Meeting Abstracts
Scientific Session papers
2017 Annual Meeting Abstracts

This booklet contains the abstracts for the Scientific Session papers as submitted by the authors. Abstracts are in presentation order by day and time. These abstracts are also available at www.ASSHAnnualMeeting.org.

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ABSTRACTS

PAPER 1
Best Papers
Top 6 – Thursday, September 7, 2017 • 2:00–2:05 PM
Treatment; Prognosis/Outcomes

Three-year Results of Needle Fasciotomy and Collagenase Injection in Treatment of Dupuytren’s Contracture: A Two-centre Prospective Randomized Clinical Trial
Level 2 Evidence

Peter Schermer, MD, PhD
Per Jenmalm, MD, PhD
Lars B. Dahlin, MD

Grant received from: Region Skåne

C01: There is no financial information to disclose.

Hypothesis: Is there a difference in recurrence rate between needle fasciotomy and collagenase injection three years after treatment of Dupuytren’s contracture?

Methods: Inclusion criterias in the original study1 were primary Dupuytren’s contracture, excluding the thumb, with a palpable cord and a total extension deficit from 30° to 135° with less than 60° in the proximal interphalangeal joint. The most affected ray was randomized to either treatment at two centres. The average total extension deficits before treatment were 60° or more in both groups, and were largely made up of contractures at the metacarpophalangeal joints. Follow-up at three months and one year showed no difference in the reduction of the total passive extension deficits between the treatment methods. Three years after treatment the patients were invited for re-evaluation. Rays that had been retreated or showed an increase in the total passive extension deficit from 30° or more from the three months time point were regarded as recurrences.

Results: Forty out of 46 needle fasciotomies and 36 out of 40 collagenase injections were possible to assess for recurrence. Two patients (one from each group) had died and the others who declined follow-up had not been retreated. Forty-three percent of the needle fasciotomies and 17% (16) in the collagenase group) had died and the others who declined follow-up had not been retreated.

Summary Points: No significant difference in recurrence rates between needle fasciotomy and collagenase injections three years after treatment of Dupuytren’s contracture was found.

BIBLIOGRAPHY

PAPER 2
Best Papers
Top 6 – Thursday, September 7, 2017 • 2:07–2:12 PM
Prognosis/Outcomes; Patient Education

Comparison of the Michigan Hand Outcomes Questionnaire, Boston Carpal Tunnel Questionnaire, and PROMIS Instruments in Carpal Tunnel Syndrome
Level 2 Evidence

Bilal Mahmood, MD
Chongshu Chen, MA
Xing Qiu, PhD
Susan Messing, MA, MS
Warren C. Hammert, MD

C01: There is no financial information to disclose.

Hypothesis: Patient reported outcomes (PRO) are increasingly important to assess improvement following surgery. Commonly used instruments for carpal tunnel syndrome include Michigan Hand Outcomes Questionnaire (MHQ) and Boston Carpal Tunnel Questionnaire (CTQ). These were a Grade B recommendation in the 2009 AAOS clinical practice guidelines. The Patient Reported Outcomes Measurements System (PROMIS) instruments are newer PRO designed to measure various health domains. We tested the null hypothesis that PROMIS Pain Interference (PI) and Upper Extremity (UE) scores will have similar responsiveness when compared to the MHQ and CTQ following Carpal Tunnel Release. Secondary analysis included the time to completion of each PRO instrument.

Methods: All adult patients with carpal tunnel syndrome treated surgically during the study period were asked to participate in this prospective study. The PROMIS instruments, MHQ, and CTQ were completed by 101 patients prior to surgery and postoperatively at 1-week, 6-week, and 3-month visits. Estimated mean and standard errors for each outcome measure were calculated and a piecewise linear mixed effects regression model was applied to the data.

Results: The MHQ Total Score did not show significant change from the preoperative to 1-week visit, but there was a significant improvement from the 1-week to 3-month visit (55.1 to 80.2). The CTQ Functional Status Score (FSS) worsened from 2.3 preoperatively to 2.6 at the 1-week visit before improving at the 6-week and 3-month visits (1.8 and 1.6). PROMIS Upper Extremity showed responsiveness similar to the CTQ FSS with a decline at the 1-week visit, 38.4 to 32.7, followed by increases at the 6-week and 3-month visits (41.5 and 44.8). The average administration time was shortest for PROMIS UE and longest for the MHQ.

CTQ Symptoms Severity Scale (SSS) and MHQ Pain Scores showed improvements as early as the 1-week visit. The CTQ SSS improved from 3.1 to 2.3 and MHQ Pain Scores improved from 54.9 to 45.5. The PROMIS Pain Interference Score did not change at the 1-week visit, but demonstrated improvements at 6-weeks and 3-months, from 56.5 to 52.2 and 49.3.

Summary Points: The CTQ FSS and PROMIS Upper Extremity instruments are more responsive, demonstrating both an initial decline in function 1-week postoperatively followed by improvement at the 6-week and 3-month visits, when compared to the MHQ. PROMIS Pain Interference does not show the responsiveness seen in the CTQ SSS and MHQ Pain Score.

PROMIS instruments require less time to complete.

BIBLIOGRAPHY

PAPER 3
Best Papers
Top 6 – Thursday, September 7, 2017 • 2:14–2:19 PM
Basic Science

Vein Wrapping Facilitated Basic Fibroblast Growth Factor-induced Heme Oxygenase-1 Expression in a Rat Chronic Constriction Injury Model
N/A - not a clinical study

Naoya Hiroswa, MD
Kentaro Uchida, PhD
Kenichi Murakami, MD, PhD
Kazuki Kuniyoshi, MD, PhD
Yusuke Matsuura, MD, PhD
**Methods:** Eight-week-old Wistar rats (n = 115) were randomly divided into chronic constriction injury (CCI) and CCI + vein wrapping (CCI+VW) groups. To assess the effect of vein wrapping on HO-1 expression was assessed using RT-PCR and enzyme-linked immunosorbent assays. In addition, the localization of bFGF and HO-1 expression levels in veins and the sciatic nerve using real-time PCR (RT-PCR) analysis. The effects of exogenous bFGF on heme oxygenase-1 (HO-1) expression were examined by sciatic nerve culture. The effect of vein wrapping on HO-1 expression was assessed using RT-PCR and enzyme-linked immunosorbent assays. In addition, the localization of bFGF and HO-1 in veins and the sciatic nerve, respectively, was examined by immunohistochemistry.

**Results:** Rats with vein wrapping exhibited a significant increase in withdrawal thresholds compared to untreated controls (P < 0.05). Moreover, bFGF immunoreactivity was predominantly detected in the tunica media and tunica adventitia. Exogenous bFGF enhanced HO-1 mRNA levels in sciatic nerve cells compared to untreated controls. Further, sciatic nerves of rats in the CCI+VW group had increased HO-1 mRNA and protein levels compared with those from the CCI control group. Immunohistochemical analysis revealed that HO-1 was localized to sciatic nerve bundles in the CCI+VW group.

**Summary Points:** Our results suggest that bFGF released by veins can induce HO-1 expression in sciatic nerves, which may constitute the underlying mechanism for the therapeutic benefits of vein wrapping.

**BIBLIOGRAPHY**


**PAPER 4**

**Best Papers**

**A Comparative Analysis of Resource Utilization Between Proximal Row Carpectomy and Partial Wrist Fusion: A Population Study**

Paymon Rahgozar, MD
Lin Zhong, MD, MPH
Kevin C. Chung, MD, MS

**COI:** There is no financial information to disclose.

**Hypothesis:** We conducted a population-level analysis comparing proximal row carpectomy (PRC) and partial wrist arthrodesis (PWA) for treatment of chronic wrist arthritis to (1) characterize national practice patterns, (2) determine the rate of conversion to total wrist arthrodesis (TWA), and (3) calculate the associated cost of care. Our null hypothesis is that there are no significant differences in rates of total wrist fusion between PRC and PWA, but that the total number of procedures and the cost is greater with PWA.

**Methods:** Using the Truven MarketScan databases from 2009 to 2014, we identified patients 18 years or older with a diagnosis of wrist osteoarthritis who had a PRC or PWA and were followed for 18 months, controlling for sex, income, insurance type, and comorbidity score. We used Chi-squared analysis and multivariate logistic analysis to evaluate the conversion to TWA with each procedure. Rates of repeat PWA were also obtained, including the total number of procedures until completion, and treatment cost.

**Results:** Of a total of 3,388 eligible patients, 1,305 had a PRC (39%), and 2,083 had a PWA (61%). In patients 54 years of age or younger PWA was more commonly performed compared to PRC (49% vs. 38%). TWA rates were significantly higher for patients of all ages who underwent PWA (19.2%) versus PRC (5.9%; P < 0.001), with PWA patients having four times greater odds of subsequent TWA compared to PRC (OR: 4.0, 95% CI: 2.9–5.5). Patients undergoing PWA required more total procedures compared to those who received a PRC (average 1.7 vs. 1.1) resulting in a greater average cost per patient ($11,525 vs. $7,171). (Tables 4-1 and 4-2)

**Summary Points:**

- Conversion rates to a TWA are significantly higher with a PWA (19.2%) than PRC (5.9%) for all age groups.
- Although younger patients are more often treated with PWA, high conversion rates to a TWA suggest that there may need to be a paradigm shift in this practice pattern.
- Given the significantly lower cost and fewer required procedures, PRC places less of a burden on the patient and the healthcare system.

### Table 4-1: Practice Patterns Demonstrating Number of Patients Who Had a Proximal Row Carpectomy (PRC) or Partial Wrist Arthrodesis (PWA) for Each Age Group

<table>
<thead>
<tr>
<th>Age</th>
<th>PRC</th>
<th>PWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-34</td>
<td>39%</td>
<td>6%</td>
</tr>
<tr>
<td>35-44</td>
<td>81%</td>
<td>6%</td>
</tr>
<tr>
<td>45-54</td>
<td>16%</td>
<td>37%</td>
</tr>
<tr>
<td>55-64</td>
<td>16%</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1305</td>
</tr>
</tbody>
</table>

**Table 4-2:** Eighteen Month Follow-up Comparing Those Who Had Proximal Row Carpectomy (PRC) and Partial Wrist Arthrodesis (PWA) Evaluating Final Outcome, Average Number of Procedures to Reach Final Outcome, and Average Cost

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Total Wrist Arthrodesis</th>
<th>Repeat PWA</th>
<th>Average Number of Procedures</th>
<th>Average Cost (Per Patient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRC</td>
<td>72 (5.9%)</td>
<td>N/A</td>
<td>102 (4.9%)</td>
<td>$7,171</td>
</tr>
<tr>
<td>PWA</td>
<td>1851 (75.9%)</td>
<td></td>
<td>1.7</td>
<td>$11,525</td>
</tr>
</tbody>
</table>

**PAPER 5**

**Best Papers**

**Prospective Evaluation of an Opioid Reduction Protocol in Hand Surgery**

C. Liam Dwyer, MD
Maximillian C. Soong, MD
Alice Anne Hunter, MD
Jesse Dashe, MD
Eric T. Tolo, MD
N. George Kasparian, MD, PhD

**COI:** There is no financial information to disclose.

**Hypothesis:** Written guidelines for surgeons and educational handouts for patients regarding safe and effective use of opioids after hand surgery may help to reduce prescription sizes while achieving high patient satisfaction and a low refill rate.

**Methods:** All patients undergoing isolated carpal tunnel release (CTR) or distal radius volar locked plating (VLP) in a hand surgery group practice during a 6-month period were prospectively enrolled. Surgeons prescribed postoperative analgesics at their own discretion based on written guidelines.
Patients received an educational handout regarding safe opioid use and disposal, a diary to record daily pain VAS score and consumption of both opioid and over-the-counter (OTC) analgesics, and a Pain Catastrophizing Scale (PCS) questionnaire. Collected data were compared with a retrospective cohort of the same surgeons, procedures, and time period one year earlier.

**Results:** In the CTR group (n = 121), average prescription size was 10 opioid pills (vs 22 in the prior year, P < .0001). Average consumption was 3 opioid pills, supplemented with 11 OTC pills. In the VLP group (n = 24), average prescription size was 25 opioid pills (vs 39 in the prior year, P < .0001). Average consumption was 16 opioid pills, supplemented with 20 OTC pills. Patient satisfaction was high in both groups (96% CTR, 88% VLP). Eight patients required opioid refills overall, including five prior to their first postoperative visit. Patients with PCS > 10 used more than twice as many opioid pills. Of 109 patients with leftover opioids, 10 reported disposal, a diary to record daily pain VAS score and consumption of both opioid and OTC analgesics, and a Pain Catastrophizing Scale (PCS) questionnaire. Collected data were compared with a retrospective cohort of the same surgeons, procedures, and time period one year earlier.

**Summary Points:**

- Written guidelines and educational handouts significantly reduced opioid prescription sizes by 35-55% while yielding high patient satisfaction and a low refill rate.
- In addition to encouraging OTC analgesics, we recommend 5-10 opioid pills for carpal tunnel release and 20-30 for distal radius volar plating.
- Pain catastrophizing is associated with greater opioid consumption and may help target patients for additional support.
- Potential for opioid abuse and diversion may persist despite prescription guidelines and patient education.

**BIBLIOGRAPHY**


**PAPER 6**

**Best Papers**

**Thursday, September 7, 2017**

**Treatment; Basic Science**

**Effect of Neurotropin on Peripheral Nerve Regeneration**

N/A - not a clinical study

Koji Suzuki, MD, PhD

Hiroyuki Tanaka, MD, PhD

Tsuyoshi Murase, MD, PhD

Hideki Yoshikawa, MD, PhD

COI: Contracted Research: Nippon Zoki Pharmaceutical Co., Ltd. (Suzuki)

**Hypothesis:** Effect of Neurotropin (NTP), a non-protein extract derived from inflamed skin of rabbits inoculated with vaccinia virus, on peripheral nerve regeneration has not been clarified, although its analgesic effect through activating descending pain inhibitory systems has been revealed.

In this study, to elucidate the effects of NTP on peripheral nerve regeneration, we examined nerve regeneration and functional recovery using dorsal root ganglion neurons in vitro and a rat sciatic nerve crush injury model in vivo.

**Methods:** We isolated dorsal root ganglion neurons from Wistar rats at postnatal day (P10) and cultured with NTP (1 μNU/mL = 100 mNU/mL) in vitro. We evaluated axonal length 48 h after the addition of NTP.

To investigate functional recovery and nerve regeneration, we used rat sciatic nerve crush injury model. Male Wistar rats weighing 180–220 g were used in the study. We divided into 2 groups; (1) untreated group, and (2) NTP group, where crush injury was performed and saline or NTP was administered systemically with osmotic minipump. At four weeks after the operation, motor and sensory function were evaluated by the sciatic functional index and von Frey filament test. The electrophysiological analysis was evaluated by the compound muscle action potentials, the terminal latency, and the nerve conduction velocity. For histological evaluation, the number of total axons and myelinated axons was counted and calculated the myelinated ratio.

**Results:** NTP promoted axonal outgrowth in dorsal root ganglion neurons in a concentration dependent manner and a significant difference compared to CTR at concentration of 10 mNU/mL (Fig. 6-1A, B).

Systemic administration of NTP with osmotic minipump contributed to the recovery of the sensory function (Fig. 6-2A), the nerve conduction velocity (Fig. 6-2B) and promoted myelination (Fig. 6-2C, D) after sciatic nerve injury.

**Summary Points:**

- We evaluated the effect of NTP on peripheral nerve regeneration.
- NTP promoted neurite outgrowth in a concentration dependent manner in vitro.
- Systemic administration of NTP contributed to the recovery of the sensory function, the recovery of nerve conduction velocity and terminal latency, and the promotion of myelination after sciatic nerve injury.
- NTP may be effective for not only chronic pain but also peripheral nerve regeneration.
BIBLIOGRAPHY


PAPER 7

Clinical Paper Session 1
Trauma 1 — Friday, September 8, 2017 • 8:00–8:05 AM
Evaluation/Diagnosis; Treatment

The Efficacy of Mini-C-Arm Fluoroscopy for the Closed Reduction of Distal Radius Fractures in Adults: A Randomized Controlled Trial

Level 2 Evidence

Steven K. Dailey, MD
Ashley R. Miller, MD
Rafael Kakazu, MD
John D. Wyrick, MD
Peter J. Stern, MD

COI: There is no financial information to disclose.

Hypothesis: Most distal radius (DR) fractures are initially managed with closed reduction and splint application. Mini-c-arm fluoroscopy allows for assessment of fracture reduction quality in real time. Mini-c-arm fluoroscopy for the closed reduction of pediatric forearm fractures has been shown to produce more accurate reductions with fewer reduction attempts when compared to conventional methods. No study to date has investigated mini-c-arm fluoroscopy for the reduction of DR fractures in adults. Our null hypothesis is that there will be no difference in the reduction quality of DR fractures in the emergency department (ED) when using mini-c-arm fluoroscopy compared to standard reduction techniques.

Methods: This is an IRB-approved, prospective, randomized controlled trial evaluating the efficacy of mini-C-arm fluoroscopy for the closed reduction of DR fractures in the ED of a single academic level one trauma center. Sixty consecutive adult patients with closed DR fractures requiring reduction between April 2015 and January 2017 were randomized to standard versus fluoroscopically-aided reductions. Patients with ipsilateral upper extremity fractures were excluded. All reductions were performed by orthopaedic residents implementing a standardized protocol. The primary outcome measurement was reduction quality (radial height, radial inclination, ulnar variance, and volar tilt) on post-reduction radiographs. Secondary outcome measurements included: number of reduction attempts, number of splints applied, subjective difficulty of reduction (measured on a visual analogue scale), and initial fracture management (operative versus nonoperative).

Results: Standard reductions were performed in 32 patients, and fluoroscopically-aided reductions were performed in 28 patients. There were no statistically significant differences between groups in regards to age, gender, BMI, mechanism of injury, fracture laterality, AO/OTA fracture classification, presence of an ulnar styloid fracture, or initial fracture displacement. No statistically significant differences were noted between groups on post-reduction radiographs in regards to radial height, radial inclination, ulnar variance, or volar tilt (Table 7-1). Overall reduction attempts were increased when using fluoroscopy (2.4 vs. 1.8, \( P = 0.03 \)), although the number of splints applied was not significantly different. Subjective difficulty of fracture reduction was significantly increased when utilizing fluoroscopy, compared to standard technique (5.7 vs. 4.3, \( P = 0.04 \)). The rate of operative management did not differ between groups.

Summary Points: Fluoroscopy exposes both the patient and practitioner to unnecessary radiation without enhancing reduction quality. Additionally, overall reduction attempts and subjective difficulty of reduction are increased when fluoroscopy is utilized. Therefore, mini-c-arm fluoroscopy appears unnecessary for the initial closed reduction of adult DR fractures.

<table>
<thead>
<tr>
<th>Table 7-1: Mean Post-reduction Radiographic Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Reduction</td>
</tr>
<tr>
<td>Radial Height</td>
</tr>
<tr>
<td>Radial Inclination</td>
</tr>
<tr>
<td>Ulnar Variance</td>
</tr>
<tr>
<td>Volar Tilt</td>
</tr>
</tbody>
</table>

n.s. = non-significant

BIBLIOGRAPHY


PAPER 8

Clinical Paper Session 1
Trauma 1 — Friday, September 8, 2017 • 8:07–8:12 AM
Evaluation/Diagnosis; Treatment

Predictors of Acute Carpal Tunnel Syndrome Following ORIF of Distal Radius Fractures: A Case-Control Series

Level 3 Evidence

Figure 6-2: (A) Paw-withdrawal thresholds were measured to assess mechanical sensitivity with calibrated von Frey filaments, and the ratio of ipsilateral/contralateral was calculated. (B) The values of NCV in the NTP group were significantly faster than that of the untreated group. (C) Fluorescence micrographs showing cross-sectional slices of sciatic nerves labeled for MBP (red) and NF200 (green) 4 weeks after the operation. (D) The NTP group displayed the higher ratio of myelinated axon (MBP positive axons per total axons). ** \( P < 0.01 \), *** \( P < 0.001 \) compared to the untreated group, one way analysis of variance followed by a t-test.
Radial Distraction to Stabilize Unstable Distal Radioulnar Joint During Distal Radius Fixation

Level 4 Evidence

Jung-Pan Wang, MD
Duretti T. Fufa, MD
Hui-Kuang Huang, MD

COI: There is no financial information to disclose.

Hypothesis: Established strategies to manage persistent distal radioulnar joint (DRUJ) instability following internal fixation of distal radius fractures (DRFs) include soft tissue stabilization and prolonged immobilization, both of which limit early mobilization. We hypothesized that indirect ulnar shortening by radial distraction through the fracture site would successfully stabilize the DRUJ while allowing for early mobilization without complications of nonunion or instability. Of note, through fracture distraction is not appropriate for AO type B fractures as it would result in malreduction of the articular surface.

Methods: We report on 23 patients who underwent this technique due to persistent DRUJ instability during standard volar plating of AO type A and C DRFs.Radial lengthening was achieved by distraction through the fracture site using the oblong hole of the plate until DRUJ stability was obtained (Fig. 9-1). Postoperatively, there was no immobilization of forearm rotation and a standard early mobilization rehabilitation program was initiated at two weeks. At minimum 1-year follow-up, patients were evaluated by clinical, radiographic and patient-rated outcomes.

Results: Nine of 23 patients were male. Average age was 54.5 (range 25-75). Distribution of AO fracture type was: A1 (6); A2 (6); C1 (3); C2 (8). The average distraction length was 2.2 mm (range 1.7-3.1). At average 21 month follow-up (range 12-35 months), clinical and radiographic outcomes were acceptable. In all cases, final evaluation demonstrated acceptable wrist range of motion, a stable DRUJ, and there were no cases of distal radius nonunion or re-operation. Average postoperative ulnar variance was -1.4 mm (-2.1-2.2mm). VAS was 0.78 (0-2). DASH score was 11.2 (0-29) (Table 9-1).

Summary Points: Our method of indirect ulnar shortening by distraction through DRFs site provides a simple and novel strategy for management of persistent DRUJ instability encountered during volar plating. Distraction successfully maintained DRUJ stability while allowing for standard mobilization protocol and achieved good clinical outcomes without complication of nonunion or instability. Of note, through fracture distraction is not appropriate for AO type B fractures as it would result in malreduction of the articular surface.

Figure 9-1: Radial lengthening steps.

| Table 9-1: Radiographic Results and Functional Results after Surgery (1 year) |
|---------------------------------|-----------------|
| Radiographic Results            |                 |
| Ulnar variance, mm (range)      | -1.42 (-2.1-2.2) |
| Volar tilting, deg (range)       | 7.9 (0-15)      |
| Radial inclination, deg (range)  | 23.5 (10-34)    |
| Ulnar styloid nonunion, No. (%)  | 4/19 (21%)      |
| Gap after lengthening, mm (range)| 2.2 (1.7-3.1)   |
| Union time, weeks (range)        | 12.3 (8-20)     |
| Functional Results               |                 |
| Flexion-Extension, deg (range)   | 70.1 (45-90)    |
| Extension                        | 71.2 (50-90)    |
| Pronation-Supination, deg (range)| 79.4 (60-90)    |
| Supination                       | 83.0 (65-90)    |
| Radio-lunar deviation, deg (range)| 24.8 (12-32)    |
| Ulnar deviation                  | 38.5 (25-50)    |
| QuickDASH, score (range)         | 11.2 (0-29)     |
| VAS, number (range)              | 0.78 (0-2)      |
| Grasp strength, kg (range)       | 22.9 (9-40)     |
Radial Translation Predicts Redisplacement After Closed Reduction and Casting of Distal Radius Fractures

Level 4 Evidence

Akash K. Shah, MD
Paul Tornetta, MD

COI: There is no financial information to disclose.

Hypothesis: To evaluate the influence of pre and post-reduction dorsal translation on the final position of displaced distal radius fractures treated nonoperatively in the context of other known factors.

Methods: We performed a retrospective review of prospectively collected data for 546 consecutive distal radius fractures treated at an academic level-one trauma center over a 6-year period. Patients were included if they had > 10° of dorsal tilt at presentation and were treated nonoperatively. All patients had a closed reduction performed at presentation. Minimally displaced fractures were excluded. Dorsal translation at the volar cortex was defined as a percentage of the anterior to posterior width of the bone at that level. Injury, post-reduction, and final union radiographs were assessed for dorsal tilt, ulnar variance, radial height, radial inclination, and carpal malalignment. Using SPSS software, univariate analysis was performed to determine the relationship of pre-reduction translation on post-reduction and final translation and dorsal tilt and pre-reduction dorsal tilt with post-reduction and final dorsal tilt. Univariate and multivariate analyses were performed to analyze the significance of dorsal translation, volar cortical alignment, age, and Lafontaine’s criteria in predicting each of the identified radiographic parameters at union.

