. Simulated total arthrodesis had consistently negative effects on task performance and compensatory motions. Compared to unrestricted wrist motion, Jebson's test time increased 19%. Shoulder abduction-adduction increased 10%, flexion-extension increased 26% and rotation increased 34%. Elbow flexion-extension increased 29% and forearm rotation increased 10%. Survey scores deteriorated on average 83%. Simulated motion preserving procedures had smaller effects on task performance and compensatory motions. Jebson's test time increased 14%. Compared to unrestricted wrist motion, the shoulder abduction-adduction increased 8%, flexion-extension increased 22% and rotation increased 31%. Elbow flexion-extension increased 15% and forearm rotation did not increase. Survey scores worsened on average 60%. In comparing simulated arthrodesis to motion preserving procedures, survey scores were significantly worse ($p < .0001$) for arthrodesis.

CONCLUSIONS Wrist motion preserving procedures, such as intercarpal fusions, PRC, and wrist replacement, provide sufficient motion for common tasks and do not require substantial compensatory motions of the trunk, shoulder, elbow and forearm. Conversely, total wrist arthrodesis has a greater impact on task performance and compensatory motions. These findings should be considered in selecting the appropriate surgical procedure, especially for patients with multiple joint involvement.

SATURDAY, OCTOBER 5 9:51 A.M.
Session IVB—Hand and Wrist Reconstruction

Paper #26B

Health Status after Wrist Arthrodesis for Post-Traumatic Arthritis

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David C. Ring, MD, Boston, MA
Jesse B. Jupiter, MD, Boston, MA

BACKGROUND Total wrist arthrodesis is regarded as the most predictable way to relieve the pain of post-traumatic wrist arthritis. Wrist arthrodesis is also believed to be compatible with a high level of upper extremity functioning. The upper extremity specific and general health status of patients with total wrist arthrodesis after trauma has not been evaluated.

METHODS Using an IRB approved protocol, twenty-two patients were evaluated an average of 6 years after total wrist arthrodesis for post-traumatic arthritis. Upper-extremity specific and general health status were measured using the DASH and SF-36 instruments respectively. Patient satisfaction and interest in pursuing a wrist mobilizing procedure, should one become available, were also assessed. Objective assessment included grip strength, digit range of motion, and radiographic fusion.

RESULTS The average DASH score was 25 out of 100 possible points (range 4 to 57) with 0 points indicating no disability. The average physical component score (PCS) of the SF-36 was 39 (range 15 to 60) and the average mental component score (MCS) was 52 (range 44 to 64) with a score of 50 representing population norms and each 10 points below 50 repre-

senting one standard deviation below population norms. Of note, 14 patients complained of wrist pain, including severe pain in 4 patients. Two of these patients had ulnar nerve damage at the time of their original injury, and continue to have nerve-related pain. Fifteen patients were satisfied or very satisfied with the result of the fusion, 5 patients were neutral, and 2 patients were mildly dissatisfied. Twenty patients would elect to have a motion restoring procedure should one become available. One patient required a second surgery to obtain successful fusion of the wrist. Subsequent surgery included neuroma excision in one patients, and hardware removal in six. Grip strength averaged 58% of the uninvolved wrist and none of the patients had stiff digits.

CONCLUSION Substantial dysfunction was noted on both upper extremity specific and general health status measures after total wrist arthrodesis for post-traumatic conditions. Pain was improved, but not eliminated. While some of the pain and dysfunction was related to associated problems, the interest in motion restoring procedures expressed by our patients reflects the residual pain and functional limitations associated with an arthrodesed wrist.

SATURDAY, OCTOBER 5 10:00 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #27B

Ulnar Shortening Osteotomy in Adult Women with Symptomatic Madelung's Deformity

Roderick J. Bruno, MD, Boston, MA
 Charles Cassidy, MD, Boston, MA
 John E. Blank, MD, Camden, NJ
 Leonard K. Ruby, MD, Boston, MA

INTRODUCTION Adult patients with Madelung's deformity may present with ulnar-sided wrist pain. Treatment often involves addressing the distal radial deformity. However, if there is focal wrist pathology and a positive ulnar variance, then an isolated ulnar shortening osteotomy may provide symptomatic relief in these patients.

METHODS From 1988 to 1994 seven wrists in seven adult patients with Madelung's deformity and ulnar-sided wrist pain underwent ulnar shortening osteotomy. The distal radial bony abnormality was not addressed. All of the patients were female, and the average age at the time of surgery was 33.1 years. Two of the individuals were mesomelic dwarfs, and the remaining five patients were otherwise normal. Surgery was performed after the patients failed at least six months of non-operative management. The technique for ulnar shortening included tension band

wiring (one patient), dynamic compression plating (three patients), and the Rayhack osteotomy system (three patients).

RESULTS All patients were asymptomatic at follow-up ranging from seven to 108 months. All of the osteotomies achieved union. One patient required replating for a delayed union. There were no infections, and no ulnar carpal subluxation. Ulnar positive variance correction averaged 4.5mm; 8.0mm in the mesomelic adults, and 3.2 mm in the "normal" adults. Postoperative range of motion and grip strength were equivalent to the contralateral, uninvolved wrist.

CONCLUSION Ulnar shortening osteotomy is a safe and reliable surgical procedure that can relieve ulnar-sided wrist pain in adult patients with symptomatic Madelung's deformity and positive ulnar variance and may eliminate the need for radial osteotomy.

SATURDAY, OCTOBER 5 10:06 A.M.
 Session IVB—Hand and Wrist Reconstruction

Paper #28B

Intra-Articular Osteotomy of the Distal Radius

Miguel Capomassi, MD, Rosaria, Argentina
 Karl-Josef Prommersberger, MD, Bad Neustadt, Germany
 Miguel Slullitel, MD, Rosaria, Argentina
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INTRODUCTION Osteotomy of malunited fractures of the distal radius has become more commonplace as awareness of the relationship between the alignment of the distal radius and function of the wrist and distal radioulnar joints has improved. Articular malunion of the distal radius can lead to disability and arthritis and may also merit reconstructive surgery. The appeal of intra-articular osteotomy has been limited by the technical difficulty of the procedure and the concern that the meager blood supply of the articular fragments may increase the risk of avascular necrosis and nonunion.

METHODS Twenty-six patients with malunited articular fractures of the distal radius had an intra-articular osteotomy at one of three medical centers over a three-year period. There were 17 men and 11 women with an average age of 42 years (range 14 to 75 years). Six fractures were shearing type fractures (AO Type B, Fernandez Type 2) with 4 involving the volar articular margin (so-called Barton's) and 2 the lunate facet. There were 20 articular compression fractures (AO Type C, Fernandez Type 3) with six complex fractures (Subtype C3) and 14 simple articular fractures (Subtypes C1 and C2). The initial treatment was nonoperative in 12 patients and operative in 14 (8 percutaneous pinning, 4 plate and screws,

and 2 external fixation). The interval from the injury to the osteotomy averaged 17 weeks (range 8 to 56 weeks). The indication for surgery was a step-off between the scaphoid and lunate facets of greater than 2 millimeters in 22 patients and volar radiocarpal subluxation related to a malunited volar shearing (Barton's) fracture in four patients. In addition, three patients had dorsal and five had volar subluxation or dislocation of the carpus with a malunited lunate facet fragment.

RESULTS At an average follow-up of 22 months (range 14 to 26 months) all of the osteotomies healed and no avascular necrosis was observed. Implant removal was performed in 14 patients. Complications included an extensor tendon rupture and a case of sympathetic dystrophy. One patient had a subsequent distal radioulnar joint procedure (Sauve-Kapandji). The radiographic result was good or excellent (Lidstrom) in 23 patients and the clinical result (Fernandez) was good or excellent in 22 patients.

CONCLUSIONS Intra-articular osteotomy of malunited articular fractures of the distal radius is associated with little risk of avascular necrosis, an acceptable complication rate, and radiographic and functional improvements in most patients.