Results: Of the 546 distal radius fractures screened, 171 fractures met inclusion criteria. In the univariate analysis, pre-reduction dorsal tilt did not correlate with either post-reduction or final dorsal tilt and fell out of the analysis. Pre-reduction translation did correlate with post-reduction translation but did not correlate with post-reduction dorsal tilt. Based on the univariate findings, the multivariate model included age, having ≥3 Lafontaine’s criteria, volar cortical alignment, dorsal comminution and post-reduction dorsal translation. Post-reduction translation was the most consistent predictor of final dorsal tilt (P = 0.027), ulnar variance (P = 0.003), radial inclination (P = 0.004), radial height (P < 0.001), and carpal alignment (P = 0.031). Age correlated with ulnar variance, radial inclination, and radial height. Volar cortical alignment correlated with dorsal tilt and carpal alignment at healing, and dorsal comminution correlated with final dorsal tilt. (Table 10-1)

Summary Points: In distal radius fractures treated nonoperatively, dorsal translation measured at the volar cortex on the initial lateral radiograph proved to be the strongest predictor of all radiographic factors measured, including carpal alignment at the time of union. Dorsal translation is a better predictor of final position at union than initial dorsal tilt.

Table 10-1: Multivariate Analysis at Union

<table>
<thead>
<tr>
<th>Dorsal Tilt</th>
<th>P Value</th>
<th>Ulnar Variance</th>
<th>P Value</th>
<th>Radial Inclination</th>
<th>P Value</th>
<th>Radial Height</th>
<th>P Value</th>
<th>Carpal Malalignment</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRT</td>
<td>0.027</td>
<td>PRT</td>
<td>0.003</td>
<td>PRT</td>
<td>0.004</td>
<td>PRT</td>
<td>&lt; 0.001</td>
<td>PRT</td>
<td>0.031</td>
</tr>
<tr>
<td>VH</td>
<td>0.01</td>
<td>Age</td>
<td>0.005</td>
<td>Age</td>
<td>0.004</td>
<td>Age</td>
<td>0.001</td>
<td>IAF</td>
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<tr>
<td>DC</td>
<td>0.02</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>VH</td>
<td>0.005</td>
</tr>
</tbody>
</table>

PRT = post-reduction translation; VH = volar hook; DC = dorsal comminution; IAF = intra-articular fracture

BIBLIOGRAPHY


Clinical Paper Session 1
Trauma 1 — Friday, September 8, 2017 • 8:21—8:26 AM
Treatment; Prognosis/Outcomes; Anatomy

Volar Internal Plate Fixation Versus Plaster in Displaced Extra-articular Distal Radius Fractures: A Randomized Controlled Trial

Level 2 Evidence

Marjolein A.M. Mulders, MD
Monique M.J. Walenkamp, MD, PhD
J. Carel Goslings, MD, PhD
Niels W.L. Schep, MD, PhD, MSc

COI: There is no financial information to disclose.

Hypothesis: Despite the high incidence of displaced extra-articular distal radius fractures and the substantial implications of suboptimal management, it is still unknown how these fractures should be treated. The recent years there is a trend towards open reduction and internal fixation (ORIF). However adequate randomized controlled trials addressing this topic in young adults are lacking. The purpose of this randomized controlled trial was to compare the functional outcome of open reduction and volar plate fixation versus plaster immobilization in displaced extra-articular distal radius fractures.

Methods: A prospective randomized controlled trial in patients from 18 to 75 years with an adequate reduced extra-articular distal radius fracture (AO type A2/3) was performed. The primary outcome was the functional outcome measured with the Disability of the Arm, Shoulder and Hand (DASH) questionnaire after 12 months. Secondary outcomes were functional outcome measured with the Patient-Rated Wrist Evaluation (PRWE) questionnaire, quality of life measured with the Short Form-36 (SF-36) health questionnaire, range of motion, grip strength, pain as measured on a Visual Analogue Scale (VAS), radiographic measurements, and complications. Follow-up took place at the outpatient clinic at 1, 2/3 and 6 weeks, and at 3, 6 and 12 months.

Results: A total of 90 patients were randomized to ORIF with a volar plate (47 patients) or plaster immobilization (43 patients). The median age was 59 years (IQR 46—65). Of all patients 74% were women. Median DASH scores were significantly lower in the operative group at 6 weeks (P < 0.001), and 3 (P < 0.001), 6 (P = 0.003) and 12 months (P = 0.011). The same applied for the PRWE scores and the physical component score on the SF-36. At 12 months, radial deviation, pronation, supination, dorsiflexion, palmar flexion, and grip strength were significantly lower in the non-operative group compared to the operative group. Moreover, VAS pain scores were significantly higher in the non-operative group till 3 months of follow-up (P < 0.001). After 12 months, radiological parameters were significantly worse in the non-operative group compared to the operative group. Twelve patients (28%) of the non-operative treated group had a redislocation within 6 weeks, requiring ORIF, and six patients (14%) had a symptomatic malunion for which a corrective osteotomy was performed. (Figs. 11-1, 11-2)

Summary Points:
• Displaced extra-articular distal radius fractures treated operatively have better functional outcomes as measured by the DASH and PRWE questionnaire.
• 42% of the initially non-operatively treated patients, should secondarily be treated operatively due to a redislocation or a symptomatic malunion.

Clinical Paper Session 1
Trauma 1 — Friday, September 8, 2017 • 8:28—8:33 AM
Treatment

Akash K. Shah, MD
Paul Tornetta, MD

COI: There is no financial information to disclose.

Hypothesis: To evaluate the relationship of pre-reduction translation on post-reduction and final translation and dorsal tilt and pre-reduction dorsal tilt with post-reduction and final dorsal tilt. Univariate and multivariate analyses were performed to analyze the significance of dorsal translation, volar cortical alignment, age, and Lafontaine’s criteria in predicting each of the identified radiographic parameters at union.

Results: Of the 546 distal radius fractures screened, 171 fractures met inclusion criteria. In the univariate analysis, pre-reduction dorsal tilt did not correlate with either post-reduction or final dorsal tilt and fell out of the analysis. Pre-reduction translation did correlate with post-reduction translation but did not correlate with post-reduction dorsal tilt. Based on the univariate findings, the multivariate model included age, having ≥3 Lafontaine’s criteria, volar cortical alignment, dorsal comminution and post-reduction dorsal translation. Post-reduction translation was the most consistent predictor of final dorsal tilt (P = 0.027), ulnar variance (P = 0.003), radial inclination (P = 0.004), radial height (P < 0.001), and carpal alignment (P = 0.031). Age correlated with ulnar variance, radial inclination, and radial height. Volar cortical alignment correlated with dorsal tilt and carpal alignment at healing, and dorsal comminution correlated with final dorsal tilt. (Table 10-1)

Summary Points: In distal radius fractures treated nonoperatively, dorsal translation measured at the volar cortex on the initial lateral radiograph proved to be the strongest predictor of all radiographic factors measured, including carpal alignment at the time of union. Dorsal translation is a better predictor of final position at union than initial dorsal tilt.

Table 10-1: Multivariate Analysis at Union

<table>
<thead>
<tr>
<th>Dorsal Tilt</th>
<th>P Value</th>
<th>Ulnar Variance</th>
<th>P Value</th>
<th>Radial Inclination</th>
<th>P Value</th>
<th>Radial Height</th>
<th>P Value</th>
<th>Carpal Malalignment</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRT</td>
<td>0.027</td>
<td>PRT</td>
<td>0.003</td>
<td>PRT</td>
<td>0.004</td>
<td>PRT</td>
<td>&lt; 0.001</td>
<td>PRT</td>
<td>0.031</td>
</tr>
<tr>
<td>VH</td>
<td>0.01</td>
<td>Age</td>
<td>0.005</td>
<td>Age</td>
<td>0.004</td>
<td>Age</td>
<td>0.001</td>
<td>IAF</td>
<td>0.05</td>
</tr>
<tr>
<td>DC</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VH</td>
<td>0.005</td>
</tr>
</tbody>
</table>

PRT = post-reduction translation; VH = volar hook; DC = dorsal comminution; IAF = intra-articular fracture

Methods: tematic review and meta-analysis of the literature. the treatment of distal radius fractures in elderly patients through a sys-

The purpose of this review was to assess the complications associated with

stable in small studies, synthesis may provide more accurate risk estimates.

less clear than for a younger patient. Since complication rates can be un-

Looking through different treatment strategies, complication profiles should be considered when making treatment de-

Summary Points:

- Elderly patients who underwent surgery had higher major complications than those treated conservatively.

- Given that complication rates are lower with percutaneous pinning than plating, this minimally invasive fixation may have advantages for fixation of fractures in older adults.

- With equivocal outcomes shown among different treatment strategies, complication profiles should be considered when making treatment decisions in this population.

BIBLIOGRAPHY


PAPER 12

Clinical Paper Session 1
Trauma 1 — Friday, September 8, 2017 • 8:35—8:40 AM
Treatment

Complications of Distal Radius Fractures in the Elderly: A Systematic Review and Meta-analysis

Level 4 Evidence

Paul Kooner, BSc
Rajeshwar S. Sidhu, MBBS, MS (Ortho)
Joy MacDermid, PhD
Ruby Grewal, MD

COI: There is no financial information to disclose.

Hypothesis: Optimal treatment for elderly patients with distal radius fractures has remained controversial as the benefits and risks of surgical fixation are less clear than for a younger patient. Since complication rates can be unstable in small studies, synthesis may provide more accurate risk estimates. The purpose of this review was to assess the complications associated with the treatment of distal radius fractures in elderly patients through a systematic review and meta-analysis of the literature.

Methods: A systematic review of the literature was conducted using the PubMed, Medline, and Cochrane databases to search for studies that satisfied predetermined inclusion and exclusion criteria. We compared the complications associated with each specific DRF treatment option. A validated complication checklist was used to grade the severity of each reported complication. The Structured Effectiveness Quality Evaluation Scale (SEQES) and the Sackett level of evidence scale was used to critically appraise the included studies.

Results: We identified 1,229 articles in the primary search, and 33 studies for full text evaluation. Based on our inclusion/exclusion criteria 20 studies were included for analysis. Sackett level of evidence (LOE) studies included were: 3 level one, 6 level two, 2 level three and 9 level four studies. There were 6 randomized control trials, 3 prospective cohorts, 2 case controls and 9 retrospective case studies identified.

The incidence of complications (i.e. requiring intervention) was significantly higher in the operative group (129/1095, 11.8%) versus the non-operative group (40/483, 8.3%) (P = 0.008). External fixation (51/227, 22.5%) had significantly higher complication rates when compared to other fixation methods except dorsal plating (3/15, 20%). Percutaneous pinning (1/83, 1.2%) had significantly lower major complications compared to volar locked plating (VLP) (14/86, 16.3%). Furthermore, percutaneous pinning (0/83, 0%) had significantly less reoperation rates when compared to the VLP group (11/86, 12.8%) (P = 0.006).

Summary Points:

- Elderly patients who underwent surgery had higher major complications than those treated conservatively.

- Given that complication rates are lower with percutaneous pinning than plating, this minimally invasive fixation may have advantages for fixation of fractures in older adults.

- With equivocal outcomes shown among different treatment strategies, complication profiles should be considered when making treatment decisions in this population.

BIBLIOGRAPHY

Hypothesis: Existing robotic hand prostheses do not provide true motor dexterity or naturalistic sensory feedback. We have designed a system to provide independent digit control and physiologically congruent sensory feedback to amputees using robotic hands. As part of the DARPA HAPTIIX program (see reference), we are using microsurgical fascicular targeting (FAST) to guide LIFE (longitudinal intrafascicular) electrode placement into the two discrete nerve bundles (i.e., fascicles) within the ulnar nerve. We hypothesize that using FAST-placement of LIFE electrodes will allow us to a) obtain motor signals encoding individual digit motions, and b) provide sensory feedback for touch and proprioception. Proprioception is of special interest to our team, as the ability to communicate a sense of “body position” would add an enormous new capability to the prosthetic rehabilitation of upper limb amputees. This work will catalyze several key areas of research on the dexterous control of prosthetic hands.

Methods: FAST surgical targeting of LIFE electrodes was performed in rat, near-human primate (NHP), and human peripheral nerve chronic implantation models. In human subjects, one LIFE electrode was placed in the ulnar motor fascicle (blue, Fig. 13-1), which carries nerve signals to and from the intrinsic hand muscles; and one in the ulnar sensory fascicle (green, Fig. 13-1), which relays tactile and motion feedback from the hand. Electrodes were examined for functional specificity; electrical performance including signal/noise ratio, impedances, stimulation thresholds; and anatomical stability over the duration of the implantation period. In human subjects, analysis included behavioral tasks with and without tactile vs. proprioceptive stimulation.

Results: Improved functional specificity, stable signal/noise ratio, and durable electrode performance has been demonstrated using FAST-LIFE interfacing in a chronic rat sciatic nerve model. In the NHP upper limb model, which includes FAST-LIFE electrodes in the median and ulnar nerves and penetrating electrode arrays within the primary sensory cortex of the brain, multiple sensory submodalities are available upon peripheral nerve stimulation and single unit motor control signals can be recorded using FAST-LIFE electrodes. Human experiments have demonstrated stable sensory and motor interfacing for ≥6 weeks, with tactile and proprioceptive submodality specificity and preliminary findings of distinct neural data specific to individual digit motor activation.

Summary Points:
• FAST implantation of LIFE electrodes provides specific access to tactile and proprioceptive sensory submodalities
• Implanted electrodes maintain stable electrical and physiologic performance over time
• Preliminary findings indicate that individual digit motor control of robotic upper limb prostheses is feasible

Figure 13-1: FAST surgical targeting of LIFE electrodes in human subjects.

BIBLIOGRAPHY

Clinical Paper Session 2
Nerve 1 – Friday, September 8, 2017 • 8:49–8:54 AM
Evaluation/Diagnosis; Anatomy

False Positive Rates of Electrodiagnostic Studies Compared to Ultrasound Examination for Carpal Tunnel Syndrome
Level 4 Evidence

Tiffany J. Pan, MD
Kevin Byrne, BA
John Fowler, MD

COI: There is no financial information to disclose.

Hypothesis: A false positive rate between 15-46% has been reported for electrodiagnostic studies (EDX) but a false positive rate has not been established for ultrasound of the median nerve (US) as a confirmatory test for carpal tunnel syndrome (CTS). The purpose of the study is to determine the rate of false positives for EDX and US in an asymptomatic population. We hypothesized that US would have a lower false positive rate than EDX.

Methods: Patients undergoing EDX for a non-carpal tunnel diagnosis were recruited from the upper extremity clinics at a single institution. Administration of the CTS-6 questionnaire, a validated clinical diagnostic tool for CTS, confirmed that only subjects with no signs or symptoms of CTS (score of “zero”) were included. Ultrasound was performed using a 13-6 MHz linear array transducer and the cross-sectional area (CSA) of the median nerve was measured at the level of the pisiform by a fellowship trained hand surgeon. EDX was performed by a blinded electrodiagnostic technician according to the standards of the American Association of Neuromuscular and Electrodiagnostic Medicine. A CSA of ≥ 10 mm² on US was considered positive and distal sensory latency (DSL) was ≥ 3.2 ms and/or distal motor latency (DML) was ≥ 4.2 ms was considered positive for EDX. A positive result on either exam despite a CTS-6 of zero was considered a false positive. Statistical analysis was performed to calculate the false positive rate of each study.

Results: Currently, 28 hands with no clinical signs and symptoms of CTS have been included in this study. US CSA was positive in 7 (25%) and EDX was positive in 10 (36%), (P = 0.26). Overall, mean US CSA was 8.2 mm², mean DML was 3.7 ms, and mean DSL was 2.7 ms. In hands with a false positive test, mean US CSA was 11.6 mm², mean DML was 4.5 ms, and mean DSL was 3.9 ms. Of the hands with a false positive test, 5 of 12 (42%) had false positive results on both EDX and US testing.

Summary Points:
• There is no significant difference in the rate of false positive results for carpal tunnel syndrome between EDX and US in asymptomatic patients
• It is concerning that our “best” confirmatory tests are positive in 25-36% of patients with no clinical signs and symptoms of CTS
• Nearly half of patients who had at least one false positive result tested positive on both examinations. Some may argue that these patients have “subclinical” disease

BIBLIOGRAPHY

Prevalence and Clinical Manifestations of the Anconeus Epitrochlearis and Cubital Tunnel Syndrome
Level 4 Evidence

PAPER 14

Clinical Paper Session 2
Nerve 1 – Friday, September 8, 2017 • 8:56–9:01 AM
Treatment; Prognosis/Outcomes; Anatomy

PAPER 15
Consulting Fee: Biomet (Lee)

COI: There is no financial information to disclose.

Hypothesis: Patient satisfaction and time to return to unrestricted activity following simultaneous bilateral carpal and cubital tunnel releases is equivalent to that of unilateral release

Methods: A series of consecutive patients who underwent simultaneous bilateral carpal and cubital tunnel (quadruple) releases were compared to a second group of patients who underwent other combinations of carpal and cubital releases, unilateral or bilateral, simultaneous or staged during the same period. All patients were queried regarding satisfaction with the procedures, willingness, in retrospect, to make the same choice regarding bilateral simultaneous releases, and the time needed to return to full unrestricted activity. A total of 437 patients who had undergone surgery were contacted and 355 of those responded to the questionnaires. 30 patients had had simultaneous quadruple release, and 13 had staged quadruple release. 12 had three simultaneous releases. 122 had unilateral carpal and cubital tunnel (dual) releases and 13 had bilateral staged single tunnel releases. 165 had a single tunnel release. We used Wilcoxon / Kruskal-Wallis Tests for statistical analysis and set significance at $P < 0.05$. Satisfaction was rated using the following scale: Very Satisfied (1), Someewhat satisfied (2), Somewhat dissatisfied (3), Very Dissatisfied (4). Willingness to make the same choice was rated as Yes (1) and No (2). In staged groups, the time to return to work was summed for both stages.

Results: The satisfaction scores for the simultaneous quadruple group averaged 1.17 compared to 1.51 to all other groups pooled together, with a $P = 0.31$. The willingness to make the same choice in the future scores averaged 1.04 for the simultaneous quadruple group compared to 1.11 for all other groups combined, with $P = 0.31$. The time to return to unrestricted use was 28.9 days for the simultaneous quadruple group, 50.3 for the staged quadruple group, 37.8 for the unilateral dual group, and 42.3 days for the bilateral staged single tunnel group. We could not find statistical significance when comparing simultaneous quadruple group to all other groups combined ($P = 0.07$). With individual group analysis, we reached significance when comparing the simultaneous quadruple group with staged quadruple group ($P = 0.04$).

Figure 15-2: Medial elbow after release of the anconeous epitrochlearis.
**Summary Points:**
- Patients with bilateral carpal and cubital tunnel syndromes who elect to undergo simultaneous quadruple releases are satisfied with their choice and have decreased time to return to unrestricted activity compared to staged releases.

**BIBLIOGRAPHY**


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**PAPER 17**

**Clinical Paper Session 2**
Nerve 1 — Friday, September 8, 2017 • 9:10—9:15 AM
Treatment; Surgical Technique; Basic Science

**Effect of Reverse End-to-Side Neurotization in Long Processed Acellular Nerve Graft in a Rat Model**

N/A - not a clinical study

Jonathan Isaacs, MD
Satya Mallu, MD
Guarang Patel, BS
Obi Ugwu-Oju, MD
Anish Desai, BS

Grant support received from: American Foundation for Surgery of the Hand

**Hypothesis:** Processed acellular nerve allograft (PNA) has been propounded as an effective and convenient tool for overcoming short and medium nerve defects encountered during nerve repair. Though the clinical implications are unclear, animal data suggests that PNA becomes less effective at longer rates presumably due at least in part to Schwann cell senescence. Though reverse or “supercharging” end-to-side nerve transfer has been shown to improve the neurotrophic potential in chronically denervated nerve tissue, the application of this strategy onto long acellular nerve allograft has not been previously investigated. We hypothesized that supercharging acellular nerve allograft would increase its effective length in supporting regenerating axons.

**Methods:** Sprague-Dawley and transgenic fluorescent protein (Thy1-green fluorescent protein) expressing rats in which axons appeared fluorescent green (under a fluorescence-enabled microscope) Sprague-Dawley rats underwent transection of the tibial nerve, followed by immediate repair with 20 mm, 40 mm, or 60 mm acellular nerve allografts using the same process as commercially available human acellular nerve allograft (AxoGen, Inc., Alachua, FL) or isograft. Half of the allograft group were supercharged with a reverse end-to-side repair from the ipsilateral peroneal nerve.

At 10 weeks, the sciatic nerve and grafts in the Thy1-green fluorescent rat groups were exposed and examined under fluorescence-enabled microscopes. At 20 weeks, the remaining rats underwent motor testing and tissue harvest for morphologic examination.

**Results:** One-Way ANOVA with Tukey’s Post-hoc testing was done to measure statistical significance between groups per gap size, comparing muscle mass and measured developed force.

Supercharging had a positive impact on the measured developed force in all gap sizes, but only showed significance in the 20 mm gap. Additionally, supercharging allograft helped retain more muscle mass than not-supercharging PNAS for nerve repair, but did not reach statistical significance (Fig. 17-1).

**Summary Points:**
- Reverse end-to-side nerve transfer supports axon regeneration with processed acellular nerve allograft in regards to developed force and muscle mass.
- These results show promise in the use of allograft for nerve defects, with possible benefit from supercharging with grafting during acute nerve repair.

This research was supported by a Basic Science Grant from the American Foundation for Surgery of the Hand.

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**PAPER 18**

**Clinical Paper Session 2**
Nerve 1 — Friday, September 8, 2017 • 9:17—9:22 AM
Treatment; Basic Science

**Protective Effect of Biodegradable Nerve Conduit Against Peripheral Nerve Adhesion After Neurolysis**

N/A - not a clinical study

Kosuke Shintani, MD
Takuya Uemura, MD, PhD
Takuya Yokoi, MD
Ema Onode, MD
Mitsuhiro Okada, MD, PhD
Hiroaki Nakamura, MD, PhD

**COI:** There is no financial information to disclose.

**Hypothesis:** Peripheral nerve adhesion caused by extraneural and intraneural scar formation after neurolysis leads to nerve dysfunction. We previously developed a novel very flexible biodegradable nerve conduit composed of poly(L-lactide) and poly(e-caprolactone) for use in peripheral nerve regeneration. In the present study, we investigated the effect of protective wrapping of nerves using this nerve conduit on preventing adhesion in a rat sciatic nerve adhesion model.

**Methods:** Rat sciatic nerves were randomly assigned to one of the following three groups: the no-adhesion group, which involved neurolysis alone without an adhesion procedure; the adhesion group, in which the adhesion procedure was performed after neurolysis, but no treatment was subsequently administered; and the nerve wrap group, in which the adhesion procedure was performed after neurolysis and protective nerve wrapping was then performed with the nerve conduit. Six weeks postoperatively, we evaluated the extent of scar formation using adhesion scores and biomechanical and histological examinations and assessed nerve function with electrophysiological examination and gastrocnemius muscle weight measurement. (Figs. 18-1, 18-2)

**Results:** In the adhesion group, prominent scar tissue surrounded the nerve and strongly adhered to the nerve biomechanically and histologically. The motor nerve conduction velocity and gastrocnemius muscle weight were the lowest in this group. Conversely, the adhesion scores were significantly lower, motor nerve conduction velocity was significantly higher, and gastrocnemius muscle weight was significantly higher in the nerve wrap group than in the adhesion group. Additionally, the biomechanical breaking strength was significantly lower in the nerve wrap group than in the
adhesion group. The morphological properties of axons in the nerve wrap group were preserved. The intraneural macrophage invasion as assessed by the number of CD68-positive cells was less severe in the nerve wrap group than in the adhesion group.

Summary Points:
- Extraneural and intraneural scarring is established during the wound healing process, leading to adhesion of the nerve.
- The nerve conduit prevented neurolysed peripheral nerves from developing adhesion and allowed them to maintain their nerve function because it effectively blocked scarring and prevented adhesion-related damage in the peripheral nerves.

**Figure 18-1:** Representative histological section of the sciatic nerve and neural bed with Masson's trichrome staining.

**Figure 18-2:** The biodegradable nerve conduit. Gross appearance of the flexible nerve conduit.

BIBLIOGRAPHY
Arthroscopic Diagnosis of the Triangular Fibrocartilage Complex Foveal Tear: A Cadaver Assessment

N/A - not a clinical study

Samir K. Trehan, MD
Lindley Wall, MD
Ryan P. Calfee, MD
Tony Shen, BS
Charles A. Goldfarb, MD

Grant received from: Arthrex (2016)

**COI:** There is no financial information to disclose.

**Hypothesis:** We hypothesized that the arthroscopic hook test would be accurate and reliable diagnostic test for foveal triangular fibrocartilage complex (TFCC) detachment.

**Methods:** Wrist arthroscopy was performed on 14 cadaveric upper extremities amputated at the mid-humerus level. Arthroscopic hook and trampoline tests were performed, graded as either positive or negative, and arthroscopic videos recorded (“baseline” condition). The deep foveal attachment of the TFCC was then detached through a small ulnar incision with a beaver blade (“foveal detachment” condition). The hook and trampoline tests were repeated and videos recorded. The foveal detachment was then repaired via an ulnar tunnel technique and the arthroscopic hook test was repeated (“repair” condition). In total, five videos were recorded for each of the 14 specimens (ie, 70 videos). Two weeks after cadaveric testing, three fellowship-trained hand surgeons independently reviewed the videos in a randomized blinded fashion and graded the trampoline and hook tests. Comparisons of proportions of categorical variables were performed via two-tailed Fisher’s Exact test. Inter-rater reliability was assessed via Cohen’s Kappa coefficient.

**Results:** Randomized blinded video review demonstrated that 14% (6/42) of hook tests were graded as positive at baseline versus 95% (40/42) after foveal detachment ($P < 0.01$). On the other hand, 29% (12/42) of trampoline tests were graded as positive at baseline versus 29% (12/42) after foveal detachment. There was 96% (27/28) agreement amongst all three reviewers for the hook test with an inter-observer reliability graded as very good (Cohen’s Kappa, 0.95) among baseline and foveal detachment videos. In contrast, the trampoline test had only 71% (20/28) agreement between the three reviewers with an inter-observer reliability graded as moderate (Cohen’s Kappa 0.48). Finally, following ulnar tunnel repair, 24% (10/42) of hook tests were graded as positive, which was significantly decreased versus foveal detachment (95% positive) ($P < 0.01$), but not significantly different than baseline (14% positive).

**Summary Points:**
- The arthroscopic hook test is an accurate and reliable test for the diagnosis of foveal TFCC detachment with very good inter-observer reliability.
- The trampoline test has only moderate inter-observer reliability for the diagnosis of foveal TFCC detachment.
- TFCC foveal repair using an ulnar tunnel technique leads to normalization of the hook test to baseline.

**BIBLIOGRAPHY**


Hypothesis: The Aptis total DRUJ prosthesis is a semi-constrained implant designed for treatment of DRUJ arthritis and instability. There are limited published studies assessing outcomes of patients undergoing the Aptis total DRUJ arthroplasty, with reports of favorable outcomes with 95% or greater 5-year survival rates.1,2 The purpose of this study is to analyze short-term complications of the Aptis total DRUJ prosthesis.

Methods: A retrospective chart review of patients undergoing Aptis DRUJ arthroplasty from 2007-2015 at a single institution was performed. Patient demographics including gender, age, etiology of injury, occupation, and prior surgical procedures were collected. Records were analyzed for complications and need for subsequent surgical procedures. Radiographs were evaluated for radiographic evidence of implant loosening, periprosthetic fracture, and heterotopic ossification.

Results: Fifty-one Aptis DRUJ arthroplasties were performed over eight years by two hand surgeons at one institution. Twenty-two complications necessitating operative management occurred in 18 of 51 patients (35%). A total of 32 procedures were undertaken to address these complications (Table 22-1). Complications requiring revision surgery included 5 periprosthetic fractures (Fig. 22-1), 3 infections, 2 implant component failures, 2 instances of aseptic loosening, and 2 cases of heterotopic ossification at the DRUJ. Five of the 51 implants (10%) were explanted with three (6%) removed due to infection.

Summary Points:
- Complications of Aptis DRUJ arthroplasty are common, with 35% (18/51) of cases requiring additional surgical procedures.
- The most common complications were periprosthetic fractures, infections necessitating explant, neuromas, and elbow pain from increased forearm motion.
- Demographics including age, smoking, etiology of injury, worker’s compensation, and number of prior procedures did not have a significant impact on rate of complications.
- There is a need for prospective studies on functional outcomes in this patient population.

Table 22-1: Procedures Performed after Replacement of DRUJ — Related to Complications

| Revision of Aptis Components | Explant | Simultaneous explant and revision arthroplasty | Delayed revision arthroplasty | Poly exchange | Revision for screw failure | Revision for aseptic loosening of screws and radial peg | ORIF for periprosthetic fracture | Repair of distal radius nonunion | I&D | Neuma excision | Dorsal cutaneous branch ulnar nerve | PIN neuroectomy | Tenolysis | EDC tenolysis | Extensor tenolysis with ECU transposition | Excision of ectopic bone DRUJ | Elbow procedures | HO excision of joint capsule | Radial head arthroplasty | Revision radial head arthroplasty | Manipulation under anesthesia | Creation of a one bone forearm |
|-----------------------------|---------|---------------------------------------------|-------------------------------|---------------|--------------------------|-------------------------------------------------|--------------------------------|-------------------------------|-----|-----------------|-------------------------------|------------------|----------|----------------|---------------------------------|-----------------|-----------------|---------------------|--------------------------|-----------------------------|------------------------|
| Revision of Aptis Components | Explant | Simultaneous explant and revision arthroplasty | Delayed revision arthroplasty | Poly exchange | Revision for screw failure | Revision for aseptic loosening of screws and radial peg | ORIF for periprosthetic fracture | Repair of distal radius nonunion | I&D | Neuma excision | Dorsal cutaneous branch ulnar nerve | PIN neuroectomy | Tenolysis | EDC tenolysis | Extensor tenolysis with ECU transposition | Excision of ectopic bone DRUJ | Elbow procedures | HO excision of joint capsule | Radial head arthroplasty | Revision radial head arthroplasty | Manipulation under anesthesia | Creation of a one bone forearm |

Figure 21-1: A 45-year-old man with stage IIIA disease. (A) Poster- oanterior radiograph. (B) Preoperative wrist bone scan.

Figure 21-2: (A) Bone scan at 5-months post-operatively, showing increased signal in the carpus. (B) Posteroanterior radiographs 12 years after surgery. The patient has no pain and excellent clinical outcome, according to the modified Mayo score.

BIBLIOGRAPHY


S14
Results: We performed 46 Aptis DRUJ implant arthroplasties in 45 patients. Average patient age was 47.9 years. Arthroplasties were performed for chronic pain and instability, post traumatic arthrosis, and DRUJ deformity in 28, 16, and 6 patients, respectively. Average duration of follow-up was 24.2 ± 3.1 months. 42 patients underwent multiple operations prior to DRUJ arthroplasty (mean 2.6 ± 0.4 previous operations). Multiple previous scars were noted in 88% of patients. Post-operative grip strength ($P < 0.05$) and VAS pain scores ($P < 0.01$) were significantly improved following DRUJ arthroplasty. 10 operations were required to address complications in 5 patients: 4 hardware complications, 4 extensor tenosynovectomy or tenolysis, 1 painful scar revision with fat grafting, and 1 implant removal. Wound healing problems, including soft tissue necrosis, hematoma, seroma, and wound dehiscence occurred in 8 patients. Extensor tendinitis or tendinopathy was reported in 4 patients. Wound-related complications were significantly increased in patients with a history of rheumatoid arthritis or immunosuppression. (Table 23-1)

Summary Points:
- Distal radioulnar joint arthrosis is a significant problem, and patients commonly undergo multiple reconstructive surgeries prior to DRUJ implant arthroplasty.
- No instances of wound-related complications or tendinopathy occurred in patients without a history of previous surgeries or scars; and occurred in a higher frequency with a history of rheumatoid arthritis or immunosuppression.
- Despite soft-tissue complications, overall satisfaction rates are high with DRUJ implant arthroplasty.

Table 23-1: Patient and Operative Characteristics

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Patients (#)</th>
<th>Wrist (#)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Mean years ± SEM)</td>
<td>47.9 ± 2.3</td>
<td>46</td>
</tr>
<tr>
<td>Male (%)</td>
<td>32.0%</td>
<td></td>
</tr>
<tr>
<td>Hand Dominance (% Right)</td>
<td>50.2%</td>
<td></td>
</tr>
<tr>
<td>Laterality (% Right)</td>
<td>91.2%</td>
<td></td>
</tr>
<tr>
<td>Duration of Symptoms (Mean years ± SEM)</td>
<td>6.2 ± 1.0</td>
<td></td>
</tr>
</tbody>
</table>

Co-Morbidities

| Diabetes (%) | 0.0% |
| Rheumatoid Arthritis (%) | 17.6% |
| Smoking (%) | 11.7% |
| BMI > 30 (%) | 44.1% |
| History of Previous Surgery | 88.2% |
| Number of Previous Surgeries (Mean ± SEM) | 2.6 ± 0.4 |

Pre-Operative Function

| Flexion | 45.5 ± 4.2 |
| Extension | 46.8 ± 4.7 |
| Pronation | 68.9 ± 3.6 |
| Supination | 66.2 ± 3.8 |
| Grip (kg) | 16.2 ± 1.8 |
| VAS Pain Score | 6.7 ± 0.7 |

Post-Operative Function

| Flexion | 52.7 ± 3.6 |
| Extension | 52.3 ± 3.8 |
| Pronation | 73.2 ± 2.4 |
| Supination | 69.2 ± 2.8 |
| Grip (kg) | 20.4 ± 3.1 |
| VAS Pain Score | 1.3 ± 0.5 |

PAPER 24

Clinical Paper Session 3

Wrist — Friday, September 8, 2017 • 9:59—10:04 AM

Treatment; Surgical Technique; Prognosis/Outcomes

Four-Corner Fusion in SLAC & SNAC Wrist: Does Method of Fixation Really Make A Difference?

Level 4 Evidence

Logan McGinn, MD

COI: There is no financial information to disclose.

Hypothesis: Four-corner fusion (4CF) has traditionally been reported to have a higher complication rate with similar functional outcomes as the PRC. To date, there have been limited comparisons that specifically focus on whether the fusion method utilized in 4CF affects functional outcomes and complication rates. In this study, we explored the differences in outcomes of two different fixation methods in 4CF and how these compare to traditionally reported 4CF outcomes in the literature.
Methods: A retrospective chart review was conducted to compare headless compression screw (HCSF) versus staple fixation (SF) in four-corner fusion for SLAC or SNAC wrist in a single surgeon’s practice over a ten-year period. Primary functional outcomes included pre- versus post-operative flexion-extension arc and grip strength, complication rate and time to fusion. Two-tailed T-tests were used to compare the outcomes of HCSF and SF methods. The Chi-squared test was used to evaluate the complication rates associated with each method.

Results: Sixty-four patients were identified; 38 patients were treated with HCSF and 26 with SF. The majority of patients were male (84%) with an average age of 60.2 years and 52.9 in the HCSF & SF groups, respectively. Patients were followed on average for a 10-month period. HCSF patients had improved flexion arc post-operatively (108% of pre-operative arc), whereas SF patients lost an average of 30.4% of their pre-operative range (P-value: 0.00003). Grip-strength was improved in both groups. A statistically significant higher complication rate was associated with SF (50%) versus HCSF (13.2%). Hardware irritation/pain (6), delayed union (4) and nonunion (1) were the most common complications of SF, whereas superficial (2) and hardware failure (2) were the most common complications associated with HCSF. The higher complication rate and equivocal functional outcomes traditionally reported for 4CF may be associated with specific fixation methods such as the SF.

Summary Points:
- 4CF patients treated with headless compression screw fixation have better arc of motion and a lower complication rate than those treated with staple fixation.
- Various fixation methods are available for 4CF, however functional outcomes and complication rates are inconsistent among these methods.
- Although 4CF is reported to have a higher complication rate than PRC in the literature, various fixation options are available and may be a key factor contributing to this discrepancy.

BIBLIOGRAPHY


PAPER 25

Clinical Paper Session 3
Wrist — Friday, September 8, 2017 10:06—10:11 AM
Prognosis/Outcomes; Anatomy; Basic Science

Four-corner Carpal Kinematics with Type 1 and 2 Lunates

Morphology

Level 4 Evidence

Shingo Abe, MD
Hisao Moritomo, MD, PhD
Kunihiro Oka, MD, PhD
Atsuo Shigi, MD
Hiroyuki Tanaka, MD, PhD
Tsuyoshi Murase, MD, PhD

COI: There is no financial information to disclose.

Hypothesis: Some wrist joint motions are known to be related to lunate morphology, but the “four-corner” kinematics of the wrist joint (joints between the lunate, capitate, hamate, and triquetrum) of type 1 and 2 lunates has not been clarified. This study aimed to describe the differences of four-corner carpal kinematics in wrists with type 1 and 2 lunates.

Methods: Three-dimensional (3-D) analysis of 15 instances of wrist motion—extension (9 type 1 and 6 type 2), 13 of radial-ulnar deviation (7 type 1 and 6 type 2), and 12 of dart-throwing motion (6 type 1 and 2 each) by normal participants was performed. A surface registration technique was used to convert computed tomography scan data from 25 wrists, in two extreme positions and one neutral position each, into 3-D bone-model movies. Rotation and translation of the four-corner carpal bones were investigated in wrists with type 1 and 2 lunates. Step-off between the lunate and the triquetrum and the distance between the lunate and hamate was measured to identify lunate—triquetrum shear and lunate—hamate impaction. Differences in mean values were tested with the t-test and a significance level of < 0.05.

Results: Proximal translation of the distal lunate—triquetrum articular point of triquetrum in type 2 lunate wrists during ulnar deviation was 2.9 ± 0.7 mm, which was significantly greater than that of the type 1 lunate (1.6 ± 0.6 mm, P < 0.05). There were no significant differences in carpal bone rotations between type 1 and 2 lunates. The hamate contacted the type 2 lunate at the extremes of wrist ulnar deviation and ulnar flexion but maintained the distance from the lunate during flexion—extension motion. The distance between the type 2 lunate and the hamate was the smallest at ulnar deviation (0.4 ± 0.3 mm), followed by ulnar flexion (0.6 ± 0.3 mm). (Figs. 25-1, 25-2)

Summary Points:
- Lunate—triquetrum step-off during radioulnar deviation was greater in wrists with type 2 than in those with type 1 lunates. This may account for increased shear stress in the lunotriquetral interosseous ligament.
- Increased lunate—hamate impaction, which was observed with type 2 lunates, can be a cause of proximal hamate arthritis.
- The observations are consistent with a clinical observation that the type 2 lunate is more vulnerable to hamate arthrosis and lunotriquetral ligament tear.

Figure 25-1: Lunate-triquetrum step-off in RUD viewed from the dorsal aspect. The lunate (white model), triquetrum, radius, ulna (translucent model), and the distal luno-triquetral (L-T) articular point of the triquetrum are shown at both ulnar deviation (blue sphere) and radial deviation (red sphere). The distal L-T articular point of the triquetrum translates proximally during wrist ulnar deviation and the distance was greater in type 2 lunates (b) than in type 1 lunates (a).

Figure 25-2: The hamate motion relative to the lunate in RUD viewed from ulnar side (a). Both hamate and lunate with proximity mapping at UD position (b, c). (a) The hamate in yellow lucent model (at UD) impinge with the lunate. (b) The hamate was viewed from the proximal side. The sphere indicates the closest point to the lunate. (c) The lunate was viewed from the distal side. The sphere indicates the closest point to the hamate.

BIBLIOGRAPHY


PAPER 26
Clinical Paper Session 4
General — Friday, September 8, 2017 ● 10:13—10:18 AM
Treatment; Patient Education

Narcotic Wasting in Hand and Upper Extremity Surgery
Level 4 Evidence

Canu Goyal, MD
Joshua S. Everhart, MD, MPH
Marissa Jamieson, MD

COI: There is no financial information to disclose.

Hypothesis: Narcotic abuse and dependence has become an epidemic, and often a person’s first exposure to narcotics is with prescription medication. Narcotics are commonly prescribed after outpatient hand and upper extremity surgery, but patients’ needs for opioids may be less than what is prescribed. The purpose of this study is to report how many narcotic pills are going unused after outpatient hand and upper extremity surgery and offer evidence to support a change in prescribing patterns.

Methods: All patients undergoing hand and upper extremity surgery at a single ambulatory surgery center over a 5-month period were recruited to the study. On the first post-operative visit, patients were given a questionnaire asking number of pills used and unused, need to obtain more medications, and pain control. Demographic data and details about surgery were obtained through chart review. Multivariate regression models were used to determine the association between the baseline data and the outcomes of interest: (1) self-rated pain control < 7/10 (10 = no pain), (2) number of narcotic pills used and unused, and (3) unplanned ER visit, clinic call for pain refill, or visit to another provider.

Results: Completed questionnaires were collected on 305 patients at a mean 15.3 days post-operatively. The average age of patients was 48.7 years, the most common procedure performed was carpal tunnel release, and the mean length of procedure was 38.5 minutes. Patients were prescribed a mean of 33 narcotic pills, and a mean of 14 pills were not used. A total of 4,276 pills went unused, accounting for 44% of all prescribed narcotics. Two-hundred three patients (66%) reported having unused pills and 77% of these patients kept these pills and did not discard them. Sixty-five patients (21%) obtained additional narcotics outside of the original prescription and had a statistically significant association with Medicaid status, unemployment, baseline narcotic use, and OR time greater than 55 minutes. Independent risk factors for poor patient rated pain control (< 7/10) included unemployment, a history of psychiatric or mood disorder, and operative time greater than 55 minutes. Higher narcotic use after surgery was associated with lower age, baseline narcotic use, procedure involving bone/tendon/ligament, regional anesthesia, unemployment, and longer surgical time.

Summary Points:
• A large number of narcotic pills are going unused after outpatient hand and upper extremity surgery, and the majority of these unused narcotics are not being discarded. Using this data we can predict how many narcotics our patients require, thereby hopefully reducing narcotic wastage.

PAPER 27
Clinical Paper Session 4
General — Friday, September 8, 2017 ● 10:20—10:25 AM
Evaluation/Diagnosis; Treatment; Patient Education

Patient Perceptions and Preferences for Osteoporosis Treatment
Level 2 Evidence

Ariana N. Mora, BA
Philip Blazar, MD

COI: There is no financial information to disclose.

Hypothesis: Studies have shown poor treatment compliance in patients who are diagnosed with low bone density (LBD) and fragility fractures.1-3 This study investigated patient perceptions about evaluation, management, and willingness to pursue osteoporosis treatment.

Methods: An IRB-approved survey was prospectively administered to patients over 50 years old presenting to the hand and upper extremity clinic. The survey addressed patient history of fragility fractures and osteoporosis treatment, medication administration preferences, and willingness to start a new medication to treat or prevent LBD. ANOVA was performed to compare different fracture and bone density subgroups.

Results: Three-hundred ten patients completed surveys (61.4% female, 38.6% male; 63.4 mean age); 33.1% of these patients were currently being treated for a fracture (73% fragility, 27% non-fragility). 103 patients belonged to the no fracture control group. From medical record review, 64.0% had a history of any fracture, and 40.0% had a history of fragility fractures (wrist, shoulder, hip, or spine fracture from a fall). Fifty-four (18.9%) patients mischaracterized their fracture history saying they did/did not have a fragility fracture when the medical record showed otherwise. Dual-energy x-ray absorptiometry (DXA) results showed 22.3% had osteopenia and 2.7% had osteoporosis.

Patients reported the following: 41.7% suffered a fracture due to a fall, 48.0% had taken Vitamin D/Calcium for low bone density, 16.7% been on hormone replacement therapy, and 16.6% have taken other prescription LBD medications. Patients who had never taken low bone density medications were asked about their willingness to take LBD medications if physician-recommended. The mean response on a 0-10 scale was 7.2 ± 3.2, which was not significantly different between fracture or bone density subgroups. When asked about barriers to taking LBD medications, 88.6% said no medical provider had prescribed them; 14.8% stated they felt they were taking too many medications; 9.3% were afraid of potential side effects; 3.0% had conflicting provider recommendations; and 0.4% cited financial concerns. If prescribed a new medication, 91.3% preferred daily oral medication over monthly subcutaneous injection (2.9%) or annual intravenous infusion (5.8%).

Summary Points:
• If medically indicated, patients held a favorable opinion on taking low bone density medications (7.2 ± 3.2).
• Since 18.9% of patients mischaracterized their fragility fracture history, a thorough review of all available medical records is warranted.
• 25.0% of patients had an abnormal DXA result, but 88.6% reported that no medical provider had prescribed LBD medications.
• There remains a sizeable gap between current practice and optimal osteoporosis education and management.

BIBLIOGRAPHY
low. One of the goals of the Affordable Care Act (ACA) of January 2014 was to decrease the number of uninsured patients. Our hypothesis was that the implementation of the ACA led to a decrease in the proportion of patients undergoing hand surgery at our institution who are uninsured, and to an increase in reimbursement rates.

Methods: A review of all patients undergoing hand surgery over 8.5 years (January 2008 to June 2016) was conducted. Insurance status, amount billed and amount collected were recorded. Physician reimbursement rate was defined as amount collected divided by amount charged. Patients treated before the ACA were compared to patients treated after the ACA.

Results: 4,257 patients were analyzed. 2,601 patients underwent surgery before the ACA, and 1,656 patients after. The highest reimbursement rate was provided by workers’ compensation (57.1%), followed by private insurance (40.9%), Medicare (24.8%), Medicaid (21.9%) and uninsured patients (0%).

After the implementation of the ACA, the proportion of uninsured patients decreased significantly (15% to 6.4%, \( P < 0.001 \)), and the proportion of patients on Medicaid increased significantly (9.5% to 17.8%, \( P < 0.001 \)). The overall reimbursement rate did not change significantly after the implementation of the ACA (32.3% vs. 30.3%, \( P = 0.5 \)).

Summary Points:
- After the implementation of the ACA, there was a significant reduction in the proportion of patients undergoing hand surgery who were uninsured, and a significant increase in those on Medicaid.
- The overall physician reimbursement rate did not increase after implementation of the ACA.
- These trends should be followed over a longer time period.

BIBLIOGRAPHY


PAPER 29
Clinical Paper Session 4
General – Friday, September 8, 2017 ● 10:34–10:39 AM
Billing/Coding; Ethics/Professionalism; Residents/Fellow/Educator Resources

What Are the “Critical Portions” of Carpal Tunnel Release, Ulnar Nerve Transposition, and ORIF Distal Radius?

Method:
A 3-round Delphi process was used to achieve consensus on the critical portions of surgery. Panelists were 10 hand surgeons (7 fellowship-trained surgeons and 3 fellows). Round 1 (in-person): panelists reached consensus on steps of each procedure. Round 2 (online): panelists rated steps from 1 (not critical) to 9 (extremely critical) and provided open-ended comments. Round 3 (online): panelists received summary statistics and open-ended comments from round 2 and re-rated the steps. We operation- alized consensus as ≥ 80% rated a step using the same range: 1-3 (not critical), 4-6 (somewhat critical), 7-9 (critical).

Results:
From round 2 to round 3 the range of scores compressed, indicating greater agreement. Final round results are summarized in Figure 29-1. For CTR, panelists reached consensus that dividing the transverse carpal ligament was critical and wound closure and dressings were non-critical. There was no consensus on skin incision or division of subcutaneous tissue. For UNT, panelists reached consensus that mobilizing the ulnar nerve, preparing the transposition, transposing the nerve, and assessing the transposed nerve were critical and closure and splint/dressings were non-critical. There was no consensus on skin incision, preservation of MABC, and hemostasis. For ORIF distal radius, panelists reached consensus that fracture reduction, skeletal fixation, and fluoroscopic evaluation were critical; fracture exposure and assessment of joint stability was somewhat critical; and hemostasis, closure, and splint/dressings were non-critical. There was no consensus on whether skin incision was critical.

Summary Points:
- For all procedures, panelists reached a consensus rating for the majority of steps, but not for skin incision.
- The project provides proof of concept that a Delphi process is useful in fostering and measuring consensus on the critical portions of surgery.