SATURDAY, OCTOBER 5 2:45 P.M.
 Session VA—Upper Extremity Reconstruction

Paper #29A

Psychological Factors in Idiopathic Arm Pain

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 Leah Fourt, BA, Boston, MA
 Sang-Gil P. Lee, MD, Boston, MA

INTRODUCTION Patients presenting with arm pain often have vague and diffuse symptoms and the examination does not disclose a discrete source of pain (idiopathic arm pain). Psychological and sociological factors may be an important element of this type of illness.

METHODS 35 patients with idiopathic upper limb pain and 35 patients with a discrete source of pain were enrolled in an IRB-approved prospective protocol after informed consent. Five quantitative psychological questionnaires were completed by each patient. The Multidimensional Health Locus of Control scale (MHLC) measures patients' perceptions of what controls their health (self, others, or chance). The Body Consciousness Questionnaire (BCQ) measures a patient's awareness of and predisposition with bodily sensations. The Pain Anxiety Symptom Scale (PASS) measures anxiety related to pain. The Pain Catastrophizing Scale measures a patients tendency to respond to pain with poor adaptive mechanisms, expecting the worst. The Wahler Physical Symptom Inventory (WPSI) measures the frequency of common physical symptoms such as headaches. It can be used to measure patients' tendency to somatize.

RESULTS Patients with idiopathic pain and patients with discrete pain had similar scores on the WPSI

indicating a similar frequency of somatic complaints. Patients with idiopathic upper limb pain had significantly greater private and public body consciousness; fear and cognitive anxiety of pain; tendency to respond to pain with catastrophizing behavior (expecting the worst); and locus of control due to chance (interpreting the pain as the result of bad luck rather than something that they or their doctor could control).

CONCLUSIONS Patients with idiopathic upper limb pain are more focused on bodily sensations, are more likely to interpret discomfort as indicating a problem, have greater fear and anxiety of pain, and believe that health problems are related to bad luck. These factors may help to explain why patients with pain but no clear pathology are motivated to come to physicians. It is important to acknowledge this pain without mislabeling patients with diagnoses such as carpal tunnel syndrome, tendonitis, fibromyalgia, or reflex sympathetic dystrophy which have far reaching psychological and sociological implications. Hand surgeons and all physicians should be more comfortable saying, "I don't know," utilizing the diagnosis of idiopathic pain, and providing frequent supportive visits and reassurance rather than ordering costly, potentially misleading diagnostic tests or performing potentially harmful operative procedures.

SATURDAY, OCTOBER 5 2:51 P.M.
 Session VA—Upper Extremity Reconstruction

Paper #30A

Validation of the Disabilities of Arm, Shoulder, Hand (DASH) Questionnaire in 342 Patients

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 Angela Harth, PhD, Ludwigshafen, Germany
 Gerhard Wind, PhD, Ludwigshafen, Germany
 Günter Germann, MD, PhD, Ludwigshafen, Germany

INTRODUCTION The Disabilities of Arm, Shoulder, Hand (DASH) questionnaire is a patient-centred instrument, developed to measure levels of impairment (symptoms) and functional disability in upper extremity conditions (functional activities, sport/ music and work). Although widely used, only 4 validation studies of DASH have been published to date. With the aim of producing a reliable tool which could be used in German-speaking countries, we performed cross-cultural adaptation of the DASH to German, which was carried out in accordance with the AAOS guidelines. We then proceeded with the first steps to evaluate the psychometric properties of the translated questionnaire.

METHODS Between March 1999 and December 2000, 342 patients were recruited from 6 diagnostic groups: amputation of one ray, burns of the hand, median nerve injury, injury to the proximal-interphalangeal (PIP) joint, wrist fusion and resection-suspension arthroplasty (RSA) of the first carpo-metacarpal joint. DASH was applied to all 6 groups. In the absence of a gold standard to test criterion validity, the RSA, amputation and PIP injured sub-groups (n=183) also completed a Disability Index which includes 7 domains of health-related activities.

Additional data was collected from the sub-group of patients with wrist fusion (n=86) using the Mayo and modified German Krimmer wrist scores, as well as clinical tests of grip strength and range of motion. Spearman rank correlations were used to examine relationships between scores. Exploratory factor analysis was carried out with Varimaxrotation on items of DASH.

RESULTS Correlations between DASH domains of symptoms and function were high for all of the 6 groups (lowest 0.66, highest 0.89), but not for the areas of sport/music (0.3). The Disability Index correlated positively with DASH symptoms (0.79) and DASH function (0.73), as did both the Mayo and Krimmer scores (0.72 and 0.78), however correlation between clinical tests and DASH was poor ($r < 0.25$). A 5 factor analysis was able to account for 70% of DASH items.

CONCLUSION These results indicate that DASH discriminates adequately between the given domains of functional activities, symptoms and sport. Our findings confirm that DASH is a suitable instrument for assessing patients' perceptions of their health status and substantiate the view that treatment outcomes cannot adequately be based on clinical data alone.

SATURDAY, OCTOBER 5 3:00 P.M.
Session VA—Upper Extremity Reconstruction

Paper #31A

Arthroscopic Ganglionectomy in the Management of Dorsal Wrist Ganglions

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Richard A. Berger, MD, PhD, Rochester, MN
Scott P. Steinmann, MD, Rochester, MN

Dorsal carpal ganglions are common causes of pain and limited function. Treatments include immobilization, aspiration with and without injection, and surgery. Recurrence is a frequent complication. Surgery affords the best chance for definitive treatment. Open resection is typically the surgical method of choice. However, difficulties with this technique may include wrist instability with over-aggressive resection and unsightly scars. Arthroscopic resection may afford some advantages such as improved visualization and a more controlled resection, decreased morbidity, and smaller incisions. The purpose of this paper is to review the results of arthroscopic resection of dorsal wrist ganglions. Between November 1994 and May 2001, forty-one patients with dorsal wrist ganglions underwent arthroscopic resection. There were 24 females and 17 males. The right wrist was affected in 19 patients and left in 22. The average patient age was 29.8 years (range 11 to 56). All of the patients demonstrated clinical evidence of a dorsal wrist ganglion, with exam findings of pain (especially with wrist dorsiflexion), localized swelling and/or limited range of motion. The most common location was at the scapholunate joint. Ultrasound confirmed diagnosis in nineteen cases and magnetic resonance imaging aided in diagnosis in three patients. The remaining 19 patients were treated based on clinical

exam and history. Twelve patients had previous injections with recurrence. The average pre-operative range of motion was flexion of 50°, extension of 42°, radial deviation of 16° and ulnar deviation of 32°. The average pre-op grip strength was 15.3 kg. The average follow-up to date is 35.2 months (range 6 to 84). In all patients, post-operative range of motion was equal to or better than pre-operative motion. Ten cases had significant stiffness immediately following surgery that resolved within 3 months with therapy. Another case had persistent swelling following arthroscopy, which eventually resolved by six months. No cases of postoperative scapholunate instability occurred. The postoperative grip strength average improved to 22 kg. Thirty-nine of 41 (95.1%) patients had no recurrence. Both cases that recurred went on to undergo two attempts at open resection to successfully eradicate the ganglion. No intra-operative complications were noted. The published recurrence rate for open ganglionectomy is approximately 5–10%. In this study, the results of arthroscopic ganglion resection are very encouraging. At nearly an average 3-year follow-up, the recurrence rate is 4.9%. No significant intra-operative or post-operative complications occurred. Based on these results, arthroscopic ganglionectomy is a safe and reliable alternative to open resection.

SATURDAY, OCTOBER 5 3:06 P.M.
Session VA—Upper Extremity Reconstruction

Paper #32A

Complications of Wrist Arthroscopy

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Complications arising from wrist arthroscopy are believed to be uncommon. The true complication rate following this procedure is largely unknown since most of our knowledge originates from surveys, individual case reports, and cadaveric studies. The purpose of this study is to determine the incidence and nature of complications following wrist arthroscopy.