Figure 29-1: Final rating ranges, medians, and statement of consensus or no consensus.
Further work is needed to address areas of disagreement and the implications of a consensus that a step is “somewhat critical.” A consensus is needed whether such areas should be eliminated through further rounds or leakage in surgical practice is appropriate.

Efforts are underway to repeat this process with additional and more diverse panelists.

BIBLIOGRAPHY


PAPER 30

Clinical Paper Session 4
General — Friday, September 8, 2017 • 10:41—10:46 AM
Treatment; Billing/Coding

Utilization and Associated Spending for Anesthesia Services During Ambulatory Hand Surgery

Sirichai Kammerndnaka, MD
Helen Huetteman, BS
Kevin C. Chung, MD, MS

Objectives: There is no financial information to disclose.

Hypothesis: We aimed to (1) describe trends of anesthesiologist-administered anesthesia services (AAS) for three common, minor hand operations, (2) investigate demographic factors associated with AAS services in low-risk patients, and (3) estimate supplementary costs incurred for potentially discretionary anesthesia administration. We hypothesized that despite the threat of bundled payment, a substantial percentage of minor procedures still employed potentially discretionary anesthesiologist-administered anesthesia services (use of a specialized anesthesia provider in patients lacking medical necessity), marking increased healthcare costs and decreased take home income for surgeons and the practice.

Methods: We performed a retrospective analysis using the Truven MarketScan database to estimate the prevalence and cost of AAS in patients who underwent carpal tunnel release, trigger finger release, or de Quervain release between January 1, 2010 and September 31, 2015. Medical necessity for anesthetic service was characterized according to the American Society of Anesthesiologists physical status classifications. Three unique predictive probability models were created to estimate an individual’s risk status for each procedure. We used the chi-squared test to determine significance between categorical variables (age, sex, region, and insurance type) and outcomes. We examined the relationship between patient risk-status and anesthetic use using multivariable regression models.

Results: Of 441,579 eligible procedures, 352,779 (80%) involved anesthesiologist-administered anesthesia services. The total proportion of estimated anesthesiologist-administered anesthesia use in low-risk patients who do not require anesthesiologist support declined over the study period (69.7% in 2010 to 65.8% in 2015; Fig. 30-1). Being female and a younger age (18-34) was significantly correlated with potentially discretionary anesthesiologist-administered anesthesia service utilization (P < 0.001). Although total payments for anesthesiologist-administered anesthesia services remained steady between 2010 and 2014, the average payment per procedure increased regardless of procedure type (from $376.8 in 2010 to $427.9 in 2015 for a carpal tunnel release operation). Approximately $133 million (83.7%) of the total payment to anesthesia providers is credited to services in low-risk patients (Table 30-1).

Summary Points:

- Although prevalence rates decreased over the study period, more than two-thirds of patients receiving AAS lacked medical necessity for a specialized anesthesia provider.
- A substantial amount of healthcare expenditure in hand surgery is attributed to potentially discretionary anesthesia service use.

Given the persistence of anesthesia services that ignore the advancement of viable, cost-saving alternatives, health reforms efforts must consider the impact and value of every facet of care individually.

Figure 30-1: Anesthesiologist-administered Anesthesia Service (AAS) Utilization, 2010-2014. Percentages indicate the proportion of the procedures per year in which AAS was utilized in low-risk patients out of the total procedure volume. Potentially discretionary use is defined as anesthesiologist-administered anesthesia services provided to low-risk patients.

Table 30-1. Comparison of Payments for Anesthesiologist-administered Anesthesia Service Utilization during Minor Hand Surgery Procedures, 2010-2015*

<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal Tunnel Release</td>
<td>Total payment for AAS (in million dollars)</td>
<td>20.4</td>
<td>21.7</td>
<td>25.2</td>
<td>19.4</td>
<td>18.7</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>Proportion of payment associated with potentially discretionary AAS, %</td>
<td>85.7%</td>
<td>84%</td>
<td>83.4%</td>
<td>84.5%</td>
<td>81%</td>
<td>82.4%</td>
</tr>
<tr>
<td></td>
<td>Average payment for AAS per procedure (dollars)</td>
<td>376.8</td>
<td>368.9</td>
<td>380.1</td>
<td>387</td>
<td>386.5</td>
<td>427.9</td>
</tr>
<tr>
<td>Trigger Finger Release</td>
<td>Total payment for AAS (in million dollars)</td>
<td>5.7</td>
<td>6.2</td>
<td>7.4</td>
<td>6.2</td>
<td>5.9</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Proportion of payment associated with potentially discretionary AAS, %</td>
<td>85.1%</td>
<td>83.5%</td>
<td>83.4%</td>
<td>84.1%</td>
<td>80.8%</td>
<td>82.1%</td>
</tr>
<tr>
<td></td>
<td>Average payment for AAS per procedure (dollars)</td>
<td>287.9</td>
<td>282.6</td>
<td>290.9</td>
<td>291.7</td>
<td>289.7</td>
<td>316.3</td>
</tr>
<tr>
<td>De Quervain Release</td>
<td>Total payment for AAS (in million dollars)</td>
<td>1.6</td>
<td>1.7</td>
<td>2.2</td>
<td>1.7</td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Proportion of payment associated with potentially discretionary AAS, %</td>
<td>87.7%</td>
<td>86.2%</td>
<td>86.9%</td>
<td>85.3%</td>
<td>85%</td>
<td>84.3%</td>
</tr>
<tr>
<td></td>
<td>Average payment for AAS per procedure (dollars)</td>
<td>380.8</td>
<td>375.3</td>
<td>394.6</td>
<td>401.5</td>
<td>386.1</td>
<td>430.9</td>
</tr>
</tbody>
</table>

*All prices adjusted to the 2015-dollar value using the consumer price index. Source: 2010-2015 Truven Health MarketScan Research Database AAS, anesthesiologist-administered anesthesia services
A Prospective Randomized Study Analyzing the Effect of Pre-Operative Opioid Counseling on Post-Operative Opioid Consumption after Hand Surgery

Level 2 Evidence

Asif Ilyas, MD
Todd Alter, BS

Methods: A prospective randomized comparison of consecutive patients scheduled to undergo CTR surgery was conducted. Patients were randomized to either receiving formal pre-operative opioid counseling or no counseling. All operations were performed with the same mini-open CTR surgical technique and the same number of opioids were prescribed post-operatively. Daily opioid pill consumption, pain levels, and any adverse reactions were recorded. Pre-study power analysis indicated that a minimum of 20 patients were needed in each group, which was achieved.

Results: On the day of surgery, patients in the group with counseling reported significantly fewer prescribed opioid pills consumed, 0.65 versus 1.50, compared to patients in the group without counseling ($P < 0.05$), while experiencing no significant difference in pain level experience. The same was found on the first postoperative day, patients in the group with counseling reported significantly fewer prescribed opioid pills consumed, 0.45 versus 1.50, compared to patients in the group without counseling ($P < 0.05$) again with no significant difference in pain level experience. In addition, patients in the group with counseling reported a significantly lower number of total pain pills consumed over the course of the study than the group without counseling, 1.40 vs. 4.20 ($P < 0.05$) (Fig. 31-1). No major adverse reactions were noted in either group.

Summary Points:
- Pre-operative opioid counseling was found to result in a significant decrease in overall opioid consumption post-operatively.
- Surgeons should consider routine pre-operative counseling of their patients to help minimize opioid use and potentially theoretical opioid abuse or diversion.
- Surgeons should also consider recommending no more than 5-10 opioids post-operatively after CTR surgery.

Figure 31-1: Postoperative pill consumption for counseling versus no counseling.
**Figure 32-1:** Pilot study results showing the diagnostic accuracy of practicing clinicians and the model on the validation dataset. The vertical axis denotes the area under the ROC curve (AUC). An AUC of .5 would be random guessing (dashed line) and an AUC of 1.0 would be a perfect predictor of the ground truth. The model achieved an AUC of .98, which is higher than any of the pilot subjects.

**Figure 32-2:** Example heatmaps produced by the model. The shading of each pixel indicates the model's confidence that the pixel is within a distal radius fracture.

---

**Table 33-1: Relative Frequency of Congenital Upper Limb Differences of Patients Enrolled in the CoULD Registry by OMT Classification Groups**

<table>
<thead>
<tr>
<th>OMT Groups</th>
<th>CoULD Total</th>
<th>&lt; 2 years</th>
<th>≥ 2 years</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Malformations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Malformations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire Limb</td>
<td>340</td>
<td>37</td>
<td>121</td>
<td>43</td>
</tr>
<tr>
<td>B. Malformations</td>
<td>440</td>
<td>49</td>
<td>251</td>
<td>63</td>
</tr>
<tr>
<td>Hand Plate</td>
<td>17</td>
<td>2</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>II. Deformations</td>
<td>113</td>
<td>12</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>III. Dysplasias</td>
<td>(n = 853)</td>
<td>(n = 372)</td>
<td>(n = 481)</td>
<td>%</td>
</tr>
<tr>
<td>IV. Syndromes</td>
<td>99</td>
<td>12</td>
<td>40</td>
<td>11</td>
</tr>
</tbody>
</table>

---

**Table 33-2: Abstract of Key Differences in Relative Frequency of Congenital Upper Limb Anomalies**

<table>
<thead>
<tr>
<th>CoULD</th>
<th>Goldfarb et al</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Malformation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. Symbrachydactyly — entire limb</td>
<td>59 7%</td>
<td>7 1%</td>
</tr>
<tr>
<td>i. Radial longitudinal deficiency</td>
<td>37 4%</td>
<td>43 7%</td>
</tr>
<tr>
<td>iv. Radialynar synostosis</td>
<td>59 7%</td>
<td>12 2%</td>
</tr>
<tr>
<td>vii. Madelung deformity</td>
<td>19 2%</td>
<td>4 0.7%</td>
</tr>
<tr>
<td>iv. Arthrogryposis</td>
<td>47 5%</td>
<td>53 9%</td>
</tr>
<tr>
<td>ii. Symbrachydactyly — hand</td>
<td>38 4%</td>
<td>41 7%</td>
</tr>
<tr>
<td>iii. Transverse deficiency — hand</td>
<td>2 0.2%</td>
<td>22 4%</td>
</tr>
<tr>
<td>ii. Camptodactyly</td>
<td>55 6%</td>
<td>21 4%</td>
</tr>
<tr>
<td>iv. Distal arthrogryposis</td>
<td>20 2%</td>
<td>5 0.8%</td>
</tr>
<tr>
<td>ix. Phalangeal synostosis</td>
<td>8 0.9%</td>
<td>0 0%</td>
</tr>
<tr>
<td>xi. Cleft hand</td>
<td>20 2%</td>
<td>32 5%</td>
</tr>
<tr>
<td>II. Deformations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Constriction ring syndrome</td>
<td>16 2%</td>
<td>29 5%</td>
</tr>
<tr>
<td>III. Dysplasias</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Osteochondromatosis</td>
<td>58 6%</td>
<td>57 10%</td>
</tr>
<tr>
<td>ii. Enchondromatosis</td>
<td>13 1%</td>
<td>2 0.3%</td>
</tr>
<tr>
<td>IV. Syndrome</td>
<td>99 12%</td>
<td>109 17%</td>
</tr>
</tbody>
</table>
Results: There were a total of 910 differences in 853 patients. Median age at enrollment was 2.9 years (IQR 0.7-8.5). Two-hundred four children (27%) had a positive family history and 241 (32%) had pregnancy-related risk factors. Three-hundred forty-seven (41%) patients had bilateral involvement. Additional orthopedic conditions were registered in 29% (213) and medical comorbidities existed in 30% (221) of subjects. According to OMT group, there were 780 malformations (86%), the majority affecting the hand plate only; 17 deformations (1.8%) and 113 dysplasias (12%). In addition 99 patients (12%) presented with a syndrome, most commonly amniotic constriction bands (Table 33-1).

Significant differences were noted in pathologies according to age. Radioulnar synostosis, Madelung deformity, congenital dislocation of the radial head and osteochondromatosis presented almost exclusively in children older than 2 years ($P \leq 0.01$); conversely polydactyly, radial longitudinal deficiency and syndactyly presented more commonly in younger patients. Compared with a cross-sectional study (1), CoULD included more pathologies of late presentation and those that do not commonly require surgical care. Similarly, when compared with a retrospective population study (2), CoULD captured more late presenting conditions but did not include the same proportion of pathologies with early surgical treatment (Table 33-2).

Summary Points:
- Congenital differences present at characteristic ages; the prospective cohort design of the CoULD registry offers the advantage of including a broad spectrum of pathologies including those of late presentation.
- This study highlights the differences in prevalence of these conditions found with different study types. CoULD identified more late-presenting and non-operative conditions such as symbrachydactyly, radioulnar synostosis, and transverse deficiency, than other study types.
- The CoULD registry will provide a more complete description of the prevalence of congenital upper limb differences presenting in a clinical environment and will offer the opportunity to better characterize this pediatric population.

BIBLIOGRAPHY

PAPER 34
Clinical Paper Session 5
Pediatrics — Friday, September 8, 2017 • 11:09—11:14 AM
Evaluation/Diagnosis; Patient Education; Ethics/Professionalism

Parenting Stress and Its Effect on Decision Making for Surgical Treatment in Mothers of Children with Congenital Hand or Foot Differences
Level 4 Evidence

Jihyeung Kim, MD
Jin Woo Park, MD
Seok Woo Hong, MD
Kee Jeong Bae, MD
Hyun Sik Gong, MD
Goo Hyun Baek, MD

COI: There is no financial information to disclose.

Hypothesis: Parenting an infant with a congenital anomaly can be burdensome and stressful. Although several studies have evaluated parenting stress in the mothers of children with congenital heart disease, a cleft lip or palate, a urogenital anomaly, or a syndromic disease, no studies have investigated parental stress in the mothers of children with congenital hand or foot differences. The main purposes of the present study were to assess the levels of parenting stress in the mothers of children with congenital hand or foot differences and to evaluate the effects of this stress on the preferred roles of mothers in surgical decision-making for their children.

Methods: This study included 89 mothers of children with polydactyly of the hand, polydactyly of the foot, a hypoplastic thumb, or macrodactyly. The parenting stress level was assessed using the Parenting Stress Index-Short Form (PSI-SF). Additionally, the mothers were requested to indicate their preferred and retrospectively perceived levels of involvement in surgical decision-making for their children using the Control Preferences Scale, which is comprised of five levels ranging from fully active to fully passive. Demographic factors that could potentially affect the mothers’ stress levels were also collected.

Results: The average PSI-SF scores of the mothers of children with polydactyly of the hand, polydactyly of the foot, a hypoplastic thumb, and macrodactyly were 73.2, 75.9, 74.1, and 72, respectively, and 15 mothers (16.9%) had a clinically significant level of stress ($\text{PSI-SF} < 90$). There was a significant congruency between the mothers’ preferred and retrospectively perceived levels of involvement in surgical decision-making. In the mothers of children with polydactyly of the foot, the PSI score was associated with the preferred role in surgical decision-making. Additionally, as the PSI score increased, the mothers preferred to be actively involved in the decision-making process.

Summary Points:
- The assessment of parenting stress levels in the mothers of children with congenital hand or foot differences can play an important role in the screening of candidates who require psychiatric treatment or support.
- The mothers of children with polydactyly of the foot who had higher levels of parenting stress preferred to have a more active role in surgical decision-making for their children.
- Thus, an evaluation of the PSI in mothers of children with congenital hand or foot differences can aid physicians to modify their style of decision-making based on the preferred role of the mother.

BIBLIOGRAPHY

PAPER 35
Clinical Paper Session 5
Pediatrics — Friday, September 8, 2017 • 11:16—11:21 AM
Evaluation/Diagnosis; Patient Education

The Epidemiology of Brachial Plexus Birth Palsy in the United States: An Analysis of Trends and Risk Factors over 16 Years
Level 4 Evidence

Christopher J. DeFrancesco, BS
Divya K. Shah, MD
Benjamin H. Rogers, BA
Apuvra S. Shah, MD, MBA
Methods: United States Healthcare Cost and Utilization Project (HCUP) in the United States has decreased since 1997.

Hypothesis: We hypothesize that the incidence of brachial plexus birth palsy (BPBP) has decreased since 1997. The database yielded a combined total of 5,564,628 sample births extrapolated to 23,385,597 population births. The incidence of BPBP has declined significantly since 1997.

Results: The database was analyzed, and the population-level incidence of BPBP was calculated for each available database year (1997, 2000, 2003, 2006, 2009, and 2012). The annual distribution of risk factors and protective factors for BPBP — including shoulder dystocia, macrosomia (> 4.5 kg birthweight), heavy for dates status, breech delivery, instrumented delivery, birth hypoxia, Cesarean delivery, and multiple gestation — was described for the general newborn population and for the study population of newborns with BPBP. Trends in the incidence of BPBP and risk factor frequency were analyzed. A multivariable logistic regression model was used to quantify the risk associated with each factor. Statistical analysis was performed with Stata® 14.2 (Statacorp; College Station, TX).

Summary Points:
- The incidence of BPBP has declined significantly since 1997.
- Shoulder dystocia remains the strongest known risk factor for BPBP.
- A large increase in Cesarean delivery rates paralleled the observed drop in BPBP incidence during the study period. However, this should not be interpreted as the only potentially causal relationship. Factors like induction and improved obstetric training could not be directly investigated here.
- The risk of BPBP increases with the number of risk factors present, but no risk factors are identified in the majority of cases.
- Prospective investigation is needed to describe new risk factors and to assess race- and gender-based disparities in disease burden.

Table 35-1: Multivariate Analysis of Brachial Plexus Birth Palsy Risk by Disease Determinants and Demographic Variables, 1997-2012

<table>
<thead>
<tr>
<th>Main Variables</th>
<th>Odds Ratio (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Factors</td>
<td></td>
</tr>
<tr>
<td>Shoulder dystocia</td>
<td>113.2 (104.9, 122.2)</td>
</tr>
<tr>
<td>Heavy-for-dates</td>
<td>8.22 (7.82, 8.66)</td>
</tr>
<tr>
<td>Macrosomia (&gt; 4.5 kg)</td>
<td>26.8 (24.0, 30.0)</td>
</tr>
<tr>
<td>Breech delivery</td>
<td>3.56 (2.11, 6.03)</td>
</tr>
<tr>
<td>Instrumented birth (Forceps- or vacuum-assisted)</td>
<td>3.05 (2.56, 3.65)</td>
</tr>
<tr>
<td>Birth hypoxia</td>
<td>3.08 (2.60, 3.64)</td>
</tr>
<tr>
<td>Protective Factors</td>
<td></td>
</tr>
<tr>
<td>Multiple gestation</td>
<td>0.45 (0.32, 0.63)</td>
</tr>
<tr>
<td>Cesarean delivery</td>
<td>0.16 (0.15, 0.18)</td>
</tr>
</tbody>
</table>

Demographic Variables Odds Ratio (95% Confidence Interval)

<table>
<thead>
<tr>
<th>Hospital Characteristics</th>
<th>Odds Ratio (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching hospital</td>
<td>1.12 (1.06, 1.20)</td>
</tr>
<tr>
<td>Patient Characteristics</td>
<td></td>
</tr>
<tr>
<td>Female sex</td>
<td>1.27 (1.22, 1.31)</td>
</tr>
<tr>
<td>Black race</td>
<td>1.88 (1.73, 2.04)</td>
</tr>
<tr>
<td>Hispanic race</td>
<td>1.35 (1.27, 1.44)</td>
</tr>
<tr>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Midwest US (States: OH, MI, IN, IL, WI, MN, IA, MO, KS, NE, SD, ND)</td>
<td>0.88 (0.79, 0.97)</td>
</tr>
<tr>
<td>West US (States: WA, MT, WY, CO, NM, AZ, UT, NV, CA, OR, HI, AK)</td>
<td>0.77 (0.70, 0.84)</td>
</tr>
</tbody>
</table>

Figure 35-1: Trends in brachial plexus birth palsy and notable risk factors.
PODCI/pain scores, although 3 of these patients remained more than 2 standard deviations below general population mean PODCI/pain scores post-treatment. The remaining 6 patients had unchanged or worse PODCI/pain scores post-treatment. Of these 9 failures, 3 underwent further intervention (2 ganglion cyst excisions, 1 TFCC repair, 1 steroid injection) with symptom relief, 3 received ongoing pain management for generalized pain syndromes, and 2 were lost to further follow-up. One additional patient underwent successful arthroscopic debridement after incomplete pain relief despite improved grip strength. No pre-treatment variables were identified that predicted outcomes of grip strengthening.

**Summary Points:**
- Grip strengthening relieves pain and improves function in the majority of adolescents with chronic, nonspecific wrist pain.
- Systematic use of this protocol can help to identify the minority of patients who require further intervention.

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**PAPER 37**

Clinical Paper Session 5  
Pediatrics — Friday, September 8, 2017 • 11:30–11:35 AM  
Evaluation/Diagnosis; Treatment; Prognosis/Outcomes

**Thirty-Five Year Clinical and Radiographic Follow-up of Preaxial Polydactyly Reconstruction**

Level 4 Evidence

J. Joseph Gholson, MD  
Joseph A. Buckwalter, V, MD  
Apurva S. Shah, MD, MBA

Grant support received from: American Foundation for Surgery of the Hand  
COI: There is no financial information to disclose.

**Hypothesis:** The long-term clinical and radiographic results of preaxial polydactyly reconstruction are unknown. We hypothesize that patients will have functional limitations as adults, weakness in pinch strength and side pinch strength, decreased range of motion, and development of same segment arthritis.

**Methods:** Patients having preaxial polydactyly reconstruction at our institution 15-60 years ago were asked to complete patient reported outcomes measures including the DASH and the PROMIS Upper Extremity Computer Adaptive Test (UECAT). Additionally, patients were invited to our institution for clinical and radiographic evaluation. Aggregate patient reported outcomes scores were compared to the general population. Pinch strength, side pinch strength, and grip strength testing was compared to the contralateral extremity. Range of motion of the interphalangeal joint and the metacarpophalangeal joint were completed using a goniometer. The student’s t-test was used to compare means for strength and range of motion compared to the contralateral extremity.

**Results:** Twenty-seven patients completed patient reported outcomes data, and twelve patients completed additional clinical and radiographic evaluation. The median follow-up for the cohort was 35 years. The most common Flatt-Wassel classification was type IV. The mean DASH score was 29.5, greater than one standard deviation worse than the general population mean of 10.1 (14.5 SD). The mean PROMIS Upper Extremity CAT score was 51.5, greater than one standard deviation worse than the general population mean of 10.1 (14.5 SD). The mean pinch strength, side pinch strength, and grip strength did not differ significantly from the contralateral extremity controls (Table 37-1). There was significantly decreased range of motion at the interphalangeal joint, regardless of Flatt-Wassel classification type. No patient had significant pain in the thumb or the hand. A minority of patients developed same segment arthritis, and each of these patients had significant malalignment (Fig. 37-1).

**Summary Points:**
- Preaxial polydactyly patients treated with reconstruction had decreased functional outcomes compared to the general population as measured on the DASH, and similar outcomes as measured on the PROMIS UECAT.
- Preaxial polydactyly patients treated with reconstruction have maintained pinch strength, side pinch strength, and grip strength.
- Preaxial polydactyly patients treated with reconstruction have decreased range of motion at the IP joint. Patient families should be counseled regarding this unexpected long-term functional deficit.
- Arthritis of the adjacent segment was present in a minority of patients, and when present was seen concomitantly with malalignment and joint incongruity. It is important at follow-up to evaluate joint congruity and alignment, and intervene when necessary to prevent this complication.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Involved Side</th>
<th>Normal Side</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip strength</td>
<td>65.3 lbs</td>
<td>56.0 lbs</td>
<td>0.285</td>
</tr>
<tr>
<td>Pinch strength</td>
<td>11.2 lbs</td>
<td>11.4 lbs</td>
<td>0.907</td>
</tr>
<tr>
<td>Side pinch strength</td>
<td>9.3 lbs</td>
<td>8.3 lbs</td>
<td>0.572</td>
</tr>
<tr>
<td>IP flexion</td>
<td>28.2 degrees</td>
<td>80.0 degrees</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MCP flexion</td>
<td>48.1 degrees</td>
<td>50.0 degrees</td>
<td>0.749</td>
</tr>
<tr>
<td>Pain with CMC grind</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Angular deformity</td>
<td>42%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 37-1: 55 year clinical and radiographic patient follow-up demonstrating significant angular deformity, with same segment and adjacent segment joint space destruction on the right. The patient had no pain and mild functional limitations at follow-up.