The outpatient records and operative reports of one hundred and fifteen consecutive patients who underwent wrist arthroscopy performed by two surgeons over a four-year period were reviewed. The most common indications for arthroscopy were triangular fibrocartilage complex (TFCC) tears (n=53), intercarpal ligament injury (n=27), wrist pain (n=19), articular degeneration (n=17), and articular distal radius fracture (n=6). Complications were subdivided into major and minor using the modified Morrey criteria. We identified a total of 13 complications in our patient group (11%). Of these, one complication was identified as major (permanent wrist contracture) while the remaining 12 were minor (9 patients with transient wrist joint stiffness, 2 with transient superficial sensory

neurapraxia, and 1 with superficial portal site infection). All of the minor complications resolved at latest follow-up with conservative care consisting of occupational therapy for the patients with wrist stiffness, observation for the patients with neurapraxia, and oral antibiotics for the patient with the wound infection. We identified no other major complications, such as vascular injury, compartment syndrome, joint infection, permanent nerve injury, or reflex sympathetic dystrophy (RSD). Surprisingly, there is little information in the literature regarding complications following wrist arthroscopy. We identified a complication rate of 11%, which is higher than we expected. Analysis of our data reveals that the majority of the complications were limited and resolved with conservative care. Only one patient in the group was identified as having a major complication (<1%). Temporary wrist stiffness was identified as the most common minor complication in our study group (8%). All patients in this group improved with occupational therapy. Wrist arthroscopy is a safe procedure with a low incidence of major complications.

SATURDAY, OCTOBER 5 3:15 P.M.
Session VA—Upper Extremity Reconstruction

Paper #33A

Extension Osteotomy of the Thumb Metacarpal Reduces Carpometacarpal Joint Laxity

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Melvin P. Rosenwasser, MD, New York, NY
Robert J. Strauch, MD, New York, NY

INTRODUCTION Osteoarthritis (OA) of the thumb carpometacarpal (CMC) joint is a debilitating disease. Extension osteotomy of the metacarpal has been reported to result in pain relief and improved hand function, but little is known about its biomechanical effects. It has been hypothesized that joint ligament laxity is an etiological factor in the promotion of OA. In this study, we propose that extension osteotomy of the thumb metacarpal results in a decrease in joint laxity. To test this hypothesis we used a custom designed CMC Joint Laxity Tester to measure the laxity of non-OA cadaveric specimens before and after a simulated extension osteotomy.

METHODS Seven fresh frozen human cadaveric hands all under age 35 without evidence of arthritis on x-ray were dissected. The trapezium, trapezoid and 1st metacarpal were removed from each specimen leaving the CMC joint capsule intact. The distal portion of the metacarpal was fixed in a specimen holder with PMMA cement. The trapezium-trapezoid complex was fixed similarly. A CMC joint laxity tester with a precision of 25 microns was then used to study the specimens. The specimen was placed into the laxity tester by manually aligning the anatomic axes of the joint with the axes of the tester. Ten cycles of preconditioning followed by ten cycles of data acquisition

were performed for each of four directions: radial-ular translation, dorsal-volar translation, pronation-supination, and joint distraction. An extension osteotomy was simulated by flexing the metacarpal on the trapezium by 30 degrees, and all testing procedures were repeated. A one-way repeated measures ANOVA was used to determine the effect of joint angle on the joint laxity and stiffness in each of the four directions.

RESULTS The simulated extension osteotomy significantly reduced laxity in the radial-ular, pronation-supination, and dorsal-volar directions: $p=0.0067$, $p=0.0092$ and $p=0.0196$ respectively. The laxity in distraction was reduced, but not significantly. In addition, the stiffness of the joint complex in the dorsal direction was significantly increased, $p=0.0059$ (see Figures 1 & 2).

DISCUSSION It was found that the simulated extension osteotomy significantly reduced the overall laxity of the CMC joint. The reduction in joint laxity coupled with increased dorsal stiffness may result in an overall decrease in joint translation, particularly in the dorsal direction, which occurs during dynamic pinch activity. The increased stability may be at least partially responsible for the reduction in symptoms and improved hand function observed with extension osteotomy.

FIGURE 1 Average (-SD) joint laxity in the distraction (Dst), radial-ular (R-U), dorsal-volar (D-V) and pronation-supination (P-S) directions.

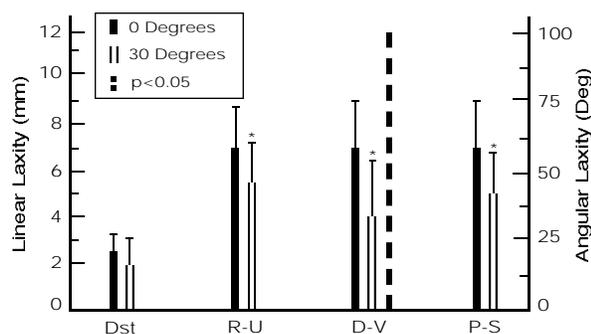
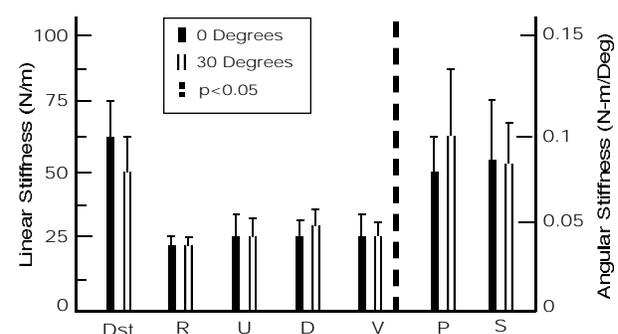


FIGURE 2 Average (-SD) joint stiffness in the distraction (Dst), radial (R), ulnar (U), dorsal (D) volar (V), pronation (P) and supination (S) directions.



SATURDAY, OCTOBER 5 3:21 P.M.
Session VA—Upper Extremity Reconstruction

Paper #34A

Outcome of Dynamic Scapula Stabilization Procedure in Late Obstetrical Brachial Plexus Palsy

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PURPOSE One of the frequent deformities in obstetrical brachial plexus palsy is winging of the affected scapula. The purpose of this study is to introduce the scapula stabilization procedure, a novel dynamic technique for the winging scapula, and to assess the functional results in a population of 26 patients. In the majority of cases the contralateral trapezius with or without the rhomboid muscle were transferred. In severe cases, the contralateral latissimus dorsi muscle has been used. This deformity is not only functional but also cosmetic. Scapulothoracic joint deformity is caused by muscle imbalance of the shoulder girdle. Powerful internal rotators and paralyzed external rotators cause upward and outward contracture of the joint. The net result is an atrophic winged scapula.

METHOD Twenty-six patients with obstetrical brachial plexus palsy underwent dynamic scapula stabilization. The mean age was 6.4 years. The mean follow up was 16.2 months. Eleven patients had global paralysis and fifteen had Erb's palsy. In 19 patients contralateral trapezius transfer was performed and in seven patients this was combined with a contralateral rhomboid muscle transfer. In five patients the contralateral trapezius was done initially, followed by a contralateral latissimus dorsi transfer. The distal third of the trapezius muscle was raised through a small

posterior midline incision. The muscle was transferred and anchored along the medial border and angle of the contralateral winged scapula. Compression dressing and a figure eight sling were applied for eight weeks postoperatively.

RESULTS Preoperative and postoperative the distance between the spine and the angle of the scapula was measured with the patient pushing against the wall. The mean difference between the paralyzed and normal side was 3.8cm preoperatively as compared to 0.6cm postoperatively. The cosmetic and functional deformity was corrected in nearly all cases. The average increase in abduction was 14° [preoperative mean 97°; postoperative mean 111°]. The mean external rotation increase was 17° [preoperative mean 34°, postoperative mean 51°].

CONCLUSIONS The transfer of the contralateral trapezius and/or latissimus dorsi muscle to the medial border and angle of the scapula is a reliable method of dynamic scapula stabilization and in addition, it can improve shoulder function in obstetrical brachial plexus palsy. Elimination of scapula winging and restoration of muscle balance in the scapulothoracic joint was achieved in nearly all cases with this innovative new procedure.

SATURDAY, OCTOBER 5 3:30 P.M.
 Session VA—Upper Extremity Reconstruction

Paper #35A

Treatment of Hand Cocooning in Patients with Epidermolysis Bullosa with Release and Apligraf Biologic Dressing

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 Elizabeth A. Ouellette, MD, Miami, FL

Epidermolysis bullosa (EB) is represented by a group of genetically determined skin fragility disorders characterized by repeated blistering of the skin and mucosae with minimal mechanical trauma. The hands are constantly exposed to shear forces and microtrauma during daily activities; therefore, blistering and scarring occurs continuously beginning in early childhood. Remarkable deformities including complete cocooning of the hands, pseudosyndactyly, adduction contractures of the thumb, and flexion/extension contractures of the thumb and fingers can occur. These patients require release of their first web space, palmar contractures, and webbing between the fingers to restore functional pinch and grasp; however, the use of autologous skin is associated with delayed healing of the donor site and chronic wound formation. The skin graft, Apligraf (Organogenesis Inc, Canton, Mass), has metabolic, morphologic, and biochemical similarities to human skin and has recently been proven effective in promoting rapid wound healing in EB. We have treated 6 patients with hereditary dystrophic epidermolysis bullosa with release of the cocooning deformities, pseudosyndactylies, finger and thumb flexion contractures, and first web space contractures followed by application of Apligraf to serve as a biologic dressing. There were 3 male and 3 female patients with an average age of 15.1 years (range: 8–30

years). The Apligraf was covered with a Mepitel dressing, and silicone spacers were placed between the fingers. Dressings were changed at one week postoperatively. Patients were started on active and active-assisted exercises for finger flexion/extension and fitted with thermoplastic resting splints for use between therapy sessions. All wounds were healed by 6 weeks postoperatively, and patients were able to achieve functional use of their hand. We followed the patients for an average of 15 months (range: 12–23 months). There were no surgical complications and all patients had 100% take of the Apligraf dressing. Additionally, patients had a marked improvement in their self esteem, functional independence, and quality of life. These results indicate that surgical release of hand deformities due to epidermolysis bullosa can be successfully managed by application of the biologic bilayered skin Apligraf without risk of rejection or adverse side effects.



SATURDAY, OCTOBER 5 3:36 P.M.
Session VA—Upper Extremity Reconstruction

Paper #36A

Biomechanical Evaluation of a Modified Pulvertaft Weave

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Michael S. Bednar, MD, Maywood, IL

Recent advances in flexor tendon repair techniques have increased the repair strength to allow early active mobilization programs within the first post-operative week. However, most tendon transfer rehabilitation protocols recommend immobilization for 3–6 weeks to protect the transfer. The purpose of this study is to biomechanically test a modification to the Pulvertaft weave to determine the creep following repetitive loading and ultimate strength of the repair. Three matched pairs of fresh-frozen arms were used. Within each pair, one hand received all Pulvertaft and the other all modified Pulvertaft weaves. All flexor tendons were transected distal to the musculotendinous junction and left attached to their respective phalanges. The FDS tendon was woven through the FDP tendon of the index, middle, and ring finger. The FPL was woven through the FDP of the small finger. One specimen was broken prematurely by the testing equipment. The matched specimen was discarded; thereby yielding 11 weaves in each group. All Pulvertaft weaves had three perpendicularly placed passes through the FDP tendon, sutured at these three points with a 2-0 Ethibond horizontal mattress. In the modified Pulvertaft group, the free end of the FDS or FPL tendon was placed over the entire length

of the weave. A 2-0 Ethibond simple, running suture with 3 mm spacing was placed for the entire length of the weave on both sides of the FDS/FPL. To test the biomechanics, a K-wire was passed through each phalanx and the specimens mounted on an Instron model 1122. The weaves were cycled at 20 N for 1200 cycles and the stretch of the weave measured. Next, the tendons were loaded to failure. The results were compared using a student's paired t-test. The modified Pulvertaft weave showed a statistically significant increased load to failure. The mean load to failure for the Pulvertaft group was $117 \pm 22.3\text{N}$ compared to $242 \pm 47.9\text{N}$ for the modified Pulvertaft group ($p < 0.001$). The modified weave also demonstrated a statistically significant decreased creep. The mean increase in the length of the weave for the Pulvertaft group was $2.62 \pm 0.84\text{mm}$ and for the modified Pulvertaft group was $1.28 \pm 0.60\text{mm}$ ($p=0.001$). The modified Pulvertaft weave offers a significant decrease in creep and increase in strength for tendon transfers with little added difficulty. Although further testing is required, this tendon weave modification may allow for immediate active range of motion following certain tendon transfers.

SATURDAY, OCTOBER 5 3:45 P.M.
 Session VA—Upper Extremity Reconstruction

Paper #37A

Mechanoreceptors of the Radiocarpal Joint—A Preliminary Report of the Dorsal Radiocarpal Ligament

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 Evelyn J. Berger, BA, Rochester, MN
 Jean Y. Jew, MD, Iowa City, IA

BACKGROUND The anterior and posterior interosseous nerves have been demonstrated to innervate the central two thirds of the anterior and posterior wrist joint capsule. Partial denervation of the wrist has been clinically applied to reduce chronic wrist pain. However, the normal anatomic relationships and functional roles of these nerves related to wrist proprioception remain unknown. An investigation of the mechanoreceptor populations in the wrist joint capsule associated with the anterior and posterior interosseous nerves has been undertaken to determine the extent and nature of their role in wrist proprioception. This specific study addresses the mechanoreceptor population in the dorsal radiocarpal (DRC) ligament.

MATERIALS AND METHODS The DRC ligaments were harvested from four wrists of two fresh cadavers within 12 hours of death. Before the tissues were harvested, radiographs were taken to exclude any arthritic conditions of the wrists. Tissues were fixed, sectioned, and collected on glass slides. Slides were processed for fluorescence immunohistochemistry using antibody to protein gene product 9.5 (PGP 9.5) and a secondary antibody conjugated to a fluorescent tag. The sections were evaluated with an LSM-510 confocal laser scanning microscope and a Kontron KS 400 image analyzer. Labeled mechanoreceptors were mapped, measured and categorized.

RESULTS Three major types of mechanoreceptors, including Type I (Ruffini ending), Type III (Golgi tendon organ) and Type IV (free nerve ending), could be identified in all four DRC ligaments. More Type I and IV receptors could be identified compared to Type III receptors. These receptors were distributed primarily over the superficial two thirds of the ligament (> 70%), and near the origin and insertion to the bones (> 80%). More than 70% of the receptors were identified in epiligamentous spaces rather than in perifascicular spaces. Type I receptors were oval or irregular in shape, and were measured from 100 to 400 μ m. Type III receptors were generally fusiform in shape, and were between 500 and 650 μ m. Type IV receptors were identified either as single strands or ramifying arborizations. The terminal axons were from 1.0 to 1.5 μ m in diameter.

CONCLUSION From this preliminary investigation, we have discovered that the DRC ligament has a rich sensory innervation from the posterior interosseous nerve. This information, along with ongoing studies of the specific afferent electrical activities obtained from the posterior interosseous nerve and studies of proprioceptive acuity in the wrist, will contribute to our understanding of the factors involved in joint proprioception.

SATURDAY, OCTOBER 5 3:51 P.M.
 Session VA—Upper Extremity Reconstruction

Paper #38A

Role of the DIC Ligament in Dynamic and Static Scapholunate Instability

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Munir Ahmad Shah, MD, Galveston, TX

Rita Patterson, PhD, Galveston, TX

Steven F. Viegas, MD, Galveston, TX

INTRODUCTION Scapholunate dissociation (SLD) is the most common carpal instability. Recent studies have suggested a greater role in stabilization of the scaphoid and lunate by the dorsal intercarpal (DIC) and the dorsal radiocarpal (DRC) ligaments. This study was designed to attempt to determine the role, if any, of the DIC in the development of SLD and resulting DISI.