This research was supported by a 2015 Fast Track Grant from the American Foundation for Surgery of the Hand.
Hypothesis: Multiple randomized trials have demonstrated equivalent outcomes and improved patient/family satisfaction in the treatment of distal radius buckle fractures (DRBF) with a removable splint or brace when compared to traditional cast immobilization, although casting still remains the default treatment.\(^4\) We tested the hypothesis that we could use quality improvement (QI) methodology to increase the proportion of patients with DRBF treated with removable braces at two tertiary care orthopaedic clinics from a baseline of 33% to 80%.

Methods: Clinic billing records were reviewed monthly to determine treatment of DRBF (brace versus cast), which was tracked using control charts (p-chart). The number of follow up visits, radiographs obtained, and total cost of treatment was collected. Baseline data were obtained over a three month period, followed by a 12-month intervention period (1/1/16 – 12/31/16) using Plan-Do-Study-Act (PDSA) cycles targeting both individuals and groups of providers. Patients/families were given a cost survey to determine non-medical costs associated with follow-up clinic visits.

Results: The proportion of DRBF treated in a brace increased at both centers from a combined baseline of 33% to a combined 94% at the end of the study period, and 83% over the last quarter. Following intervention, 83% (15/18) of providers began using braces for a majority of patients (defined as > 67%), although 1 provider continued to use casts 100% of the time. Patient preference was cited as the most common reason for use of cast treatment. There was a significant decrease in the number of radiographs obtained at one of two institutions. The charges for brace treatment averaged $630 less per patient than for cast treatment, leading to an estimated medical-cost savings of $205,000 overall following intervention. Furthermore, 98% of patients treated in a brace did not return for follow-up, saving each patient an average of $70 per visit in lost wages, travel, and childcare expenses. (Fig. 38-1)

Summary Points:
- Implementation of brace treatment for DRBF using QI methodology at two tertiary care centers resulted in a significant increase in brace treatment, leading to substantial medical and non-medical cost savings.
- Although patient preference was cited as the most common reason for persistent cast treatment, the data demonstrate the use of cast treatment to be more dependent upon individual provider preference.
- Quality improvement methodology can be utilized to enact and track implementation of Level-I medical evidence into practice, although barriers still exist that may be provider-dependent.
relations, pain interference, and depressive symptoms. We also performed a retrospective chart review to capture relevant demographic and clinical information.

**Results:** One-hundred twenty-four patients met inclusion criteria; 51 completed both the PODCI and PROMIS surveys (response rate, 41.1%). Average PODCI and PROMIS scores for upper extremity function were 42.5 ± 19.96 and 41.8 ± 11.8, respectively (Table 39-1). For patients with a documented history of developmental delay, PODCI and PROMIS scores for upper extremity function were 23.8 ± 6.2 and 18.2 ± 30.7, respectively. PROMIS scores for pain interference were higher for the parent-proxy group compared to the self-report group (parent-proxy: 47.7, self-report: 38.3, P = 0.0052). PODCI scores for comfort (absence of pain) were lower for the parent-proxy group compared to the self-report group (parent-proxy: 51.3 ± 9.6, self-report: 55.5 ± 3.4, P = 0.028) (Fig. 39-1).

**Summary Points:**
- Patients who have undergone reconstruction for congenital syndactyly report impairments in upper extremity function, but other components of health-related quality of life are comparable to the general population.
- Developmental delay was associated with additional impairments in upper extremity function.
- Parents of children who have undergone reconstruction for syndactyly overestimate the amount of pain their children experience.

### Table 39-1: Mean PROMIS and PODCI Scores for All Patients Who Completed Surveys

<table>
<thead>
<tr>
<th>Score</th>
<th>PROMIS Score</th>
<th>PODCI Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Extremity</td>
<td>41.8 ± 11.8</td>
<td>42.5 ± 20.0</td>
</tr>
<tr>
<td>Function</td>
<td>51.5 ± 9.5</td>
<td>42.5 ± 20.0</td>
</tr>
<tr>
<td>Pain Interference</td>
<td>46.0 ± 9.9</td>
<td>42.5 ± 20.0</td>
</tr>
<tr>
<td>Depressive Symptoms</td>
<td>44.0 ± 8.1</td>
<td>42.5 ± 20.0</td>
</tr>
</tbody>
</table>

Scores are presented as mean ± SD.

**Figure 39-1:** Reported pain interference and comfort scores for patients and parent-proxy.

---

**A Systematic Investigation of PIK3CA Mutations in Isolated Macrodactyly: Indication for Accurate Classification, Diagnosis and Potential Novel Therapeutics**  
Level 4 Evidence

Jingheng Wu, MD  
Guanglei Tian, MD  
Kelli Sumner, BA  
Douglas T. Hutchinson, MD  
Yuan Ji, PhD

Grant received from: Beijing Talent Funding  
**COI:** There is no financial information to disclose.

**Hypothesis:** Macrodactyly, a rare congenital digital anomaly, has been challenging the hand surgery society. The recent discovery of somatic PIK3CA mutations in a few isolated macrodactyly patients shed light on the fundamental understanding of this disabling deformity. We set up to systematically test the association between PIK3CA mutations with isolated macrodactyly in order to establish a molecular pathophysiology-based diagnosis, classification and possibly a novel therapeutic strategy.

**Methods:** Overgrowth tissues including skin, nerve, adipose tissues from clinically diagnosed isolated macrodactyly patients (N = 12) were removed during routine surgical debulking or correction procedures and preserved as formalin-fixed-paraffin-embedded (FFPE) blocks. DNA recovered from these FFPE samples were tested for PIK3CA mutation status using a modified and targeted Sanger DNA sequencing method with greatly improved sensitivity for detecting low level somatic mosaic mutations. PIK3CA mutation level, tissue(s) of occurring, type of mutations and their genomic locations were analyzed.

**Results:** PIK3CA mutations were detected from affected tissues in 9 out of the 12 patients studied, with mutation level ranging from 8 to 27%. The mutations detected include p.His1047Arg (N = 4), p.His1047Leu (N = 2), p.545Glu > Lys (N = 2) and p.542Glu > Lys (N = 1). These are codons in the PIK3CA gene that are frequently mutated in cancers. In terms of the tissue sources in which a mutation was found, adipose tissue has the highest mutation detection rate (100%), followed by nerve (83%) and skin (71%). No mutations found in bone tissues from two patients with PIK3CA mutations detected in other tissues of the same patients. Patients and/or tissues negative for PIK3CA mutations are subjected to downstream analysis using high throughput next generation DNA sequencing. (Figs. 40-1, 40-2)

**Summary Points:**
- A high proportion (75%) of isolated macrodactyly patients harbors activating PIK3CA mutations that lead to digital overgrowth as a result of abnormally activated Akt-PI3K signaling.
- Adipose and nerve tissues provide the highest PIK3CA mutation detection yield among all the sources of affected tissues.
- A modified Sanger DNA sequencing method is a cost-effective way to examine PIK3CA mutations in isolated macrodactyly patients clinically.
- Patients negative for PIK3CA mutations may harbor other PIK3CA mutations beyond the detection of our assay or due to different molecular mechanisms.
- To our knowledge, our study is the largest study linking PIK3CA mutations to isolated macrodactyly.

**Figure 40-1:** DNA sequencing. (Figs. 40-1, 40-2)
Figure 40-1: Representative photographs of two isolated macrodactyly cases and their PIK3CA mutation results. A: Patient 5, showing enlarged 2nd and 3rd fingers of her right hand. The PIK3CA c.3140A>G (p.His1047Arg) mutation detected by Sanger sequencing in the affected scar, fat, and skin tissues. B: Patient 10, showing enlarged 1st, 2nd, and 3rd right toes. The PIK3CA c.1633G>A (p.Glu545Lys) mutation detected by Sanger sequencing in two affected fat tissues. Mosaic mutations were minor peaks under the wild-type nucleotide peak and indicated by red arrows; levels of mutation in tested tissues were also shown.

A: Patient#11 (nerve tissue) • Mutation level: 24% • c.3140A>G, p.1047His>Arg B: Patient#7 (nerve tissue) • Mutation level: 26% • c.1624G>A, p.542Glu>Lys

Figure 40-2: PIK3CA mutations in isolated macrodactyly patients. PIK3CA gene structure with critical domains, targeted regions, and mutations identified in isolated macrodactyly patients are summarized. Red arrows indicate three targeted regions (p.418-435, p.527-555, and p.1009-1058) by Sanger DNA sequencing. Mutations previously reported and numbers of patients are depicted above the gene structure and highlighted in red.

BIBLIOGRAPHY

Table 42-1: Pearson Correlation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>PF</th>
<th>UE</th>
<th>qDASH</th>
<th>Anxiety</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROMIS Physical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function CAT (PF)</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>PROMIS Upper</strong></td>
<td>0.71</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Extremity CAT (UE)</td>
<td>P &lt; 0.0001</td>
<td>1</td>
<td>-</td>
<td>0.73</td>
<td>-</td>
</tr>
<tr>
<td>Quick DASH (qDASH)</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td><strong>PROMIS Anxiety CAT</strong></td>
<td>-0.46</td>
<td>-0.48</td>
<td>0.53</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Anxiety CAT (PI)</td>
<td>P &lt; 0.0001</td>
<td>P &lt; 0.0001</td>
<td>P &lt; 0.0001</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PROMIS Pain</td>
<td>-0.60</td>
<td>-0.65</td>
<td>0.76</td>
<td>0.55</td>
<td>1</td>
</tr>
<tr>
<td>Interference CAT (PI)</td>
<td>P &lt; 0.0001</td>
<td>P &lt; 0.0001</td>
<td>P &lt; 0.0001</td>
<td>P &lt; 0.0001</td>
<td></td>
</tr>
</tbody>
</table>
Summary Points:
- Increased levels of patient anxiety and pain interference, as measured by the PROMIS Anxiety and PI CATs, are associated with decreased patient-reported upper extremity function as measured by the three studied functional metrics (PROMIS PF CAT, UE CAT, qDASH).
- The three functional metrics were significantly correlated with one another.
- Our results are consistent with the biopsychosocial model of perceived upper extremity disability.

BIBLIOGRAPHY

PAPER 43
Clinical Paper Session 6
Outcomes/Thumbs — Saturday, September 9, 2017 • 8:14–8:19 AM
Prognosis/Outcomes

Ceiling Effect of the PROMIS Upper Extremity Function Assessment
Level 3 Evidence

Casey Beleckas, BS
Alexander Padovano, BS
Jason Guattery, BS, MS
Aaron Chamberlain, MD
Jay Keener, MD
Ryan P. Calfee, MD

COI:
Consulting Fee: Arthrex (Chamberlain, Keener), DePuy (Chamberlain), Shoulder Innovations (Kener)Zimmer (Chamberlain)
Contracted Research: Zimmer (Chamberlain, Keener), NIH (Keener), Medartis (Calfee)
Royalty: Shoulder Innovations, Imas cap (Keener)

Hypothesis: The NIH developed the Patient Reported Outcome Measurement Information System (PROMIS) to provide assessments of multiple health domains. Initially, musculoskeletal function assessment was limited to general Physical Function but now a PROMIS Upper Extremity Function is available. Although PROMIS Upper Extremity Function scores offer a potentially more sensitive measure of function and treatment effect in patients with isolated upper extremity conditions, this scale has been critiqued for lacking higher function questions. Although all PROMIS measures are designed around a mean of 50 with a theoretical range from 0-100, the actual ceiling scores are unclear. This study was designed to quantify the actual ceiling scores and determine the number of patients reaching that ceiling on the PROMIS Upper Extremity Computer Adaptive Test (CAT) compared to the PROMIS Physical Function CAT in patients seeking specialty care for upper extremity conditions.

Methods: This observational trial analyzed prospectively collected PROMIS Upper Extremity v1.2 and Physical Function v1.2 CAT scores from a series of new outpatient clinic visits of adult patients presenting to a tertiary orthopaedic clinic from 6/22/2015-10/5/2016. Inclusion in the study required each patient to have presented with hand or shoulder conditions and to have completed both PROMIS Upper Extremity and Physical Function CATs. Univariate statistics described the score distributions for each PROMIS assessment and maximum achieved scores represented the actual ceiling scores as higher scores indicate greater function.

Results: PROMIS Scores from 5202 patients were eligible for inclusion (Table 43-1). The PROMIS Upper Extremity scores presented in a bimodal distribution, while the PROMIS Physical Function scores were normally distributed (Fig. 43-1). Only 0.6% of patients scored the ceiling, 73, on the Physical Function CAT, while 7.2% of patients scored 56, the maximum achieved score, on the Upper Extremity CAT. No Upper Extremity scores were reported between 50 and 56, suggesting a secondary ceiling at 50.

Summary Points:
- There is a substantial ceiling effect in the PROMIS Upper Extremity CAT that occurs at only 0.6 standard deviations above the proposed normal population mean indicating that the current assessment is unable to discriminate higher levels of function.
- Seven percent of patients presenting for treatment of a symptomatic upper extremity condition already score at the ceiling on the PROMIS Upper Extremity assessment precluding any demonstration of treatment benefit.
- The PROMIS Upper Extremity CAT would most benefit from greater ability to query higher levels of upper extremity function.
Figure 43-1: Histograms of PROMIS Upper Extremity scores.

BIBLIOGRAPHY


PAPER 44
Clinical Paper Session 6
Outcomes/Thumb — Saturday, September 9, 2017  ●  8:21—8:26 AM
Treatment; Surgical Technique; Anatomy

Selective Denervation to Treat Pain and Disability Associated with Thumb Carpometacarpal Arthritis
Level 4  Evidence

Sami Tuffaha, MD
Amy Quan, BS
Shar Hashemi, MD
Justin Michael Broyles, MD
A. Lee Dellon, MD, PhD
Scott D. Lifchez, MD

COI: There is no financial information to disclose.

Hypothesis: Selective denervation of the thumb carpometacarpal (CMC) joint is a viable approach to treat pain and disability associated with CMC arthritis, with less morbidity and faster recovery as compared to trapeziectomy.

Methods: Cadaveric dissections were performed in 9 fresh upper extremities to better define the innervation patterns to the thumb CMC joint and guide the surgical approach for denervation. Histologic confirmation of candidate nerves was performed with H&E staining. Results from a consecutive series of 13 patients with thumb CMC arthritis who underwent joint denervation were retrospectively reviewed.

Results: Cadaveric dissections- Nerve branches to the thumb CMC joint were found to arise from the lateral antebrachial cutaneous nerve (9/9 cadavers; 100%), the palmar cutaneous branch of the median nerve (6/9 cadavers; 67%), and the radial sensory nerve (2/9 cadavers; 22%). Case series- A Wagner incision was used to identify and resect nerve branches innervating the thumb CMC joint. Twelve of 13 patients reported complete or near complete relief of pain following surgery, with improvement noted at the first post-operative visit. Of the 11 patients who underwent formal testing, improvement in grip strength was observed in 7 patients (64%) and improvement in lateral pinch strength in 10 patients (91%). Nine of 13 patients (69%) reported patchy areas of peri-incisional numbness that were generally well tolerated and tended to improve with time. With an average follow up of 6 months (range 1-20 months), neither recurrence of arthritic pain or development of neuromatous pain was observed in any patients.

Figures 44-1, 44-2, and 44-3: Intraoperative photographs of articular nerve branches innervating thumb CMCJ originating from (1) LACBN; (2) PCBMN; and (3) RSN.

Summary Points:
- Selective denervation of the thumb CMC joint is an effective approach to treat pain and disability associated with CMC arthritis.
- The procedure is well tolerated, with faster recovery as compared to trapeziectomy.
- Ideal candidates include younger patients with favorable range of motion and joint integrity and significant functional demands who wish to avoid or postpone the need for trapeziectomy.
- Branches arising from the lateral antebrachial cutaneous nerve, palmar cutaneous branch of the median nerve, and radial sensory nerve can be identified and resected with a single Wagner incision.

Figure 44-1: Articular nerve branches innervating thumb CMCJ originating from LACBN.
**PAPER 45**

Clinical Paper Session 6  
Outcomes/Thumb — Saturday, September 9, 2017 • 8:28—8:33 AM  
Treatment

**Long-term Outcomes of APL Suspensionplasty with No, Partial, or Complete Trapezoid Excision**

Level 4 Evidence

Kevin J. Renfree, MD  
Ryan A. Odgers, MD  
Nan Zhang, MS  
Cody Tillinghast, BS

**COI:** There is no financial information to disclose.

**Hypothesis:** Partial or complete trapezoid excision, combined with trapeziectomy and abductor pollicis longus (APL) suspensionplasty, impacts long term radiographic and clinical results.

**Methods:** Sixty-nine patients (79 hands) underwent surgery for basal joint arthritis. Eighty-seven percent were female with a mean age 64. The dominant hand was involved in 57%. Advanced scaphotrapezial-trapezoid arthritis was noted intraoperatively in 55%, and treated with resection of the proximal 50% of the trapezoid (PT) in 21 hands (27%), and complete trapezoid (CT) resection in 22 (28%). No trapezoid excision was required (NT) in 36 hands. Fisher’s exact tests compared categorical outcomes and linear regression investigated whether predictors of interest (PT, CT or NT) had any effect on continuous variables such as Patient Rated Wrist Evaluation (PRWE), or DASH.

**Results:** Mean follow up was 95 months. There was no significant difference in satisfaction or the desire to have the procedure again. Mean total pain score was significantly lower with CT (4.89) and PT (4.94) when compared to NT (11.37). CT had significantly lower (better) mean total functional and usual activity scores on the PRWE, and four sub-scores on the quickDASH when compared to NT, but not to PT. Significant decreases in mean carpal height ratio (CHR) were seen in NT and CT. There was no significant difference between PT and CT; NT and PT had significantly more proximal collapse of the thumb metacarpal relative to the scaphoid compared to CT. Only NT had a significant change in the scapholunate angle. Both PT and CT had significant proximal migration of the index metacarpal. Complication rates trended higher in CT (27.3%) when compared to NT, but not to PT. Significant increases in mean carpal height ratio (CHR) were seen in PT and CT. There was no significant difference between PT and CT; NT and PT had significantly more proximal collapse of the thumb metacarpal relative to the scaphoid compared to CT. Only NT had a significant change in the scapholunate angle. Both PT and CT had significant proximal migration of the index metacarpal. Complication rates trended higher in CT (27.3%) when compared to PT (23.8%)and NT (16.7%) but was insignificant. Secondary procedures were highest in CT (18%) and involved arthrodesis of the index and long finger carpometacarpal joints.

**Summary Points:**

- Complete trapezoidectomy had the greatest decrease in CHR and radiographic collapse of the index metacarpal, but without significant change in the scapholunate angle. It had the lowest (best) total pain and functional scores on the PRWE.
- While CT also led to the greatest improvement in total functional scores (PRWE), the authors now only do PT for two reasons: (1) No significant differences in radiographic or clinical outcomes between PT and CT. (2) Higher complication rate with CT, notably an 18% incidence of symptomatic index CMCJ collapse and arthritis requiring arthrodesis.
- NT patients had the highest total pain score and this may be due to impingement between the thumb metacarpal and trapezoid.

**PAPER 46**

Clinical Paper Session 6  
Outcomes/Thumb — Saturday, September 9, 2017 • 8:35—8:40 AM  
Treatment; Prognosis/Outcomes

**LRTI Post-operative Rehabilitation Protocol: A Randomized, Prospective, Multicenter Study Comparing a Conservative Casting Regimen to an Earlier Mobilization Splinting Regimen**

Level 2 Evidence

Douglas T. Hutchinson, MD  
Stephanie Sueoka, MPT, DPT, CHT  
Angela A. Wang, MD  
Andrew Tyser, MD
Hypothesis: Increased immobilization after LRTI creates a more stable thumb and better outcomes.

Methods: We prospectively randomized patients undergoing ligament reconstruction tendon interposition (LRTI) surgery into two post-operative immobilization protocols at two different institutions. Our ‘immobilization’ protocol consisted of post-op thumb spica splinting for 10 days, followed by forearm-based thumb spica casting for 5 weeks, followed by a custom forearm-based thermoplastic thumb spica splint for an additional 6 weeks — range of motion (ROM) started at 6 weeks post-operatively. Our ‘early mobilization’ protocol consisted of the same post-operative splint for 10 days, followed by a forearm-based thermoplastic thumb spica splint for 3 weeks, then a hand-based thumb spica splint for 4 weeks — range of motion was initiated at 4 weeks. Primary outcomes were the DASH, strength, Nine-hole peg test (NHP), VAS pain and patient satisfaction, ROM (wrist and opposition): these were measured pre-operatively, and at 6, 12, 26, 52, and 104 weeks post-operatively. Basic descriptive statistics were calculated. Differences in continuous variables were evaluated using Tukey confidence intervals following one-way ANOVA, using Box-Cox transformation as needed for data displaying non-constant inter-group variance or skewness. Differences in categorical variables were determined using the Chi-square test. A 95% confidence level (α = 0.05) was chosen.

Results: 234 patients were randomized over a 5 year period and demographics including age (average 62 years), sex, and associated diseases were identical between groups and across institutions. In general for all patients, DASH, VAS satisfaction and pain, NHP tests, strength, or thumb opposition at 12, 26, 52, and 104 week time points.

Summary Points:

- A conservative immobilization protocol does not improve functional outcomes, satisfaction, strength, or ROM following LRTI as compared to an early motion protocol.
- Further study is required to determine whether even more aggressive early mobilization protocols are efficacious and safe.

PAPER 47

Carpal Tunnel Syndrome and Amyloid Cardiomyopathy

Level 2 Evidence

Bryan A. Reyes, MD
Asad Ikram, MD
Brett Sperry, MD
David B. Shapiro, MD
Mazen Hanna, MD
William H. Seitz, Jr., MD

COI: There is no financial information to disclose.

Hypothesis: Carpal tunnel syndrome (CTS) can be the initial manifestation in patients with amyloidosis, often presenting years before cardiac involvement becomes apparent. We hypothesized that a significant percentage of older patients undergoing surgery for idiopathic CTS would be diagnosed with amyloidosis through tenosynovial biopsy, and that early detection of amyloid cardiomyopathy using advanced cardiac imaging techniques may be possible.

Methods: This is an ongoing prospective, longitudinal study that includes patients with amyloidosis, often presenting years before cardiac involvement becomes apparent. We hypothesized that a significant percentage of older patients undergoing surgery for idiopathic CTS would be diagnosed with amyloidosis through tenosynovial biopsy, and that early detection of amyloid cardiomyopathy using advanced cardiac imaging techniques may be possible.

Results: Preliminarily, 205 patients undergoing carpal tunnel decompression were screened for eligibility (Fig. 47-1). Of the 120 patients who met...
inclusion criteria, 58 consented to participate and underwent biopsy. Seven patients (7/58, 12.1%) were found to have amylodosis. Tissue subtyping revealed that five patients had transthyretin amyloidosis (ATTR) and two patients had light chain amyloidosis (AL). Upon further cardiac workup, two patients were found to have associated amyloid cardiomyopathy (one patient with ATTR and one patient with AL).

Summary Points:
- Seven patients (12.1%) undergoing carpal tunnel decompression for ‘idiopathic’ carpal tunnel syndrome were diagnosed with amyloidosis through tenosynovial biopsy.
- Two out of seven of these patients were found to have evidence of amyloid cardiomyopathy upon further work up with advanced cardiac imaging.
- Two patients were found to have the AL subtype caused by a plasma cell disorder. This subtype is rapidly progressive and early diagnosis and intervention is of paramount importance for survival.
- Hand surgeons should be aware of the association between carpal tunnel syndrome and amyloidosis. Performing a tenosynovial biopsy and staining for amyloid with Congo red in an older cohort with idiopathic CTS may lead to early diagnosis of amyloidosis, thereby allowing for timely intervention of this life-threatening disease.

Carpal tunnel syndrome and amyloid cardiomyopathy

BIBLIOGRAPHY

PAPER 48

Clinical Paper Session 7
Nerve 2 — Saturday, September 9, 2017 • 8:49–8:54 AM
Treatment; Surgical Technique; Prognosis/Outcomes

Spinal Accessory Nerve to Triceps Transfer for Recovery of Elbow Extension in Traumatic Brachial Plexus Injuries
Level 4 Evidence
Liselotte Bulstra, MSc
Nadia Rbia, MD
Femke Mathot, MD
Robert Spinner, MD
Allen T. Bishop, MD
Alexander Y. Shin, MD

COI: There is no financial information to disclose.
Hypothesis: To facilitate stabilization of the elbow after brachial plexus injury, reconstruction of not only elbow flexion but also elbow extension is desired. The aim of this study was to evaluate prevalence and quality of restored elbow extension in brachial plexus injury patients, who underwent spinal accessory nerve (SAN) to the radial nerve branch to the long head of the triceps (BLHT) transfer with an autologous nerve graft interposition and to identify patient and injury related factors that influence functional triceps outcome.