MATERIAL AND METHODS Five fresh frozen cadaver arms were used (Male 3, Female 2; age 52 to 68, average age 60.8; right 3, left 2). Six increasing stages of instability were developed by progressively sectioning the following structures: stage 1; partial dorsal capsulectomy retaining both the DIC and DRC ligaments, stage 2; sectioning of the palmar and proximal (membranous) portion of the scapholunate interosseous ligament, stage 3; detaching the DIC from its insertion on the scaphoid and trapezium, stage 4; sectioning of the dorsal scapholunate interosseous ligament (dSLIO) from the scaphoid, stage 5; detaching the DIC ligament from its attachment on the lunate, stage 6; sectioning of the lunotriquetral ligament. PA and lateral x-rays of the wrist were obtained at each stage, both with an axial load of five kilograms and without loading, and the position of the scaphoid and lunate were analyzed. In addition, a 3D digitizer was used to evaluate the

scaphoid and lunate position using nine points (three on the radius, two on the scaphoid, one on the lunate, one on the capitate and two on the third metacarpal bone). Each specimen was evaluated in six different positions both with and without the 5 kg axial load. The forearm was maintained in full supination, and the wrist was tested in neutral, 10 degrees of radial deviation, 20 degrees of ulnar deviation, and in 20 and 40 degrees of flexion and 20 degrees of extension.

RESULTS The scaphoid position changed significantly after sectioning the dSLIO (Stage 4) although only when the 5kg load was applied, but the lunate position was unchanged in both the loaded and the unloaded conditions. Therefore stage 4 resulted in what could be considered a dynamic instability of the scaphoid without a DISI. After detaching the DIC from the lunate (Stage 5), both the scaphoid and lunate moved significantly in both loaded and unloaded conditions and demonstrated a DISI deformity. Therefore stage 5 resulted in a static DISI deformity.

SUMMARY Complete disruption of the SL ligament did not necessarily imply the development of a static collapse of the lunate. The DIC had an important role to stabilize the scaphoid and lunate and to prevent DISI deformity.

SATURDAY, OCTOBER 5 2:45 P.M.

Session VB—Carpal Tunnel

Paper #29B

A Novel In-Vitro Model of Forearm Fracture and the Influence of Forearm Rotation

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 Brendon Hopgood, Philadelphia, PA
 Scott H. Kozin, MD, Philadelphia, PA

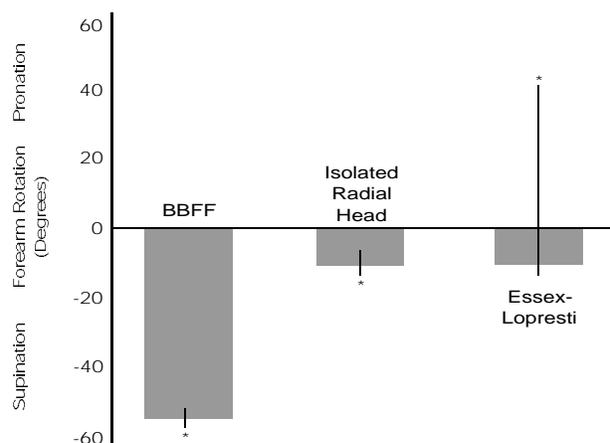
PURPOSE The purpose of this study was to develop an in-vitro forearm fracture model and determine the role of forearm rotation in the production of particular injury patterns.

METHODS A novel in-vitro model was developed to simulate impact loading within the forearm. Twenty fresh frozen cadaveric arms were thawed in a warm isotonic saline solution. The wrist of each specimen was excised and the proximal humerus was dissected. The arm was potted at the proximal humerus and positioned in extension using a plate across the distal forearm and against the elbow (no clamps or pins were used in arm positioning). The rotational range of motion was measured using a goniometer starting from a neutral position ($_ = 0^\circ$) and the forearm was then placed in the desired rotational position. The impactor consisted of a horizontal metal bar with an impact extension traveling on vertical frictionless guides. The specimens were aligned with the impactor and a 27 kg weight was raised to 90 cm and dropped upon the distal radius. Each arm was dissected and the type of injury and location was assessed.

RESULTS The impact model reliably reproduced predictable fracture patterns. A concomitant mid-shaft radius fracture, distal ulna fracture and partial IOM tear occurred at $51.1 \pm 2.6^\circ$ of supination ($n=4$). Isolated radial head (RH) fractures occurred at $11.7 \pm 5.2^\circ$ of supination ($n=7$). Further rotation resulted in comminuted RH fractures and IOM tears at $13.9 \pm 25^\circ$ of pronation ($n=9$). There was a significant difference between the degree of forearm rotation and pattern of injury (Figure 1, $p < .01$).

DISCUSSION This study was able to reproduce in-vitro forearm fractures and demonstrated that the injury pattern was dependent upon forearm rotation. Rotation of the forearm from supination to pronation changed the radiocapitellar joint (RCJ) and IOM loads in a predictable pattern. In full supination, impact forces were completely maintained by the IOM, resulting in both bone forearm fractures (BBFF) and partial membrane tears. In slight supination, there was mild loading of the RCJ, which yielded isolated RH fractures. In pronation, minimal IOM loading resulted in comminuted RH fractures followed by traumatic IOM tearing. This fracture model demonstrated that as the forearm is rotated from supination to pronation, impact loading will result in a progression from a BBFF to an isolated RH fracture to an Essex-Lopresti lesion.

FRACTURE TYPE



SATURDAY, OCTOBER 5 2:51 P.M.

Session VB—Carpal Tunnel

Paper #30B

Forearm Rotation Stiffness: Efficacy of Non-operative Management with Static Progressive Splinting

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Jeffrey C. King, MD, PT, Kalamazoo, MI

INTRODUCTION Loss of forearm rotation can lead to significant loss of upper extremity function. Operative treatment to improve rotation of the forearm has been reported, however, limited information exists about the efficacy of conservative management. Non-operative management is not effective in cases of mechanical mal-alignment or bony block. We present the results of static progressive splinting (SPS) for improvement of forearm rotation caused by soft tissue contracture of the proximal radio-ulnar joint (PRUJ) and/or distal radio-ulnar joint (DRUJ).

MATERIALS AND METHODS The records of 28 patients with loss of forearm rotation treated with static progressive stretching splints were reviewed. 14 patients had PRUJ stiffness, 13 related to the DRUJ and one with both. Causes included elbow fracture/dislocation (5), isolated radial head injury (3), status post radial head resection (5), distal radius fracture (10), wrist ligament reconstruction (2) and ulna fracture (2). Patients with synostosis or malunited forearm fractures were excluded. All patients had 50 degrees or less of supination, pronation or both.

RESULTS Mean time from injury to initiation of splinting was 18.1 weeks, (6–62 weeks) with a median of

12 weeks. Duration of splinting was 12–24 weeks. Average initial supination was 29.8 (0–48), and final supination averaged 61.7 (10–90). Average gain was 31.9 degrees (-20–80). 23 of 25 (92%) patients gained motion; 17 of 25 (68%) gained a functional arc. Initial pronation averaged 28.7 (0–50) and final pronation was 69.2 (40–90). Average pronation gain was 39.9 degrees (10–69). All gained pronation, 13 of 15 (87%) achieved a functional arc. Complications included radial sensory nerve neuropraxia in 2. Only two patients required surgery for failure to achieve functional rotation.

DISCUSSION Static progressive stretching splints have been effectively applied to elbow flexion contractures, but have received limited attention for forearm rotation. This type of splint allows for infinite adjustability and control of tissue tension and joint position to improve forearm rotation. Technical challenges to designing effective forearm stretching splints include difficulty with aligning the axis of rotation, as well as short lever arms with which to apply stretching force. Despite these limitations, this report demonstrates the efficacy of this type of static progressive stretching splint for the improvement of forearm stiffness related to soft tissue contracture.