Methods: In this retrospective cohort study, 42 patients with brachial plexus injury were included and evaluated. As a part of their reconstructive plan, all patients underwent SAN transfer to the BLHT using long autologous nerve grafts to achieve tension free nerve connections. The primary outcome measurement was elbow extension strength (MRC score).

Various statistical tests were used for group comparisons as appropriate (e.g. Mann-Whitney U and Fisher’s exact tests). The effect of individual clinical and demographic factors was evaluated using univariate logistic regression analysis.

Results: Evaluating the total cohort (n = 42) with a follow-up between 12 and 45 months (mean 24.3 months), we found clinically meaningful recovery in 52.4% of patients. Triceps muscle strength of M0 and M1 was accomplished by 45.2%; 19.1% achieved M2 and 35.7% reached a muscle strength of M3 or more. A negative correlation was found between the existence of concomitant vascular injury and the functional outcomes of the triceps muscle. A subgroup with a minimum of 20 months follow up (n = 26) showed a clinically meaningful recovery of 69.5%. In the same group, 7.7% had no muscle function recovery (M0), 19.2% reached M1 and 23.1% achieved M2. In this cohort, 50% of the patients obtained a functional recovery of M3 or better, with 34.5% reaching M4 elbow extension.

Summary Points:
- Transfer of the SAN to the BLHT is an adequate option for restoration of elbow extension after brachial plexus injury, despite the relatively long time to reinnervation.
- Concomitant vascular injury impairs the functional recovery of the triceps muscle.
- Use of shorter nerve grafts is recommended when possible.

Figure 47-1: Carpal tunnel syndrome and amyloid cardiomyopathy.

PAPER 49

Clinical Paper Session 7
Nerve 2 — Saturday, September 9, 2017 • 8:56–9:01 AM
Treatment; Surgical Technique; Prognosis/Outcomes

Comparison of Nerve Transfer and Nerve Grafting for Restoration of External Rotation of Shoulder Function in Traumatic Brachial Plexus Injuries
Level 4 Evidence
Nina Suh, MD
Eric R. Wagner, MD
Michelle Kircher, BS
Robert Spinner, MD
Allen T. Bishop, MD
Alexander Y. Shin, MD

COI: There is no financial information to disclose.
Hypothesis: We aimed to critically evaluate our results of patients with traumatic brachial plexus injury who underwent either C5 or C6 root grafting or spinal accessory nerve transfer to suprascapular nerve transfer.

Methods: A review was performed on all patients who underwent suprascapular nerve reconstructions for traumatic brachial plexus injury between 2001 to 2011. Exclusion criteria were any patients below the age of 18 and follow-up less than one year. Eighty-seven patients were identified and made the cohort of the study (36 grafting, 51 transfers). Mean age was 32 (range: 18-65) with 74 males and 13 females. There were 12 upper trunk (UT), 38 upper trunk with C7 (UT+C7), and 37 complete brachial plexus injuries in our study population with mean time to surgery of 5.2 months (range: 0.8-11 months) and mean follow-up of 2.8 years (range 1-9.9 years). Eighteen percent were smokers, and mean BMI was 28 (range: 19-46).
Results: Nerve transfers were found to be statistically superior to nerve grafting for recovering MRC > 3 for external rotation. External rotation ROM was 10.9 degrees for transfers versus 2 degrees for grafting ($P = 0.003$). No significant difference in VAS or DASH scores was found favoring a particular method of reconstruction but EMG recovery favored the nerve transfer group. Additionally, age, BMI, smoking, time to surgery, length of graft, and type of graft were not found to affect strength or motor recovery for either groups.

Summary Points:

- Best clinical results for improved shoulder muscle grade (MRC > 3), shoulder range of motion, and EMG signs of recovery were obtained in patients who underwent spinal accessory nerve to suprascapular nerve transfer.
- No significance found for DASH or VAS scores, age, BMI, smoking, time to surgery, length of graft, and type of graft for either transfers or grafting.

**Table 50-1: Patient Data**

<table>
<thead>
<tr>
<th>No.</th>
<th>Age/ Sex</th>
<th>Mechanism of Injury</th>
<th>Age at Injury (Years)</th>
<th>Injury Pattern</th>
<th>Previous Brachial Plexus Surgery</th>
<th>Time from Injury to Transfer (Months)</th>
<th>Status before Brachialis Muscle Transfer (BMRC)</th>
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</thead>
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<tr>
<td>1</td>
<td>48/F</td>
<td>MVC</td>
<td>40</td>
<td>Lower trunk</td>
<td>None</td>
<td>15.2</td>
<td>Deltoid 4, Biceps 4, Triceps 4, PT 3, FDP 1, II 0, FDP III, IV 0, FDI 2, EDC 4, ECRB 5, ECRL 3</td>
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<tr>
<td>2</td>
<td>39/F</td>
<td>MVC</td>
<td>32</td>
<td>CB-T1</td>
<td>AIN to ulnar nerve transfer</td>
<td>12.1</td>
<td>Deltoid 3, Biceps 5, Triceps 4, PT 3, FDP 1, II 0, FDP III, IV 0, FDI 2, EDC 4, ECRB 5, ECRL 3</td>
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<td>3</td>
<td>36/M</td>
<td>Blast IED</td>
<td>34</td>
<td>Lower trunk</td>
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<td>34.1</td>
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<td>43/M</td>
<td>Latrogenic</td>
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<td>CB-T1</td>
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<td>10.6</td>
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<td>5</td>
<td>48/M</td>
<td>Tractor rollover</td>
<td>46</td>
<td>Lower trunk</td>
<td>None</td>
<td>17.6</td>
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<td>6</td>
<td>64/M</td>
<td>Tumor extirpation</td>
<td>58</td>
<td>Lower trunk</td>
<td>None</td>
<td>9.6</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
</tr>
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<td>7</td>
<td>47/M</td>
<td>MVC</td>
<td>38</td>
<td>CB-T1</td>
<td>None</td>
<td>108.1</td>
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<tr>
<td>8</td>
<td>19/F</td>
<td>MVC</td>
<td>18</td>
<td>Lower trunk</td>
<td>Triceps branch to axillary transfer</td>
<td>18.7</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
</tr>
<tr>
<td>9</td>
<td>38/F</td>
<td>MVC</td>
<td>35</td>
<td>Pan plexus with upper trunk recovery</td>
<td>None</td>
<td>42.6</td>
<td>Deltoid 4, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<tr>
<td>10</td>
<td>19/F</td>
<td>Spontaneous</td>
<td>17</td>
<td>Bi-brachial neuritis</td>
<td>None</td>
<td>5</td>
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<td>11</td>
<td>65/M</td>
<td>Tree fell on shoulder</td>
<td>62</td>
<td>CB-T1</td>
<td>None</td>
<td>15.7</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<tr>
<td>12</td>
<td>23/M</td>
<td>MVC motorcycle</td>
<td>22</td>
<td>CB-T1</td>
<td>Auxillary to triceps branch transfer</td>
<td>8.6</td>
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<tr>
<td>13</td>
<td>50/M</td>
<td>MVC</td>
<td>48</td>
<td>C5-T1</td>
<td>Spinal accessory to triceps transfer</td>
<td>32.5</td>
<td>Deltoid 3, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<tr>
<td>14</td>
<td>58/F</td>
<td>MVC</td>
<td>55</td>
<td>C7-T1</td>
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<td>10.9</td>
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<tr>
<td>15</td>
<td>73/M</td>
<td>MVC</td>
<td>69</td>
<td>C7-T1</td>
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<td>Deltoid 2, Biceps 4, Triceps 4, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<td>16</td>
<td>35/F</td>
<td>Object fell on shoulder</td>
<td>33</td>
<td>CB-T1</td>
<td>None</td>
<td>8.3</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<tr>
<td>17</td>
<td>22/M</td>
<td>MVC</td>
<td>21</td>
<td>Incomplete C5- T1</td>
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<td>10.8</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
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<tr>
<td>18</td>
<td>57/M</td>
<td>Tree fell on shoulder</td>
<td>55</td>
<td>CB-T1</td>
<td>None</td>
<td>15.8</td>
<td>Deltoid 5, Biceps 5, Triceps 5, PT 0, FDP 0, EDC 0, ECRB 0, ECRL 0</td>
</tr>
</tbody>
</table>

Mean: 43.6, 40.3, 23.5, 4.2, 4.5, 3.3, 3.8, 0.1, 0.2, 0.2, 0.9, 2.7, 3.8

BMRC: British Medical Research Council grade; MVC: Motor vehicle collision; PT: Pronator teres; FDP: Flexor digitorum profundus; FDI: First dorsal interosseous; EDC: Extensor digitorum communis; ECRB: Extensor carpi radialis brevis; ECRL: Extensor carpi radialis longus
Results: Eighteen adult patients with lower trunk brachial plexus palsy underwent brachialis muscle transfer to FDP with the goal of restoring rudimentary prehensile function (Table 50-1). Mean patient follow-up was 28.4 months (range 6.7–76.5 months). Brachialis muscle transfer resulted in restoring modified British Medical Research Council (BMRC) grade 3 or better function in 11 of 18 patients and grade 4 function in 8 of 18 patients. Eleven of the 18 patients demonstrated a post-operative functional grasp for assistance with activities of daily living. Mean post-operative DASH scores were significantly decreased following brachialis muscle transfer (53.6 ± 5.4 vs. 35.4 ± 3.6, P < 0.05). Overall patient satisfaction following brachialis muscle transfer was 56%. Patient pre-operative wrist extension (P < 0.018) and finger extension (P < 0.029) strength correlated with improved outcomes; whereas concomitant upper extremity fracture (P < 0.023) was associated with poorer outcomes. (Table 50-2)

Summary Points:
- Brachialis muscle transfer is an option for reconstruction of prehensile function in patients with lower trunk brachial plexus palsy with preserved wrist extension.
- Brachialis muscle transfer is particularly useful in patients who are a poor candidate for microsurgical free-functioning muscle transfer for grasp; however its functional outcomes are not universally successful.

### Table 50-2: Brachialis Muscle Transfer Outcomes

<table>
<thead>
<tr>
<th>No.</th>
<th>FDP II to V</th>
<th>Graft Used</th>
<th>Concomitant Procedures</th>
<th>Secondary Procedures</th>
<th>Finger Flexion BRMRC</th>
<th>Functional Grasp</th>
<th>Patient Satisfaction</th>
<th>Total Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>None</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>76.5</td>
</tr>
<tr>
<td>2</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>Scar revision BR to FPL; Thumb IP Arthrodesis</td>
<td>Tenolysis</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>75.9</td>
</tr>
<tr>
<td>3</td>
<td>FDP II to V</td>
<td>Semitendinosus allograft</td>
<td>BR to FPL; PT to APB; Thumb IP Arthrodesis</td>
<td>Tenolysis</td>
<td>2.0</td>
<td>No</td>
<td>No</td>
<td>25.7</td>
</tr>
<tr>
<td>4</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; PT to APB; Thumb IP Arthrodesis; Thumb CMC Arthrodesis</td>
<td>None</td>
<td>4.0</td>
<td>Yes</td>
<td>No</td>
<td>21.7</td>
</tr>
<tr>
<td>5</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; PT to APB Arthrodesis</td>
<td>Tenolysis; Re-tension Index FDP</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>40.8</td>
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<td>6</td>
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<td>Gracilis allograft</td>
<td>BR to FPL; PT to APB; Thumb IP Arthrodesis</td>
<td>None</td>
<td>4.0</td>
<td>No</td>
<td>No</td>
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<td>Semitendinosus allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis; Thumb CMC Arthrodesis</td>
<td>None</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>37.6</td>
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<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis; Thumb CMC Arthrodesis</td>
<td>None</td>
<td>3.0</td>
<td>Yes</td>
<td>Yes</td>
<td>8.6</td>
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<td>Gracilis allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>None</td>
<td>2.0</td>
<td>No</td>
<td>No</td>
<td>9.3</td>
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<td>Gracilis and semitendinosis autograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>Tenolysis</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>39.8</td>
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<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>PT to FPL Tenolysis</td>
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<td>2.0</td>
<td>No</td>
<td>No</td>
<td>14.7</td>
</tr>
<tr>
<td>12</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>None</td>
<td>2.0</td>
<td>No</td>
<td>No</td>
<td>31.7</td>
</tr>
<tr>
<td>13</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>None Tenolysis; Re-tension with palmaris autograft</td>
<td>None</td>
<td>1.0</td>
<td>No</td>
<td>No</td>
<td>10.2</td>
</tr>
<tr>
<td>14</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL Tenolysis; Intraoperative rupture requiring posterior tibialis allograft</td>
<td>None</td>
<td>1.0</td>
<td>No</td>
<td>No</td>
<td>28.0</td>
</tr>
<tr>
<td>15</td>
<td>FDP II to V</td>
<td>Gracilis allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>Tenolysis; Intraoperative rupture requiring posterior tibialis allograft</td>
<td>4.0</td>
<td>Yes</td>
<td>Yes</td>
<td>11.0</td>
</tr>
<tr>
<td>16</td>
<td>FDP II to V</td>
<td>Posterior tibial allograft</td>
<td>PT to FPL</td>
<td>None</td>
<td>3.0</td>
<td>Yes</td>
<td>Yes</td>
<td>8.0</td>
</tr>
<tr>
<td>17</td>
<td>FDP II to V</td>
<td>Posterior tibial allograft</td>
<td>BR to FPL; Thumb IP Arthrodesis</td>
<td>None</td>
<td>2.0</td>
<td>Yes</td>
<td>Yes</td>
<td>7.1</td>
</tr>
<tr>
<td>18</td>
<td>FDP II to V</td>
<td>Posterior tibial allograft</td>
<td>BR to FPL</td>
<td>None</td>
<td>3.0</td>
<td>Yes</td>
<td>Yes</td>
<td>6.7</td>
</tr>
</tbody>
</table>

BMRC: British Medical Research Council grade; FDP: Flexor digitorum profundus; BR: Brachioradialis; FPL: Flexor pollicis longus; APB: Abductor pollicis brevis; IP: Interphalangeal joint; CMC: Carpometacarpal joint; FDI: First dorsal interosseous; EDC: Extensor digitorum communis
Symptomatic Neuroma following Revision Amputation for Traumatic Digital Amputation

**Hypothesis:** We assessed the incidence of painful neuroma in patients with traumatic digital upper extremity amputations and the revision rate for surgery following initial treatment. We tested the null hypothesis that there are no factors independently associated with the development of symptomatic neuroma after traumatic digital amputation.

**Methods:** We performed a retrospective review of 1,083 patients who underwent revision amputation for traumatic digital amputation. Patients undergoing replantation or revascularization as initial treatment were excluded. We studied the incidence of painful neuromas and the rate of revision surgery and performed multivariable logistic regression analysis to identify factors independently associated with painful neuroma and neuroma surgery.

**Results:** Seventy-one of 1083 patients (6.6%) reported a symptomatic neuroma surgery. Mean time to diagnosis was 6.4 months. Forty-seven patients (66%) underwent surgery for painful neuroma. Eleven patients had a recurrent, symptomatic neuroma (15%) after secondary surgery and three patients had recurrence of painful neuroma (4.2%). Mean time to surgical intervention was 11 months. Index finger injury and avulsion mechanism were associated with higher odds of symptomatic neuroma ($P < 0.05$). (Figure 51-1, Table 51-1)

**Summary Points:**
- Approximately 1 in 15 patients will develop a symptomatic neuroma after traumatic digital upper extremity amputation.
- More than half of these patients will undergo revision surgery for neuroma with a mean time to operative intervention of 11 months.

<table>
<thead>
<tr>
<th>Odds ratio (95% confidence interval)</th>
<th>Standard error</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.99 (0.97 to 1.0)</td>
<td>0.0087</td>
</tr>
<tr>
<td>Workers’ compensation</td>
<td>1.6 (0.83 to 3.1)</td>
<td>0.53</td>
</tr>
<tr>
<td>Type of injury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharp</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>Crush</td>
<td>1.5 (0.83 to 2.6)</td>
<td>0.42</td>
</tr>
<tr>
<td>Avulsion</td>
<td>2.6 (1.2 to 5.4)</td>
<td>0.96</td>
</tr>
<tr>
<td>Burn</td>
<td>0.90 (0.10 to 7.7)</td>
<td>0.99</td>
</tr>
<tr>
<td>Blast</td>
<td>1.4 (0.17 to 12)</td>
<td>1.6</td>
</tr>
<tr>
<td>Amputated digit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index finger</td>
<td>2.2 (1.2 to 3.8)</td>
<td>0.62</td>
</tr>
<tr>
<td>Ring finger</td>
<td>1.7 (0.89 to 3.2)</td>
<td>0.55</td>
</tr>
<tr>
<td>Level of amputation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal phalanx</td>
<td>1.4 (0.80 to 2.4)</td>
<td>0.39</td>
</tr>
<tr>
<td>Multiple digits affected</td>
<td>1.3 (0.66 to 2.4)</td>
<td>0.48</td>
</tr>
</tbody>
</table>

*6 patients were excluded due to unknown values for type of injury

**Figure 51-1:** Results.

**Table 51-1: Multivariable Logistic Regression Analysis (n = 1,077*)

**BIBLIOGRAPHY**


**PAPER 52**

Clinical Paper Session 7
Nerve 2 — Saturday, September 9, 2017 • 9:17—9:22 AM
Treatment; Prognosis/Outcomes

Predicting Increased Resource Utilization After Carpal Tunnel Release

**Hypothesis:** Health care providers are facing increased pressure to provide efficient care and minimize costs as payment models are evolving with efforts to move toward bundled payments. This study was designed to determine if patient mental health and preoperative experience with pain could predict resource consumption postoperatively. Our hypothesis was that greater depressive symptoms and greater pain interference (quantified with PROMIS scores), and pre-operative opioid usage would be associated with an increased number of post-operative encounters after carpal tunnel release.

**Methods:** This retrospective cohort study evaluated all adult patients undergoing isolated unilateral or bilateral carpal tunnel release at a tertiary orthopaedic center from 6/1/2015-6/30/2016. All patients completed the PROMIS Pain Interference and Depression Computer Adaptive Testing (CATs) at their pre-operative visit. All PROMIS CATs are scored 0-100 with 50 as the normal mean and higher scores representing more of that health domain (i.e., higher score means greater depression, greater function, greater pain). Postoperative encounters were quantified as a summation of postoperative office visits, phone calls, or electronic messaging related to their carpal tunnel syndrome. Pre-operative opioid use was determined by patient report and prescriptions recorded within 90 days preoperatively. Independent t-tests and chi square testing assessed the differences in initial PROMIS scores between the patients who had one versus more than one
postoperative encounter as well as differences in age, sex, race, and opioid use between groups.

**Results:** Two-hundred nineteen patients who underwent carpal tunnel release were eligible for the study (Table 52-1). Fifty-nine percent of patients had a single postoperative encounter while 41% had multiple postoperative encounters (25% had two, 8% had three, and 8% required four or more). Patients who required multiple post-operative encounters had significantly higher pre-operative PROMIS Depression scores (average difference 3 points, 95% CI 0.1-5.5) (Table 52-2). There was no difference in PROMIS Pain Interference scores or opioid use (each \( P > 0.05 \)). There was also no difference between the groups by unilateral versus bilateral surgery, average age, sex, or race (all \( P > 0.05 \)).

**Summary Points:**
- While depressive symptoms are thought to influence ultimate patient-reported outcomes, our data now indicate that greater depressive symptoms are also associated with more postoperative encounters after carpal tunnel release.
- If considering care within a bundled reimbursement model for carpal tunnel syndrome, preoperative PROMIS Depression scores may predict variability in postoperative resource consumption.
- Although disproportionate pain and narcotic use preoperatively are concerning, these factors did not predict the need for more postoperative encounters.

**Table 52-1: Demographic Characteristics of the Study Population, n = 219**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (SD)</td>
<td>56.9 years (14.7)</td>
</tr>
<tr>
<td>Female</td>
<td>147</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>180</td>
</tr>
<tr>
<td>Black/African-American</td>
<td>37</td>
</tr>
<tr>
<td>Opioid Use</td>
<td>54</td>
</tr>
</tbody>
</table>

**Table 52-2: Average (SD) PROMIS Depression Scores, PROMIS Pain Interference Scores, and Preoperative Opioid Use by Frequency of Postoperative Encounters**

<table>
<thead>
<tr>
<th>Encounter</th>
<th>1 Postoperative Visit (n = 130)</th>
<th>2+ Postoperative Visits (n = 89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression*</td>
<td>47 (9)%</td>
<td>50 (10)%</td>
</tr>
<tr>
<td>Pain Interference</td>
<td>62 (7)</td>
<td>62 (7)</td>
</tr>
<tr>
<td>% of Patients Using</td>
<td>27%</td>
<td>19%</td>
</tr>
<tr>
<td>Opioids Preoperatively</td>
<td>7%</td>
<td>7%</td>
</tr>
</tbody>
</table>

*Significant at \( P < 0.05 \)

**BIBLIOGRAPHY**

1. Mechanic R. Medicare’s Bundled Payment Initiatives: Considerations for Providers. 2016; Available at: http://www.aha.org/content/16/issbrief-bundledpmt.pdf.

**PAPER 53**

Clinical Paper Session 8
Trauma 2 — Saturday, September 9, 2017 • 9:24—9:29 AM
Evaluation/Diagnosis

**Plain Radiographs Detect Dorsal Scaphoid Translation in Scapholunate Dissociation**

Level 4 Evidence

Kevin Chan, MD
Emil Stefan Vutescu, MD
Michelle Gerwin Carlson, MD
Scott W. Wolfe, MD
Steve K. Lee, MD

**Figure 53-1:** Dorsal scaphoid translation (DST) was assessed using concentric circles and dorsal tangential line methods. The first method measured the horizontal distance between the centers of two best-fit circles seen on lateral projections of the wrist; one corresponding to the scaphoid fossa of the distal radius and the other to the proximal articular surface of the scaphoid. The second method utilizes a line drawn through the dorsal articular rim of the distal radius that is parallel to the longitudinal axis of the radius.
Summary Points:

- This study confirms that patients with complete SLIL dissociations demonstrate static dorsal scaphoid translation, which should be considered part of the carpal instability pattern seen in patients with SLIL injury.
- Radiographs and MRI demonstrate similar reliabilities for the detection of DST.
- Both concentric circle and dorsal tangential line radiographic measurement techniques for DST had excellent reliabilities, but the dorsal tangential line method is easier and quicker to perform.

Table 53-1: Mean Dorsal Scaphoid Translation Values Measured Using the Concentric Circle and Dorsal Tangential Line Methods on Both Radiographs and MRI

<table>
<thead>
<tr>
<th></th>
<th>SLIL</th>
<th>Control</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentric circles (radiographs)</td>
<td>2.9 mm</td>
<td>0.8 mm</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Concentric circles (MRI)</td>
<td>2.5 mm</td>
<td>0.5 mm</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Dorsal tangential line (radiographs)</td>
<td>2.3 mm</td>
<td>0.5 mm</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Dorsal tangential line (MRI)</td>
<td>1.8 mm</td>
<td>0.2 mm</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

BIBLIOGRAPHY

1. Meister DW, Hearns KA, Carlson MG. Dorsal scaphoid subluxation on sagittal MRI as a marker for scapholunate ligament tear. iPoster presented at: American Society for Surgery of the Hand Annual Meeting: September 29—October 1, 2016, Austin, TX.

PAPER 54

Clinical Paper Session 8
Trauma 2 — Saturday, September 9, 2017 • 9:31—9:36 AM
Treatment; Prognosis/Outcomes

Reoperation Rates for Scaphoid Fractures and Nonunions: A Statewide Study

Level 4 Evidence

Daniel M. Avery, III, MD
Krystle A. Hearns, MA
Huong Do, MS
Michelle G. Carlson, MD

COI: There is no financial information to disclose.

Hypothesis: To perform a statewide review of scaphoid fractures and nonunions over a 10-year period to identify reoperation rates, procedures performed, and related patient factors.

Methods: A retrospective review of surgically treated scaphoid fractures and nonunions from 2004 to 2013 was performed using the New York Statewide Planning and Research Cooperation System (SPARCS) database. Patients were identified using CPT codes 25440 and 25628. These procedures were evaluated for procedure type, reoperations, subsequent procedure type, and timing.