SATURDAY, OCTOBER 5 3:00 P.M.
Session VB—Carpal Tunnel

Paper #31B

Innervation of the Elbow

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Thomas M. Brushart, MD, Baltimore, MD

Painful elbow disorders are encountered frequently in clinical practice. However, the pathways that carry elbow pain are poorly defined. The purpose of this study was to create a detailed 3-D reconstruction of elbow innervation from fetal tissue. The lengths, branch points, and degree of interspecimen variation in the course of the ulnar, median, and radial nerves at the elbow joint were determined. Serial 100 micrometer sections were taken of three human fetal elbows (gestational ages 22–24 weeks) and stained with anti-S-100 antibody to label nerve. Digital images of each structure were stacked into proper alignment using Adobe PhotoShop version 6.0. Relevant structures were traced and exported in Adobe Illustrator format, where the resultant paths were reconstructed into 3-D images using Strata Studio Pro version 2.5. This powerful modeling program allowed for detailed analysis of nerve pathways, branching sites, and precise relationships with respect to different bony landmarks and furthermore offered the advantage of visualizing the elbow from any view and isolating specific structures of interest for advanced study or review. For the ulnar nerve, an average of 7.3 (range 7–8) total branches (TB), and

4.0 (range 3–5) capsular branches (CB) were detected and traced. Corresponding values obtained for the median and radial nerves were 3.0 (2–4) TB, 2.7 (2–3) CB; and 4.7 (4–6) TB, 3.3 (3–4) CB, respectively. The three reconstructed specimens demonstrated (1) overlap of innervation from all nerves at the radio-ulnar joint; (2) predominately ulnar innervation with sparse contribution by median nerve at the humero-ulnar joint and medial epicondyle; and (3) solely radial nerve contribution to the innervation of the lateral epicondyle. While significant interspecimen variation was noted in the course and termination of capsular branches of the ulnar, median, and radial nerves, careful inspection of the 3-D constructs revealed considerable pattern uniformity in the nerve pathways and branch sites from specimen to specimen. In particular, significant interspecimen homogeneity was present in a minimum of 3 ulnar and radial CB and 2 median CB. Having defined the anatomic relationships of these nerves and their branches to the surrounding osteology, we can now identify the pathways transmitting pain from each elbow compartment. This knowledge can serve as the basis for designing minimally invasive denervation procedures.

SATURDAY, OCTOBER 5 3:06 P.M.
 Session VB—Carpal Tunnel

Paper #32B

Direct Electrical Stimulation for Chronic Regional Pain Syndrome-Somatic Peripheral Nerve Pain

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 Barbara J. Metcalf, LPN, Rochester, MN

We report on the treatment of painful peripheral nerves (Chronic Regional Pain Syndrome-I) with a direct electrical nerve stimulation (DENS) program of pain management. A specific screening program of transcutaneous stimulation (TENS), nerve blocks and psychiatric assessment was used in 30 patients followed for greater than five years. We report reasonable long-term success in controlling pain and improved quality of life. From a total of 62 patients treated by DENS, we report on 30 with long-term success of pain relief for radial (2), ulnar (10), median (17), and brachial plexus (1) related nerve pain. A pre-operative pain scale and assessment of narcotic medications, work status, and sleep were recorded. All patients required relief of pain with one or more peripheral nerve blocks, failed medical pain management, and reasonable psychiatric profile before surgical treatment by neurolysis and implantation of

a direct electrical stimulation electrode system (Itriel system, Medtronic Corp). The results from treatment are long-term improved pain in 25 of 30 patients (83%), ability to sleep (100%), and relief from narcotic-based analgesics (100%) (Figure 1). Pain improved from a mean of 8.5 (scale 1-10) and range 6-10 (Figure 2) to 3—from range of 0.5. Six patients remained disabled, seven retired, while 17 returned to some form of work or homemaker activities. Twenty patients have near complete pain relief with the Itriel unit removed, and ten patients continue intermittent use of direct electrical stimulation with pain improved 60-90%. Further surgery except for Itriel removal has not been required for any patient. We conclude that DENS, in proper selected patients, can improve chronic nerve pain (CRPS- I) long term with improved sleep, work potential, and relief from narcotic analgesics and overall improved quality of life.

FIGURE 1—PAIN LEVEL (scale 1-10)

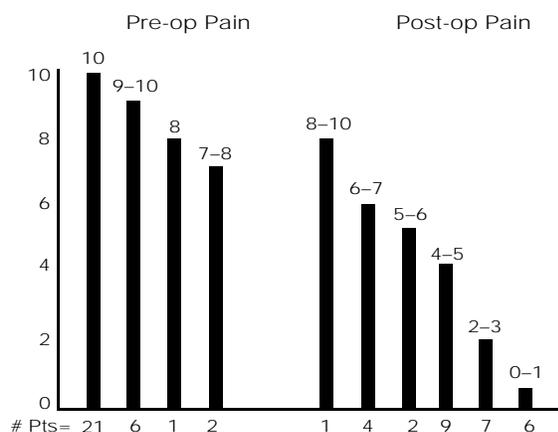
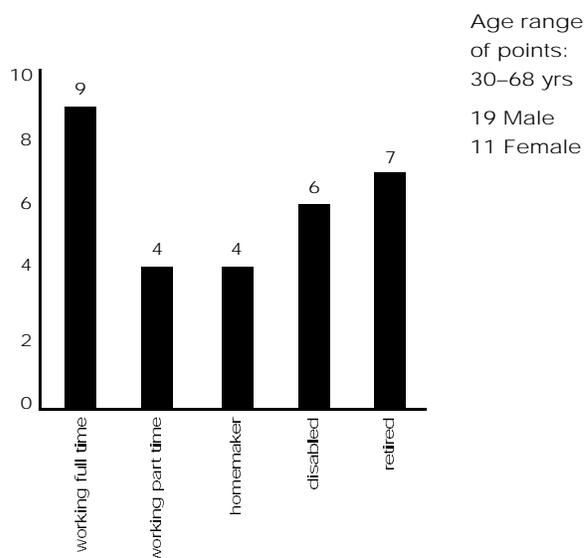


FIGURE 2—OCCUPATIONAL STATUS



SATURDAY, OCTOBER 5 3:15 P.M.

Session VB—Carpal Tunnel

Paper #33B

Surgical Treatment for Chronic Radial Head Dislocation

Emiko Horii, MD, Nagoya, Japan
 Ryogo Nakamura, MD, Nagoya, Japan
 Shukuki Koh, MD, Nagoya, Japan
 Hironobu Inagaki, MD, Nagoya, Japan

The late treatment of unrecognized radial head dislocation remains controversial. A reported surgical outcome for the treatment of chronic dislocation showed a high re-dislocation ratio with many complications. We think that correction of mal-alignment by ulnar osteotomy is a key to good surgical outcomes and refined surgical techniques. This paper introduces our surgical techniques and outcomes.

METHODS Twenty-two patients were surgically treated since 1975. The mean interval between traumas to reconstructive surgeries was 10 months (range: 2 months to 5 years and 2 months). There were 8 males and 14 females; the mean age at surgery was 10 years and 2 months (range: 4 to 20 years). The right elbow was injured in 13 patients, the left in 9. Open reduction of the dislocated radial head was followed by radial or ulnar osteotomy with or without annular ligament reconstruction. Since 1991, we modified surgical techniques; the ulna was osteotomized obliquely at the proximal metaphysis, angulated and elongated, then rigidly fixed by a plate. An annular ligament reconstruction was performed by using a triceps fascia rounded around the radial neck and sutured back to the fascia itself. Postoperatively, the cast was applied in 90° of flexion and neutral pro-

supination for 2 weeks. Nine out of 22 patients were treated based on this modified technique. Follow-up ranged from 8 months to 12 years and 9 months, with a mean of 36 months.

RESULTS There were no serious surgical complications such as nerve palsy or delayed union. Before 1991, good reduction was obtained in 4 patients, subluxation remained in 2, and re-dislocation was observed in 7. An average prosupination arc was 124 degrees; 7 out of 13 patients resulted in restricted forearm rotation postoperatively. By modified osteotomy, good reduction was obtained in 7 patients, and 2 patients who had already had slight radial head deformity resulted in subluxation. An average prosupination arc was 146 degrees, and restricted forearm rotation was observed in 2 patients.

CONCLUSIONS Since we modified ulnar osteotomy, good reduction of the radial head was achieved without causing serious contracture. Not only angulation but also elongation of the ulna, so as to let the radial head into a reduced position, was the key to treatment of chronic radial head dislocation.

See page 68 for more images.

FIGURE 1A

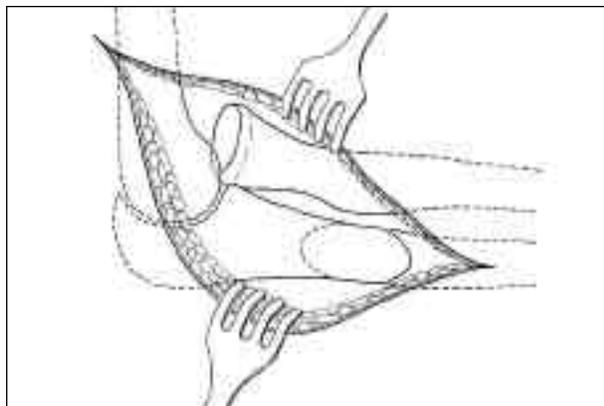
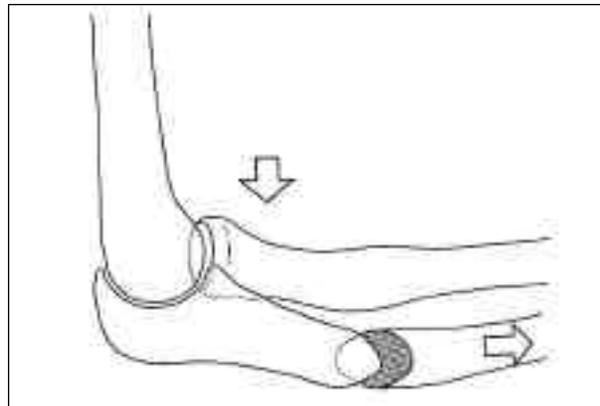


FIGURE 1B



SATURDAY, OCTOBER 5 3:15 P.M.

Session VB—Carpal Tunnel

Paper #33B (cont.)

Surgical Treatment for Chronic Radial Head Dislocation

Emiko Horii, MD, Nagoya, Japan
Ryogo Nakamura, MD, Nagoya, Japan
Shukuki Koh, MD, Nagoya, Japan
Hironobu Inagaki, MD, Nagoya, Japan

FIGURE 1C

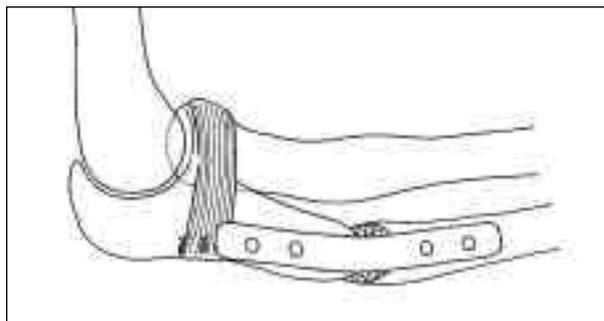


FIGURE 2B



FIGURE 2C



FIGURE 2A



FIGURE 2D



FIGURE 2E



SATURDAY, OCTOBER 5 3:21 P.M.

Session VB—Carpal Tunnel

Paper #34B

Outcome of Open Contracture Release of the Elbow

Virak Tan, MD, Newark, NJ
 Aaron Daluiski, MD, Las Vegas, NV
 Todd Melegari, MD, Newark, NJ
 Robert Hotchkiss, MD, New York, NY

INTRODUCTION Elbow contracture is a well recognized but potentially difficult problem. Previous authors have reported good success from capsular release and/or excision of heterotopic ossification. The senior author's approach to a stiff elbow is based on the concept that contracture is caused either by a soft-tissue tether or a bony block, or both. These structures can exist both anteriorly and posteriorly. The authors present a series of elbow contracture releases that entailed removing the "block" and/or "tether" to motion.

METHODS The study group consisted of fifty-two patients (52 elbows) who had elbow contracture; 34 had prior operative procedures on their elbow. All patients had open anterior and posterior capsulectomies with excision of olecranon and coronoid osteophytes, as needed. Post-operatively, the patients underwent a rehabilitation program consisting of passive motion and static splinting regimen. All 52 elbows were followed clinically for a mean of 20.4 months (range, 14–70). Comparison of pre- vs. post-operative ranges of motion was performed with the paired t-test.

RESULTS The mean preoperative limitation of extension of 48 degrees was reduced to 16 degrees ($p <$

0.0001), and the mean elbow flexion improved from 103 degrees preoperatively to 130 degrees postoperatively ($p < 0.0001$). The total arc of motion improved from a preoperative mean of 55 degrees to 114 degrees ($p < 0.0001$). Forearm supination and pronation increased by 21.2 degrees and 9.9 degrees, respectively. Fourteen patients (27%) required closed manipulation under anesthesia (MUA), post-operatively. Another 6 patients required a second contracture release for recurrence. Five patients failed due to: painful motion requiring total elbow replacement ($n=2$) or distraction arthroplasty ($n=1$), and elbow instability requiring a hinged fixator ($n=2$). Other complications included wound infection ($n=3$) and reflex sympathetic dystrophy ($n=1$).

DISCUSSION Similar to other published data, this operative approach to elbow contracture has been met with much success. However unlike previous studies, we found that a high percentage of our patients required subsequent procedures. Manipulation under anesthesia in the early post-operative period was not predictive of inferior results. Additionally, a certain subset of patients may require a second operative procedure in order to obtain and maintain the improved range of motion.

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Session VB—Carpal Tunnel

Paper #35B

Radial-Ulnar Synostosis after the Two-Incision Biceps Repair: A Standardized Treatment Protocol

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Kent Chou, MD, Pittsburgh, PA

Dean Sotereanos, MD, Pittsburgh, PA

PURPOSE To evaluate the results of a one-incision posteriolateral surgical approach with concomitant irradiation (700 rads) for early resection of synostosis after the 2-incision biceps repair.

INTRODUCTION Radial ulnar synostosis is the most common complication of the two-incision biceps repair. Thus far, only one study in the literature has described this complication and treatment thereof.

MATERIALS AND METHODS Between 1992 and 2000, 8 patients with radioulnar synostosis after a two-incision biceps repair were evaluated and treated by the senior author, with a mean age of 38 (range 29–47) years old. The mean time between tendon repair and resection of the synostosis was 8 (6–18) months. The average follow-up was at 27 (range 13–36) months. An average pronation-supination arc of 27° (range 0°–70°) was noted preoperatively. All patients underwent post-operative radiotherapy in two divided doses for a total of 700 rads.

OPERATIVE TECHNIQUE The posterolateral incision was extended and the interval between the extensor digitorum communis and the extensor carpi radialis brevis is developed to expose the supinator muscle. The posterior interosseous nerve is identified and protected. The synostosis is subperiosteally exposed through a separate interval, from the ulna to the radius. After resection, bone wax is applied over

bleeding surfaces, the wound is irrigated and the tourniquet is released to obtain excellent hemostasis. A drain is placed for 24 hours.

RESULTS At an average follow-up of 27 months, it was noted that the rotation arc of the forearm improved to 155° (range 140°–170°) with an average gain of 128 degrees. The strength of supination was 80% (range 70%–90%) of the contralateral limb. Seven of the eight patients had no pain after activities of daily living or work. One had mild pain after prolonged activity. No radiographic or clinical evidence of synostosis recurrence was noted at final follow-up.

DISCUSSION The complication most often noted after the two-incision biceps repair is radioulnar synostosis. Several articles have suggested that resection of post traumatic radioulnar synostosis can be safely performed even during nascent bone formation. Based on our results, we believe that these authors are correct in that resecting the synostosis earlier should achieve movement with less contracture of the interosseous membrane. At final follow-up, all patients were satisfied with the result of the procedure described.