Results: Over the 10-year period there were 3074 ORIF and 2463 repair of nonunions performed in 5,537 patients. Operations for ORIF and repair of nonunion of scaphoid increased over the 10-year period by 210% and 144%, respectively (P < 0.001 both analyses, Fig. 54-1).

ORIF Reoperations: There were 246 primary reoperations (8%) at an average of 346 days (range; 7-3012). 57% were for removal of hardware, 26% re-repair nonunion/ORIF, 7% debridement procedure, 9% for salvage procedure, and 1% for other wrist surgery. After the first reoperation, 34 second reoperations (1%), 4 third reoperations and 1 fourth reoperation were performed, totaling 285 reoperations (Fig. 54-2).

Repair of Nonunion Reoperations: There were 340 primary reoperations (14%) at an average of 362 days (range; 6-2700). Forty-seven percent were for removal of hardware, 28% for re-repair nonunion/ORIF, 4% for a debridement procedure, 19% for a salvage procedure, and 2% for other wrist surgery. After the first reoperation, 50 second reoperations (2%), 5 third reoperations and 1 fourth reoperation were performed, totaling 396 reoperations (Fig. 54-2).

Salvage Procedures: 115 salvage procedures were performed in 106 patients (2% of all ORIF/repair of nonunions). Seventy-five percent (86) were performed as a first reoperation, 23% (26) as a second, and 2% (3) as a third. Salvages included scaphoid carpectomy (23%), proximal row carpectomy (30%), limited fusion (36%), complete fusion (11%), and wrist arthroplasty (1%). Subsequent reoperations occurred after 15%, 6%, 29%, 40%, and 100% of each salvage type, respectively. For scaphoid nonunions that failed, those treated with a reoperation for repair of nonunion eventually needed a salvage procedure in 10%.

Summary Points:

- The number of scaphoid operations over the 10-year period has significantly increased.
- 8% of scaphoid ORIF’s and 14% of repair nonunions required at least one reoperation, primarily removal of hardware.
- A reoperation for repair of nonunion after a failed previous treatment of a nonunion led to an eventual salvage procedure in only 10% of patients.

- Of salvage procedures performed, limited fusion was the most common but proximal row carpectomy demonstrated the lowest subsequent reoperation rate.

Figure 54-1: ORIF and repair of nonunion primary procedures over a 10-year period.

Figure 54-2: Total number of reoperations.

PAPER 55

Clinical Paper Session 8
Trauma 2 — Saturday, September 9, 2017 • 9:38—9:43 AM
Treatment; Surgical Technique; Prognosis/Outcomes

Outcomes of Scaphoid Nonunion with Segmental Defect Treated with Plate Fixation and Autogenous Cancellous Graft: First Clinical Report

Level 4 Evidence

Jill Goodwin, MD
Sean Mitchell, MD
Ryan DiGiovanni, MD
Scott Edwards, MD

COI: There is no financial information to disclose.

Hypothesis: Treatment of scaphoid nonunion with segmental defect presents a challenging clinical problem. Various techniques have been proposed,
usually involving vascularized bone grafting with or without structural bone. Outcomes of these complex procedures have been inconsistent in the medical literature. The authors hypothesize that similar or perhaps better clinical and radiographic outcomes are possible with a relatively simplified technique of volar plate fixation augmented with autogenous pure cancellous graft.

Methods: The authors performed a retrospective chart review of 49 consecutive patients with scaphoid nonunion with segmental defect treated with plate fixation and pure cancellous bone grafting. Surgical management included a single volar incision, reduction, insertion of bone graft from ipsilateral olecranon and/or distal radius, and application of a volar locking plate. Post-operative outcome measures included time to union based on computerized tomography (CT), return to work, patient-reported pain and disability scores, grip strength, and range of motion (ROM).

Results: The average patient was 31 years old and treated an average of 28 months after initial injury. Twenty-nine patients (59.0%) were treated for nonunion at the scaphoid waist, 19 (38.8%) at the proximal pole, and 1 (2.0%) at the distal pole. 13 patients (26.5%) were treated specifically for avascular necrosis confirmed with magnetic resonance imaging (MRI). Mean follow-up was 18.9 months (range, 12-34). Union was achieved in all patients and average time to union was 78 +/- 18.4 days post-operatively. Complications included symptomatic hardware that required plate removal for 1 patient. Mean DASH score improved from 13.4 +/- 3.7 post-operatively to 41.4 +/- 3.7 post-operatively. Mean visual analogue scale (VAS) improved from 7.0 +/- 0.7 pre-operatively to 2.1 +/- 0.7 post-operatively. All employed patients returned to work, although 5 (13.9%) did not return to full capacity. Grip strength improved from 79.9% of the non-operative side pre-operatively, to 93.5% post-operatively. At final follow-up, ROM including wrist flexion, extension, ulnar deviation, and radial deviation improved 128%, 173%, 112%, and 164%, respectively, compared to pre-operative ROM.

Summary Points:
- The combination of scaphoid plate fixation and pure cancellous bone grafting for scaphoid nonunions with segmental defects yields reliable union rates and good patient outcomes.
- Autogenous cancellous bone grafting is a reliable alternative to more technically demanding or morbid grafting procedures for the treatment of scaphoid nonunions with segmental bone defects.
- In cases of avascular necrosis, outcomes of volar locked plating with pure cancellous grafting appear to be similar, if not superior, to those reported for vascularized bone grafting techniques.

BIBLIOGRAPHY

PAPER 56
Clinical Paper Session 8
Trauma 2 – Saturday, September 9, 2017 ● 9:45–9:50 AM
Treatment; Surgical Technique; Prognosis/Outcomes

The Role of Medial Femoral Condyle Free Vascularized Bone Graft for the Treatment of Failed Scaphoid Nonunion
Surgery associated with Proximal Pole Avascular Necrosis
Level 4 Evidence

Nicholas Pulos, MD
Kathleen M. Kohlitz, MD
Allen T. Bishop, MD
Alexander Y. Shin, MD

COI: There is no financial information to disclose.

Hypothesis: Revision surgery for scaphoid nonunions with proximal pole avascular necrosis is a challenge. We hypothesize that the use of free-vascularized medial femoral condyle bone grafts can heal the bone, revascularize the proximal pole, and restore scaphoid architecture, resulting in acceptable functional outcomes.

Methods: We retrospectively reviewed patients who had failed prior operative treatment for a scaphoid nonunion and proximal pole avascular necrosis. Between May of 2005 and September of 2016, 49 patients were identified with this preoperative diagnosis and subsequent treatment with a medial femoral condylar free vascularized bone flap. Mean time from injury to revision surgery was 24 months, and a mean 15 months following the initial surgery. Of the 49 patients, 36 had a prior bone graft procedure and 6 patients had two previous surgeries. Initial internal fixation was with a scaphoid screw in 43 patients and K-wires alone in 3. All patients had documented avascular necrosis of the proximal pole at the time of our surgery, defined by complete absence of punctate bleeding of the proximal pole with the tourniquet deflated. Carpal indices, time to union, functional outcomes and complications were recorded.

Results: Forty-one of 49 previously operated on scaphoid nonunions healed (84%) at a mean of 16 weeks (range, 9 to 31 weeks) based upon CT scan imaging. Radiographs demonstrated significant improvement in carpal alignment following surgery, as determined by the lateral scaphoid angle, scapholunate angle, radiolunate angle, scaphoid height to length ratio and carpal height ratio. There was a trend towards improved grip strength and no significant change in total wrist range of motion pre- and post-operatively. Twenty-nine patients underwent 21 subsequent planned procedures (removal of buried K wires). There were two superficial postoperative donor site infections, however no patients complained of medial thigh pain at final follow-up. Age, smoking status, BMI, time to surgery, or preoperative radiographic findings were not found to be statistically significant predictors of failure.

Summary Points:
- We present the largest series to date of patients who have undergone revision scaphoid nonunion surgery with documented avascular necrosis of the proximal pole.
- 84% of patients who had failed prior scaphoid nonunion surgery healed at a mean of 16 weeks after treatment with free-vascularized medial femoral condyle grafts.

PAPER 57
Clinical Paper Session 8
Trauma 2 – Saturday, September 9, 2017 ● 9:52–9:57 AM
Evaluation/Diagnosis; Treatment; Basic Science

Biomechanical Strength of Scaphoid Partial Unions
N/A - not a clinical study

Adam C. Brekke, MD
Mark C. Snoddy, MD
Sasidhar Uppuganti, MS
Donald H. Lee, MD
Marc J. Richard, MD
Mihir J. Desai, MD

Grant received from: VICTR

COI: Consulting Fee: Biomet (Lee)

Hypothesis: It is not known how much force a partially united scaphoid can sustain without refracturing. This is critically important in determining when to discontinue immobilization in laborers or active individuals and when considering return to play in athletes. The purpose of this study was to test the biomechanical strength of simulated partially united scaphoids using a validated testing model for scaphoid fractures. We hypothesized that
there would be no difference in the strength of scaphoids with 50% or greater bone at the wrist compared to intact scaphoids.

**Methods:** Forty-one lightly embalmed cadaver scaphoids were divided into 4 groups: 3 experimental osteotomy groups (25%, 50% and 75% of the scaphoid waist) and 1 control group (intact). Each specimen was potted and tested using a validated protocol. Using a materials testing machine (MTS), each scaphoid was subjected to a dorsal to volar cantilever force of 80 N to 120 N for 4,000 cycles, representing a sub-failure physiological load, followed by load-to-failure. Permanent deformation was measured during the physiologic load phase and stiffness, max force, work to failure and mechanism of failure were recorded during load-to-failure testing. Analysis of variance between groups was determined using the Kruskal-Wallis test.

**Results:** All scaphoids survived the sub-failure conditioning with no significant difference in permanent deformation ($P = 0.34$) (Table 57-1). Intact scaphoids endured an average maximum load of 333 N prior to failure, compared to 321 N for the 25% group, 297 N for the 50% group and 324 N for the 75% group, with no statistically significant variance ($P = 0.86$) (Fig. 57-1). There were also no statistically significant differences in stiffness ($P = 0.15$) or work to failure ($P = 0.93$) between the intact, 25%, 50% and 75% groups. One specimen from each osteotomy group failed by fracturing through the osteotomy site; all others failed by fracturing at the distal pole near the loading site. This is consistent with previous reports in the literature.

**Summary Points:**
- Scaphoids with at least 25% of intact cortical bone at the waist can withstand normal physiologic loads.
- The data provide valuable information regarding partial scaphoid union and supports return to play or mobilization once the scaphoid has reached 25% union across the fracture site.

**Table 57-1: Average Values During Physiologic Sub-failure Conditioning and Load-to-failure Testing**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Deformation (mm)</th>
<th>Stiffness (N/mm)</th>
<th>Max Force to Failure (N)</th>
<th>Work to Failure (N-mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>1.42</td>
<td>263</td>
<td>334</td>
<td>781</td>
</tr>
<tr>
<td>25%</td>
<td>2.13</td>
<td>271</td>
<td>321</td>
<td>720</td>
</tr>
<tr>
<td>50%</td>
<td>2.42</td>
<td>194</td>
<td>297</td>
<td>655</td>
</tr>
<tr>
<td>75%</td>
<td>1.82</td>
<td>168</td>
<td>343</td>
<td>703</td>
</tr>
</tbody>
</table>

**Figure 57-1: Max Load to Failure**

**BIBLIOGRAPHY**

Results: Thirty-four (94%) patients healed by average 13 weeks. One experienced delayed union secondary to hardware failure and healed 18 weeks following revision ORIF. Another patient is at 22 weeks with gradual bony bridging. Thirty-nine percent of proximal poles demonstrated ischemia by MRI criteria, but none were infarcted. Fifteen percent had poor punctate bleeding intraoperatively. Forty-five percent proximal poles demonstrated >50% necrosis on histopathologic analysis yet 91% demonstrated foci or robust remodeling. Inter-observer agreement for pathology viability was 0.667. There was no significant association between time to union and histologic viability (P = 0.349), remodeling potential (P = 0.743), or MRI signal (P = 0.419). There was no association between mean MRI viability or signal and pathology grading (P = 0.224, P = 0.743). There was also no association between MRI viability or signal and intraoperative bleeding (P = 0.364, P = 0.386), or between pathologic grading and intraoperative bleeding (P = 0.904). (Figs. 59-1, 59-2)

Summary Points:
- There was no correlation between time to union and any diagnostic modality. MRI and histology did not demonstrate a correlation, indicating that these two assessments measure different aspects of the dysvascular response to injury.
- Despite pathological evidence of dysvascular bone in nearly half of our patients, removal of necrotic bone and non-vascularized bone grafting with rigid internal fixation led to healing in the overwhelming majority of cases.
- We conclude that true proximal pole infarction is a decidedly rare occurrence, and that vascularized bone grafting is seldom required.

BIBLIOGRAPHY


Methods:

Hypothesis: Scaphoid vascularity following nonunion is of considerable concern when planning screw fixation and is thought to correlate with likelihood of healing. We hypothesized that greater proximal pole vascularity would correspond with increased union rate and shorter time to union. Healing was assessed on CT scan according to a 3-point system. Bleeding points were assessed intraoperatively as none, focal, robust, or necrotic trabeculae (yes/no) and remodeling potential as evident by osteoblastic and osteoclastic activity apparent at 10x magnification.

BIBLIOGRAPHY


PAPER 60

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:13—10:18 AM
Treatment; Prognosis/Outcomes

Factors Associated with Recurrent Giant Cell Tumors of the Upper Extremity
Level 4 Evidence

Jonathan Lans, MD
Neal C. Chen, MD
Kamlican Ofbazoglu, MD
Santiago A. Lozano-Calderon, MD

COI:
Consulting Fee: Miami Device Solutions (Chen)
Speakers Bureau: Dupuy-Mitek (Chen)

Hypothesis: There are no factors associated with giant cell tumor recurrence in the upper extremity.

Methods: We retrospectively reviewed 43 patients with a giant cell tumor (GCT) of the upper extremity above the age of 18 years treated at one of our five urban hospitals from 1992-2015. All GCTs were histologically confirmed. Factors evaluated included demographics, clinical information and Enneking and Campanacci classifications. A bivariate analysis was performed to identify factors associated with recurrence. Variables with a P-value of <0.10 in the bivariate analysis were analyzed using a multivariable logistic regression model to identify factors independently associated with recurrent GTC.

Results: The local recurrence rate of GCTs was 39.3%, over a mean follow-up of 68.7 ± 51.1 months. Three quarters of the recurrences occurred within 37 months after initial diagnosis. The most common location for a GCT was the radius (48.8%), followed by the humerus (18.6%), the ulna (18.6%), metacarpal bone (9.3%) and phalangeal bone (4.7%). Giant cell tumors of the radius showed a significantly higher recurrence of 57.1% compared to all other locations combined 25.0% (P = 0.031). Intralesional curettage was performed most frequently (74.4%), followed by resection (23.3%) and amputation (2.3%). In bivariate analysis, resection or amputation had a significantly lower recurrence than in patients treated with intralesional curettage (9.1% vs. 50.0%, P = 0.029). Tumor location and surgery type were not independent factors for recurrence in multivariable logistic regression analysis. There was a positive correlation between treatment with intralesional curettage and GCT’s of the distal radius (r = 0.25). (Tables 60-1, 60-2)

Summary Points:
• We found a more aggressive biological behavior in the distal radius when compared to other locations, characterized by higher recurrence rates, but this appears to co-vary to some degree with intralesional curettage.
• Our findings give support for tumor resection with negative margins in the radius. Reconstruction techniques with hemicortical, intercancellary, osteocartilaginous or hemiosteoarticular allografts may have more utility for management of GCT of the distal radius.

Table 60-1: Bivariate Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients (n = 43)</th>
<th>Recurrence</th>
<th>Location, n (%)</th>
<th>Yes (n = 17)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(n = 26)</td>
<td></td>
<td></td>
<td>0.031†</td>
</tr>
<tr>
<td>Radius</td>
<td>21 (48.8)</td>
<td>9 (42.9)</td>
<td>12 (57.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other locations</td>
<td>22 (51.2)</td>
<td>17 (77.3)</td>
<td>5 (22.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.029†</td>
</tr>
<tr>
<td>Intralesional curettage</td>
<td>32 (74.4)</td>
<td>16 (50.0)</td>
<td>16 (50.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resection or amputation</td>
<td>11 (25.6)</td>
<td>10 (90.9)</td>
<td>1 (9.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

†Logistic regression showed no independent significance

Table 60-2: Logistic Regression Including Tumor Location and Surgery Type

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Odds Ratio</th>
<th>Standard Error</th>
<th>95% Confidence Interval</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location (reference: radius)</td>
<td>3.65</td>
<td>0.27</td>
<td>[0.91, 14.6]</td>
<td>0.0068</td>
</tr>
<tr>
<td>Surgery (reference: intralesional curettage)</td>
<td>0.13</td>
<td>0.14</td>
<td>[0.01, 1.2]</td>
<td>0.0068</td>
</tr>
</tbody>
</table>

PAPER 61

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:20—10:25 AM
Treatment; Prognosis/Outcomes

Survival Rate of Revascularization and Replantation of Digits with Vein Graft Versus Direct Arterial Anastomosis
Level 3 Evidence

Michael T. Milone, MD
Christopher Klifto, MD
Z-Hye Lee, MD
Vishal Thanik, MD
Jacques H. Haqueboud, MD

COI: There is no financial information to disclose.

Hypothesis: The use of vein graft in revascularization and replantation of dysvascular digit yields survival rates similar to direct arterial anastomosis.

Methods: A retrospective review of all patients > 18 years old at a public urban teaching hospital from 2007 to 2017 that required revascularization and/or replantation of one or more digits due to traumatic full or partial amputation was performed. Demographic data, mechanism of injury, level of injury, and digits requiring revascularization and/or replantation were collected. In addition, length of vein graft used, donor site, and use of graft (for artery or vein) were collected. Digit survival was the primary outcome measure.

Results: 135 patients (129 male, 6 female) were identified with 186 affected digits, 127 of which required revascularization and 59 replantation. The data set included 39 thumb, 36 index, 54 middle, 38 ring, and 19 small digits. The average length of stay was 9.2 days. The average peri-operative transfusion requirement was 1.1 units (range 0-13).

Vein graft for arterial anastomosis was utilized in 45.7% of all digits (53% of replanted and 40% of revascularized digits). The average vein graft length was 4.4 cm (range 0.15-12 cm). The overall digit survival rate was 80%. The 81% survival rate of digits requiring a vein graft was not different (P = 0.74) than the 79% survival rate of those that underwent direct arterial anastomosis. Similarly, the survival rate of revascularized digits was not different for digits treated with or without a vein graft (93% survival for both vein grafted digits and for those
treated with direct arterial anastomosis, \(P = 0.86\). Finally, digits replanted with a vein graft survived 53% of the time compared to the 52% survival rate of those replanted without the use of a vein graft, which was also not statistically different \((P = 0.94)\).

**Summary Points:**
- Vein grafts were utilized for arterial repairs in nearly half of all dysvascular digits that underwent revascularization or replantation.
- There was no statistical difference in the survival rate of dysvascular digits treated with a vein graft versus those that underwent direct arterial anastomosis.
- The need for a vein graft for a large zone of injury should not be considered a relative contraindication to perform revascularization or replantation of dysvascular digits.
- If the zone of injury is large, surgeons should have a low threshold to use vein grafts for the revascularization or replantation of digits.

**PAPER 62**

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:27—10:32 AM Evaluation/Diagnosis; Treatment; Basic Science

**Involvement of Thrombin and Osteopontin in the Pathophysiology of Dupuytren’s Contracture**

*Masaya Tsujii, MD, PhD
Haruhiko Satonaka, MD, PhD
Akihiro Sudo, MD, PhD*

**C0:** There is no financial information to disclose.

**Hypothesis:** Pathophysiology of Dupuytren’s contracture (DC) remains unclear.1,2 Thrombin is a multi-functional serine protease and a potent inducer of fibrogenic cytokines in various cells. Osteopontin (OPN), one of ECM proteins, can also modulate a variety of cellular activities associated with various chronic inflammatory disease including myocardial fibrosis after ischemic heart disease, liver cirrhosis and lung fibrosis.3,4 Additionally, the presence of the thrombin-cleaved form of OPN is well correlated with various inflammatory disease activities.5 We herein presented that myofibroblast (MF) expressed osteopontin, especially of thrombin-cleaved form, and the administration of thrombin induced differentiation into MF of fibroblast derived from Dupuytren’s fascia.

**Methods:** The study group consisted of 25 patients (4 women and 21 men) who underwent resection of the palmer fascia for DC. The patients’ mean age was 69.1 years (range, 58 to 82 years). All patients signed an informed consent document, and the study was approved by the institutional review board. The palmer aponeurosis resected in carpal tunnel release were used as control. Immunohistochemical studies were performed on serial sections with antibody against aSMA, OPN and thrombin cleaved-form of OPN antibody. For the determination of the effect of thrombin on DC, cells isolated from nodules and cords were starved in serum-free medium overnight prior to treatment with thrombin, 1 U/ml. After 24 hours, expression of aSMA and OPN were analyzed in total proteins collected from cells.

**Results:** Morphometric analysis showed that expression of aSMA was significantly correlated with that of OPN in the nodules of Dupuytren’s fascia. In addition, there was expression of OPN and aSMA in 16 (67%) and 5 (20%) of 25 cases, respectively. Furthermore, thrombin-cleaved OPN was also immunelabeled on similar areas with OPN in nodules of Dupuytren’s fascia (Fig. 62-1), considered that the majority of OPN’s expression was thrombin-cleaved form in the nodules centered in the pathology. After treatment of thrombin, expression of aSMA and OPN were clearly upregulated in the cells from nodules as well as cord in western-blotting (Fig. 62-2), although there were weak expression of these molecules without application of thrombin.

**Summary Points:** The present study showed that myofibroblast expressed osteopontin (OPN) as well as thrombin-cleaved OPN in the nodules of Dupuytren’s contracture (DC). In in vitro study, thrombin induced differentiation into myofibroblast from fibroblasts of both nodules and cords. Thrombin may involve in the pathology of progression and recurrence by direct effect or indirect pathway via cleavage of OPN.

**Figure 62-1:** Immunolabeling for osteopontin.

![Immunolabeling for osteopontin](image1)

**Figure 62-2:** Western-blotting after treatment of thrombin.

**BIBLIOGRAPHY**

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:34–10:39 AM
Evaluation/Diagnosis; Treatment; Prognosis/Outcomes

Quantifying the Effect of Diabetes on the Pathogenic Microbiology, Infection Severity, and Clinical Outcomes of Surgical Hand Infections: A High-Powered, Prospective Analysis
Level 1 Evidence
Ketan Sharma, MD, MPH
Deng Pan, BA
James Friedman, MD
Aaron Blake Mull, MD
Amy Moore, MD

COI: There is no financial information to disclose.

Hypothesis: The effect of diabetes on surgical hand infections in a prospective, high-powered, and inclusive analysis remains unknown. We hypothesize that diabetes worsens the burden of disease, and that diabetic inpatients may benefit from stronger glycemic control.

Methods: A prospective cohort study enrolled diabetic and non-diabetic surgical hand infection patients over three years. Patient background, clinical presentation, pathogenic microbiology, and surgical triage variables were recorded. Surgical triage included setting of first drainage (bedside vs. operative) and level of care (outpatient vs. inpatient). Diabetic factors included baseline glycosylated hemoglobin (HbA1c), blood glucose (BG) at presentation, and average value of inpatient BG measurements. Consistent with existing guidelines, poor baseline control was defined as HbA1c > 9.0%, and poor inpatient control as average BG > 180. Clinical outcomes included need for repeat drainage and inpatient length-of-stay (LOS), with prolonged LOS defined as > 75th percentile. Multivariate logistic regression quantified the effect of diabetic factors on outcomes.

Results: 322 patients were accrued: 76 diabetic and 246 non-diabetic. Diabetics were more likely to be older (median 54 vs. 37 years, P = 0.05). However, poor inpatient glycemic control predicted both need for repeat drainage (OR3.16, P = 0.05) and prolonged LOS (OR4.65, P < 0.01). (Fig. 63-1, Table 63-1)

Summary Points:
- Diabetes exacerbates the burden of disease of surgical hand infections, as evidenced by more-proximal locations and deeper involved anatomy (bone/joint/fascia) at presentation, broader microbiology, increased need for repeat drainage, and longer inpatient LOS, when compared to non-diabetics.
- Diabetic surgical hand infections should have fungal cultures sent from first drainage.
- Diabetics would benefit from more-aggressive inpatient glycemic control to reverse hyperglycemia-induced impairment of native immunity and hasten resolution of infection.