CONCLUSION Based on our results we believe that resection of early radioulnar synostosis can be effectively achieved through one posteriolateral incision and postoperative radiotherapy.

SATURDAY, OCTOBER 5 3:36 P.M.

Session VB—Carpal Tunnel

Paper #36B

Are X-Rays Necessary for the Evaluation of Carpal Tunnel Syndrome?

Eric Vanderhooft, MD, Salt Lake City, UT

David Tsai, MD, Salt Lake City, UT

PURPOSE Numerous manuscripts in the hand literature have advocated routine wrist radiographs as integral to the evaluation of carpal tunnel syndrome (CTS). This places a legal imperative upon physicians and added expense to the health care system. A prospective study was undertaken to assess the value of such radiographs and determine if specific criterion may be present to guide the physician.

METHOD 272 extremities from a series of consecutive patients being evaluated for CTS were examined and radiographed. The history included questions regarding the nature of symptoms (e.g. numbness, tingling, dysesthesia, night pain, swelling), onset of symptoms, contributing or exacerbating factors, employment history, past medical history, and treatment to date. Physical examination included gross inspection, Tinel's test, Phalen's maneuver, wrist range-of-motion, intrinsic and extrinsic motor function, carpal stability assessment, reflexes, and two-point discrimination. Radiographs were obtained at the time of clinical evaluation, and read by the orthopedic hand surgeon. Prior to reading the films, the hand surgeon listed his predicted radiographic findings. Later, a fellowship-trained musculoskeletal radiologist, who was blinded to the findings of the surgeon, independently assessed the radiographs.

RESULTS Radiographs documented 67 cases of trapezial arthrosis, 15 cases of carpal instability, and

9 healed fractures. No significant case of arthrosis, instability, tumor nor fracture was demonstrated that was not predicted by the clinical evaluation of the patient. 33 insignificant morphologic anomalies were found that had not been predicted by history or physical examination, and 183 extremities had no pathologic radiographic findings. One patient was excluded from the study, as she was pregnant. The most predictive clinical parameters of radiographic pathology included pain, range of motion, and stability tests.

DISCUSSION During the year prior to the collection period, it was reported that an estimated 500,000 carpal tunnel releases were performed in the United States. The cost of routine radiographs for these patients was calculated to exceed \$50 million for that year. This does not take into account those patients who were evaluated for CTS but did not undergo surgery. As routine x-rays on all of these patients are unlikely to reveal significant pathology, such studies should not be recommended as standard of care in the evaluation of CTS. The decision to obtain radiographs should be deferred to the treating physician following an appropriate examination. Written guidelines dictating that such studies routinely be performed cannot be supported and are based on anecdotal experiences, create legal ramifications, and create added expense.

SATURDAY, OCTOBER 5 3:45 P.M.

Session VB—Carpal Tunnel

Paper #37B

Bilateral Simultaneous Open Carpal Tunnel Release: Post-operative Activities of Daily Living and Patient Satisfaction

Angela A. Wang, MD, Salt Lake City, UT

Douglas T. Hutchinson, MD, Salt Lake City, UT

Eric Vanderhooft, MD, Salt Lake City, UT

PURPOSE The purpose of this study was to determine patient satisfaction with bilateral simultaneous open carpal tunnel release. Bilateral simultaneous hand surgery is often discouraged due to concerns about the patient's post-operative management of activities of daily living, and hygiene. We gathered data on the difficulty level of several activities after surgery, as well as overall patient satisfaction with the bilateral procedure.

MATERIAL AND METHODS Thirty-nine patients who underwent bilateral simultaneous open carpal tunnel release completed a functional activity questionnaire modeled after the Brigham and Women's Hospital carpal tunnel scale (1–5), relating to their immediate post-operative status (first week after surgery) for activities of daily living and hygiene tasks. They also rated their satisfaction with the procedure on a scale 0–10, and were asked if they would have the surgery again. All patients underwent the procedure under a tourniquet with a local anesthetic, and all were placed in bilateral volar wrist splints after the surgery.

RESULTS The patients included 24 women and 15 men. The average age of the patients was 52 years (range 30–77 years). Six patients (15%) were worker's compensation patients. Thirty-six patients (92%)

had a family member or friend available to help after the surgery. Thirty-three patients (85%) stated that they needed the help. The most difficult task was opening a jar (avg. 4, range 1–5), and the easiest task was eating (avg. 1.9, range 1–4). "Severely difficult" tasks included writing, buttoning, household chores, carrying groceries, and driving. All hygiene tasks, including perineal care, averaged "moderately difficult", as did cooking. Tasks that were rated "less difficult" included using a computer, holding a book and phone, and shopping. Average return to work was 2.9 weeks (range 1 day–6 weeks). Average satisfaction with the surgery was 9.1 (range 5–10), and 37/39 patients (95%) would have or recommend the bilateral simultaneous procedure again.

DISCUSSION Patients demonstrated a high satisfaction rate (95%) with bilateral simultaneous open carpal tunnel release, and almost all would undergo the procedure again. Most patients had assistance after the surgery, however, and we would not recommend a bilateral procedure for a patient who lives alone. These data are useful for patient education and decision-making when planning a surgical procedure in a patient with bilateral carpal tunnel syndrome.

SATURDAY, OCTOBER 5 3:51 P.M.

Session VB—Carpal Tunnel

Paper #38B

A Prospective Study of the Effectiveness of Carpal Tunnel Release in Patients 65 Years or Older

Robert A. Weber, MD, Temple, TX

Malcolm J. Rude, MD, Temple, TX

BACKGROUND The effectiveness of carpal tunnel release in patients aged 65 or older is controversial. Based on evidence of declining nerve conduction velocities with age, surgery has been thought to be less effective and more morbid in older patients. In addition, numerous studies show that older patients have poorer recovery after peripheral nerve injury and repair than younger patients. As such, many surgeons feel that elderly patients do not benefit from carpal tunnel release.

METHOD This study prospectively examined patients 65 years of age or older with carpal tunnel syndrome warranting surgical release. All of the patients underwent an open carpal tunnel release through a limited palmar incision and a standardized three week postoperative protocol for wound care, exercise, and sensory reeducation. The patients' subjective and objective signs and symptoms were measured preoperatively and six months after their surgery. The subjective parameters—paresthesias, numbness, day pain, night pain, and nocturnal numbness—were assessed on a 1 to 5 scale. Scar tenderness and patient satisfaction were also recorded. The Michigan Hand Outcome Questionnaire, a validated instrument of measuring outcome, was used to determine overall hand function, activities of daily living, work performance, pain, aesthetics, and satisfaction

with hand function. The objective measurements—Tinel's sign, Phalen's sign, thenar atrophy, grip strength, pinch strength, and sensibility—were likewise measured before and after surgery. The Pressure Specified Sensory Device(tm) was utilized to determine two-point discrimination.

RESULTS Sixty-two hands in 45 patients were enrolled; the mean age was 74 ± 6 years. By patient report, paresthesias, numbness, day pain, night pain, and nocturnal numbness were each significantly reduced from severe or very severe to mild or none (each $p < 0.0001$). All but one of the Tinel's signs ($p < 0.0001$), and 100% of the Phalen's signs ($p < 0.0001$) became negative. Mean static two-point discrimination improved from 6.3 ± 1.4 mm to 4.9 ± 1.1 mm ($p < 0.0001$). Grip and pinch strength increased by 2.8 ± 17.8 lb. and 1.1 ± 5.4 lb. ($p = 0.23$ and 0.12 , respectively). The Michigan Hand Questionnaire confirmed a significant improvement in overall hand function, activities of daily living, work performance, pain, and satisfaction with hand function ($p < 0.0001$). Overall 80% of patients were either very or completely satisfied with their results.

CONCLUSIONS Patients 65 years of age or older benefit significantly from carpal tunnel release. Age alone should not be a contraindication to carpal tunnel release.