Table 63-1: Controlled Effect of Diabetic Factors on Outcomes, Amongst Diabetics Only

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (OR) [95% CI]</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for Repeat Drainage&lt;sup&gt;a&lt;/sup&gt; (n = 38)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor Baseline Control&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.53 [0.67, 9.48]</td>
<td>0.17</td>
</tr>
<tr>
<td>Blood Glucose at Presentation</td>
<td>1.00 [1.00, 1.00]</td>
<td>0.07</td>
</tr>
<tr>
<td>Poor Inpatient Control&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.16 [1.07, 10.15]</td>
<td>0.05</td>
</tr>
<tr>
<td>Prolonged Inpatient Length-of-stay&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.65 [1.13, 19.06]</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

<sup>a</sup>Defined as need for additional surgical drainage, after initial drainage.
<sup>b</sup>Defined as HbA1c ≥ 9.0, consistent with U.S. Department of Health and Human Services recommendations.
<sup>c</sup>Defined as average blood glucose ≥ 180 during hospital course for inpatients only, consistent with American Diabetes Association recommendation.
<sup>d</sup>Defined as length-of-stay ≥ 75<sup>th</sup> percentile (8 nights), for inpatients only.

BIBLIOGRAPHY

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:41–10:46 AM
Treatment; Surgical Technique; Prognosis/Outcomes

Optimizing Therapeutic Anticoagulation for Finger Replantation: A Retrospective Analysis of Outcomes
Level 4 Evidence
Johnny Ionut Efanov, MD, CM

COI: There is no financial information to disclose.

Hypothesis: While indications for initiation of postoperative anticoagulation in finger replantation have been established, specific protocols for duration, methods of infusion and modalities for cessation have yet to find a consensus and remain subject to surgeons’ preference. The aim of this study is to investigate the best cessation protocol of intravenous anticoagulation in patients treated for finger replantation.

Methods: A retrospective review of all patients treated for a finger replantation between December 2014 and July 2016 was performed. From these procedures, we extracted only those who required postoperative treatment with intravenous heparin. Primary outcome was survival of finger at hospital discharge and data collection focused on patient characteristics, surgical technique and postoperative anticoagulation regimens. Statistical analysis was conducted with Pearson’s chi-squared test and presented as odds ratios with 95% confidence intervals and a significant P-value of P < 0.05. (Fig. 64-1)

Results: From 182 patients with replantation, 108 (163 fingers) were included in the analysis when treated with intravenous heparin. Among this group, survival rate was 60% (n = 65) at hospital discharge, wherein arterial insufficiency accounted for 60% of reasons for failure and venous thromboses represented 40%. Descriptive analysis failed to demonstrate an increase in failure rates when tested for duration of intravenous heparin, fixed or variable infusion rates of anticoagulation and need for vascular grafts. However, there was a 2.8-fold (95% CI [1.258, 6.230], P = 0.009) increase in the rate of survival with progressive weaning of...
anticoagulation rather than abrupt discontinuation. Subgroup analysis demonstrated similar findings when considering arterial insufficiencies alone (OR 5.2, 95% CI [1.420, 19.039], P = 0.012), but did not show any significant difference for venous thromboses (OR 1.7, 95% CI [0.433, 6.381], P = 0.344). (Table 64-1)

**Summary Points:**
- Progressive tapering of intravenous heparin perfusion appears to increase survival rates of finger replantation, particularly for arterial insufficiencies.
- There are currently no recommendations to be made with regards to length of anticoagulation, methods of infusion and indications for vascular grafts.
- Further prospective and randomized trials are necessary to elucidate these factors.

**Table 64-1: Survival Outcomes of Finger Replantation at Hospital Discharge in Relation to Variables of Anticoagulation Protocols.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total Number</th>
<th>Number of Failure (Total Percentage)</th>
<th>Rate</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 7 days vs 8 days</td>
<td>36</td>
<td>16 (44.4%)</td>
<td>0.750</td>
<td>0.333-1.690</td>
<td>0.487</td>
</tr>
<tr>
<td>8-14 days vs ≥ 15 days</td>
<td>72</td>
<td>27 (37.5%)</td>
<td>1.547</td>
<td>0.701-3.414</td>
<td>0.278</td>
</tr>
<tr>
<td>&lt; 8 days or ≥ 14 days</td>
<td>67</td>
<td>24 (35.8%)</td>
<td>1.547</td>
<td>0.701-3.414</td>
<td>0.278</td>
</tr>
<tr>
<td>≥ 15 days vs ≤ 14 days</td>
<td>103</td>
<td>40 (38.8%)</td>
<td>0.423</td>
<td>0.068-2.645</td>
<td>0.345</td>
</tr>
<tr>
<td>Vascular graft vs no graft</td>
<td>35</td>
<td>15 (42.9%)</td>
<td>0.380</td>
<td>0.366-1.882</td>
<td>0.655</td>
</tr>
<tr>
<td>Primary end-to-end anastomosis</td>
<td>73</td>
<td>28 (38.4%)</td>
<td>0.000</td>
<td>0.000-1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**Table 65-1: Management of Pseudoaneurysm**

<table>
<thead>
<tr>
<th>Case #</th>
<th>Treatment</th>
<th>Indication</th>
<th>Res?*</th>
<th>Days**</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excision</td>
<td>Bleeding</td>
<td>Yes</td>
<td>21</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Excision</td>
<td>Fever/size</td>
<td>Yes</td>
<td>7</td>
<td>Wound</td>
</tr>
<tr>
<td>3</td>
<td>Excision</td>
<td>Pain/size</td>
<td>Yes</td>
<td>29</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Excision</td>
<td>Pain/size</td>
<td>Yes</td>
<td>16</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Nonoperative</td>
<td>NA</td>
<td>Yes</td>
<td>13</td>
<td>Finger ischemia</td>
</tr>
<tr>
<td>6</td>
<td>Excision/CT release</td>
<td>Acute CTS</td>
<td>Yes</td>
<td>5</td>
<td>Reoperation</td>
</tr>
<tr>
<td>7</td>
<td>Embolization</td>
<td>Pain/size</td>
<td>Yes</td>
<td>7</td>
<td>Elbow pain/stenosis</td>
</tr>
<tr>
<td>8</td>
<td>Nonoperative</td>
<td>NA</td>
<td>Yes</td>
<td>42</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Nonoperative</td>
<td>NA</td>
<td>Yes</td>
<td>30</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Excision/repair x 3</td>
<td>Compliance</td>
<td>Yes</td>
<td>11</td>
<td>Renal failure</td>
</tr>
<tr>
<td>11</td>
<td>Nonoperative</td>
<td>NA</td>
<td>Yes</td>
<td>23</td>
<td>No</td>
</tr>
</tbody>
</table>

**BIBLIOGRAPHY**


**PAPER 65**

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:48–10:53 AM
Evaluation/Diagnosis; Treatment

**Catheter Associated Radial Artery Pseudoaneurysm**

Level 4 Evidence

Rick Tosti, MD
Sezai Ozkan, MD
Kyle R. Eberlin, MD

**Hypothesis:** Hand surgeons may be asked to manage pseudoaneurysm more frequently, as the radial artery has been increasingly utilized for arterial access during cardiac catheterization in recent years. We hypothesized that small radial artery pseudo aneurysms (PSA) may resolve spontaneously and without sequel.

**Methods:** We reviewed all patients diagnosed with radial artery PSA resulting from arterial line placement or radial artery access for cardiac procedures from 2010 — 2015.

**Results:** We identified 11 cases — 5 caused by arterial lines and 6 caused by cardiac procedures. The diagnosis was confirmed by duplex ultrasound in all cases; PSA size ranged from <1 cm to 5 cm in diameter. Spontaneous thrombosis (over a mean of 27 days) occurred in 4 cases, which were all smaller than 3 cm. Surgery was performed in 7 cases with excision of the stalk and repair of the artery as the most common procedure. Only one case was performed emergently for acute carpal tunnel syndrome. Complications occurring either from the PSA or the treatment were recorded in 5 cases. One patient was affected by ischemia in the digits; no patients experienced compartment syndrome or aneurysm rupture. (Tables 65-1, 65-2)

**Summary Points:**
- Spontaneous thrombosis may occur in smaller lesions over a few weeks.
- When required, surgery to evacuate the hematoma and repair the artery was effective in all cases.
- Ischemia occurred in one patient; compartment syndrome or aneurysm rupture did not occur in this series.
For the continuous variables differences in the averages between two groups were tested by either a two sample t-test or Wilcoxon rank sum test as appropriate. Categorical variables were assessed with Chi-square and Fisher exact tests as appropriate (A P value 0.05).

**Results:** We had 9 subjects enrolled: 2 Hispanics, 3 Caucasians, and 4 African-American. We found a consistently reliable decrease in the tissue oxygenation using NIRS in all patients regardless of skin pigmentation. On average, there was a decrease of 19.4% in tissue oxygenation (range 14%-25%) using NIRS with the starting oxygenation at 76.6% (range 66%-85%) and ending oxygenation at 57.2% (range 48%-67%). There was no such decrease in the temperature readings. There was no significant difference in the change in NIRS tissue oxygenation or temperature between patients with Fitzpatrick 3, 4, and 5 skin types or when patients were grouped into Fitzpatrick less than and equal to or greater than 3 or less than and equal to or greater than Fitzpatrick 4 (P > 0.05). There was also no significant difference seen in patients with Von Luschan scores less than and equal to or greater than 20 (P > 0.05).

Summary Points:
- NIRS identified ischemia in all patients. It is a reliable way to non-invasively monitor tissue ischemia regardless of skin pigmentation.
- Surface temperature probes did not identify ischemia in any patient.
- Our study suggests that NIRS should be strongly considered in patients with increased skin pigmentation when evaluating tissue for ischemia.

**Table 65-2: Patient Demographics and Risk Factors**

<table>
<thead>
<tr>
<th>Case #</th>
<th>Age</th>
<th>Sex</th>
<th>Procedure</th>
<th>Urgent?</th>
<th>Anticoagulation</th>
<th>Catheter</th>
<th>Platelet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>94</td>
<td>F</td>
<td>A line</td>
<td>Yes</td>
<td>aspirin/warfarin</td>
<td>NA</td>
<td>111</td>
</tr>
<tr>
<td>2</td>
<td>54</td>
<td>F</td>
<td>A line</td>
<td>Yes</td>
<td>none</td>
<td>NA</td>
<td>168</td>
</tr>
<tr>
<td>3</td>
<td>83</td>
<td>F</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>aspirin/clonidine</td>
<td>5F</td>
<td>165</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>F</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>warfarin/exenatide</td>
<td>5F</td>
<td>217</td>
</tr>
<tr>
<td>5</td>
<td>74</td>
<td>F</td>
<td>A line</td>
<td>Yes</td>
<td>aspirin/clonidine/</td>
<td>hep gtt</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>66</td>
<td>F</td>
<td>A line</td>
<td>No</td>
<td>fondaparinux</td>
<td>NA</td>
<td>121</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
<td>F</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>aspirin/clonidine</td>
<td>NR</td>
<td>205</td>
</tr>
<tr>
<td>8</td>
<td>61</td>
<td>M</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>aspirin/warfarin</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>M</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>aspirin</td>
<td>6F</td>
<td>153</td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>F</td>
<td>A line</td>
<td>No</td>
<td>rivaroxaban</td>
<td>NA</td>
<td>140</td>
</tr>
<tr>
<td>11</td>
<td>77</td>
<td>F</td>
<td>Cardiac cath</td>
<td>Yes</td>
<td>aspirin/exenatide</td>
<td>6F</td>
<td>253</td>
</tr>
</tbody>
</table>

A line = arterial monitoring line. Cardiac cath = cardiac catheterization. NA = not applicable. NR = not recorded.

**BIBLIOGRAPHY**


**PAPER 66**

Clinical Paper Session 9
Vascular/Soft Tissue/Tumor — Saturday, September 9, 2017 • 10:55—11:00 AM
Evaluation/Diagnosis

**Relative Tissue Oxygenation Changes are More Reliable than Clinical Exam or Temperature Changes for Detecting Early Tissue Ischemia**

*Level 2 Evidence*

Elizabeth M. Polfer, MD
Jennifer Sabino, MD
Isaac Fleming, CCRC
Kenneth R. Means, MD

Grant received from: Raymond M Curtis Foundation

**COI:** There is no financial information to disclose.

**Hypothesis:** In a prior study, it was demonstrated that increased skin pigmentation results in a significant difference in the ability for board certified plastic and orthopaedic hand surgeons to clinically assess an ischemic limb with a physical exam alone (92.9% for Caucasians versus 23.3% for African Americans). We hypothesized that there are non-invasive adjuvants to physical exam to better assess ischemia regardless of skin pigmentation.

**Methods:** A prospective study of healthy controls exposed to limb ischemia was conducted to determine if adjuvants to physical exam are reliable methods to determine ischemia regardless of skin pigmentation. The subjects were classified based on skin pigmentation using a defined skin type assessment tool (Fitzpatrick Scale), a visual color scale (Von Luschan), and self-description of race. Ischemia was induced by tourniquet insufflation to 250 mmHg. A surface temperature probe and a near-infrared spectroscopy (NIRS) monitor were placed on the skin in the PIA skin territory. The readings from both monitors were taken at baseline and every 15 seconds thereafter until 10 minutes.
baseline with Finkelstein test (P = 0.194) and palpation (P = 0.802), pa-
tients in the betamethasone group had significantly lower pain at 6 weeks
with the Finkelstein test (22/100 vs. 46/100; P = 0.031) and palpation (15/
100 vs. 52/100; P = 0.002). Over half of patients in the ketorolac group
required an additional injection at six-weeks, compared to less than one-
quarter in the betamethasone group (9/17 = 52.9% vs. 3/13 = 23.1%; P =
0.098). While there was no significant difference in the VR-12 between
groups at six weeks, DASH disability/symptom (8.5 vs. 35.6; P = 0.001)
and work (9.4 vs. 33.2; P = 0.0210) scores were significantly better in the
betamethasone group.

Summary Points:
• Patients randomized to betamethasone injection had significantly lower
pain scores and better patient-recorded outcomes at six weeks compared
to patients randomized to ketorolac injection.
• While not statistically significant, patients randomized to the ketorolac
group (9/17) were more likely to require a second injection compared to
patients randomized to betamethasone (3/13).
• Preliminary results indicate that betamethasone is a superior treatment for
DeQuervains tenosynovitis, which suggests that the mechanism of action of
betamethasone may not be its anti-inflammatory action.

BIBLIOGRAPHY
1. Min KS, St Pierre P, Ryan PM, Marchant BG, Wilson CJ, Arrington ED. A double-
blind randomized controlled trial comparing the effects of subacromial injec-
tion with corticosteroid versus NSAID in patients with shoulder impingement

PAPER 68
Clinical Paper Session 10
Tendon/Trigger Finger — Saturday, September 9, 2017 • 11:09–11:14 AM
Evaluation/Diagnosis; Treatment; Prognosis/Outcomes
Factors of Delayed Symptom Relief after A1 Pulley Release
for Trigger Fingers
Level 4 Evidence
Jong Hun Baek, MD
Jae Hoon Lee, MD
Duke Whan Chung, MD
Kyu Jin Kim, MD
Chung Hwan Lee, MD
Hyun-Ho Lee, MD
COI: There is no financial information to disclose.
Hypothesis: This study aimed to analyze the factors that affect the length of
time required until symptom relief after A1 pulley release in trigger finger
patients.
Methods: The authors reviewed 106 patients (163 fingers) who underwent
open A1 pulley release for trigger finger from 2006 to 2016 and were fol-
lowed up for more than 1 month after operation. There were 16 males and 90
females. The mean age at operation was 56 years (range: 21-81). The average
follow-up period was 21.5 months (range: 1-127). Delayed symptom relief
was defined as cases in which symptom relief required more than 6 weeks
after operation. The factors analyzed for delayed symptom relief were pre-
operative symptom duration, number of preoperative corticosteroid injec-
tions, proximal interphalangeal joint flexion contracture, multiple trigger
finger lesions, type 2 diabetes mellitus, and carpal tunnel syndrome.
Results: 98.7% of patients had symptom relief after operation. The mean
symptom relief period was 5.1 weeks (range: 2-34) after operation. 28.2%
of patients had delayed symptom relief. In these cases, the mean symptom
relief period was 10.5 weeks (range: 6-34). The symptom relief period was
positively correlated with preoperative symptom duration (P < 0.001;
Pearson correlation coefficient, 0.709) and the number of preoperative corticosteroid injections (P < 0.001; Pearson correlation coefficient, 0.772).
Risk of delayed symptom relief increased with more than 2 preoperative
corticosteroid injections (P < 0.001; OR, 5.57). No significance was found
in gender, multiple trigger finger lesions, proximal interphalangeal joint
flexion contracture, type 2 diabetes mellitus, or carpal tunnel syndrome.
There was no nerve injury, infection, or recurrence after operation.
Summary Points:
• Symptom relief period after open A1 pulley release for trigger fingers was
positively correlated with preoperative symptom duration and number of
preoperative corticosteroid injections.
• More than 2 preoperative corticosteroid injections may increase the risk
derelated symptom relief.
• We recommend physicians to consider the preoperative symptom dura-
tion, number of corticosteroid injection when deciding the timing of
operation, and to explain the patients about the possibility of delayed
symptom relief.

PAPER 69
Clinical Paper Session 10
Tendon/Trigger Finger — Saturday, September 9, 2017 • 11:16–11:21 AM
Evaluation/Diagnosis; Treatment; Prognosis/Outcomes
A Prospective Study of Risk Modeling for Stenosing
Tenosynovitis
Level 2 Evidence
Andrew D. Sobel, MD
Adam E.M. Eltorai, MSc
Peter Mansuripur, MD
Barrett Weiss, BS
Paul F. Velleman, PhD
Arnold-Peter C. Weiss, MD
COI:
Royalty: Depuy, Extremity Medical (Weiss)
Receipt of Intellectual Property Rights/Patent Holder: Depuy, Integra,
OsteoSpring (Weiss)
Contracted Research: NIH (Weiss)
Ownership Interest: Illuminoss, Extremity Medical LLC (Weiss)
Hypothesis: Multiple patient-related risk factors have been identified as
contributors to failure of non-operative treatment for stenosing tenosyno-
vitis (STS). Identifying patients most “at-risk” for progression to surgery
after corticosteroid injection would allow providers to select appropriate
patients for earlier surgical release, avoid costs, and optimize treatment.
Methods: Patients were prospectively enrolled in an IRB-approved study
between March 2014 and June 2015 after a new diagnosis of STS was
made. Demographic and symptom-related information was collected. Each
affected digit received a corticosteroid injection. Patients were followed for
2 years by evaluating medical records and surveying via phone every 6
months. Patients with recurrent symptoms were treated with up to three
corticosteroid injections prior to A1-pulley release, though patients could
elect for surgery at any time. Comparative statistical analysis of using
Fisher’s exact tests, t- and F-tests, and logistic regressions were performed.
Results: One hundred sixty-seven patients with 186 affected digits were
enrolled and injected. Patients were an average of 61.6 years old (SD 11.2)
and 63.1% were female. Sixty-five digits (34.9%) went on to surgery, 81.5% having progressed to surgery within 1 year from initial injection (Fig.
69-1). Digits that were symptomatic for <3 months prior to first
injection were 1.8 times more likely to progress to surgery than those that
had ≥3 months of symptoms (P = 0.005). Of the 48 diabetics, 29.2%
progressed to surgery vs. 37.0% of non-diabetics (RR 0.79, P = 0.33), with
no difference in non-operative treatment time prior to surgery (243.3 vs.
231.5 days, P = 1.0). There was no difference in progression to surgery
between insulin-dependent and noninsulin-dependent diabetics (RR 1.05,
P = 1.0). Patients of increasing age were less likely to have surgery (P = 0.016) and were more likely to have suffered from symptoms of longer
duration prior to presentation (P = 0.009). Digits that were one of multiple
fingers affected with STS in the same person at the time of presentation
were less likely to progress to surgery (RR 0.37, P = 0.01).
Only 34.9% of patients with new STS required surgery within a 2-year follow-up period with most (81.5%) having surgery within 1 year of presentation.

Digits symptomatic for < 3 months were 1.8 times more likely to require surgery than those with symptoms = 3 months.

Diabetic and non-diabetic digits do not respond differently to corticosteroid injections.

Patients with multiple symptomatic digits are less likely to need surgery than single-digit patients after corticosteroid injection(s).

Despite longer symptom duration, older patients are less likely to progress to surgery.

Summary Points:

- 3-dimensional tenocyte tissue constructs can be created using human tenocytes engrafted onto electrospun nanofiber scaffolds, and maintained in low and normal oxygen conditions over time.
- Human tenocyte tissue constructs achieve a tendon-like phenotype to a greater extent in hypoxic conditions, under tensile stress, as compared to static normoxic conditions.
- Knowledge of the molecular mechanism underlying maintenance of the human tenocyte phenotype in a 3-dimensional environment over time will enhance construct survival and success in the in vivo environment.

BIBLIOGRAPHY


Figure 69-1: Survival curve of trigger digits free from surgery.

PAPER 70

Clinical Paper Session 10
Tendon/Trauma — Saturday, September 9, 2017 • 11:23—11:28 AM
Basic Science

Hypoxia and Tension Maintain Human Tenocyte Tissue Constructs in the 3D Microenvironment

N/A - not a clinical study

Rowena McBeath, MD, PhD
Richard W. Edwards, BS, MS
Robert L. Mauck, PhD
Irving Shapiro, PhD
A. Lee Osterman, MD

Grant received from: NIA AG048118 (2014) and Jahnigen foundation/AGS GEMSSTAR (2014)

C0I: There is no financial information to disclose.

Hypothesis: Tendon tissue constructs are urgently needed in surgical treatment of patients with traumatic tendon loss. Previous studies have elucidated the effects of time, cell density and oxygen levels on maintenance of the human tenocyte phenotype in vitro; we hypothesized that these conditions could be translated to a 3D construct fit for future in vivo clinical applications.

Methods: Human tenocytes were isolated from patients (ages 20-35) undergoing revision amputation for traumatic hand injury using IRB-exempt protocols (1#14E.621). To form the tenocyte tissue constructs, electrospun nanofiber scaffolds were fabricated using collagen I solution expressed through a spinneret along 15kV electric field over a defined air gap, collected onto a rotating mandrel, and sterilized under UV prior to cell seeding according to established protocols (1). Human tenocytes (p4) were seeded onto scaffolds and cultured in normal oxygen (21%O2, normoxic) and low oxygen (1%O2, hypoxic) conditions, and harvested after 2, 4, and 8 weeks in static or dynamic (bioreactor, (2)) culture for immunohistochemical, qRT-PCR and western blot analysis of tenocyte (collagen I, scleraxis, tenomodulin), fibrocartilage (collagen III) and chondrocyte (collagen II, sox9) markers.

Results: Human tenocytes engrafted onto electrospun nanofiber scaffolds and maintained a tissue-like phenotype over time in hypoxic culture. When cultured statically – in the absence of tension or compression – culture of tenocyte tissue constructs in hypoxic conditions resulted in more robust tenocyte tissue appearance, increased collagen I and decreased aggrecan expression compared to normoxic conditions at 8 weeks. When cultured dynamically under bioreactor tensile conditions, tenocyte tissue constructs collagen III expression levels were inhibited to a greater extent than those in static conditions.

Summary Points:

- 3-dimensional tenocyte tissue constructs can be created using human tenocytes engrafted onto electrospun nanofiber scaffolds, and maintained in low and normal oxygen conditions over time.
- Human tenocyte tissue constructs achieve a tendon-like phenotype to a greater extent in hypoxic conditions, under tensile stress, as compared to static normoxic conditions.
- Knowledge of the molecular mechanism underlying maintenance of the human tenocyte phenotype in a 3-dimensional environment over time will enhance construct survival and success in the in vivo environment.

BIBLIOGRAPHY


PAPER 71

Clinical Paper Session 10
Tendon/Trauma — Saturday, September 9, 2017 • 11:30—11:35 AM

Treatment

The Outcomes of Extension Block Pinning and Non-operative Management for Mallet Fracture

Level 3 Evidence

Jaekwang Kim, MD, PhD
Taekyoon Lee

C0I: There is no financial information to disclose.

Hypothesis: The null hypothesis of this study was that no difference exists in the clinical outcomes of surgically and non-operatively managed mallet fractures involving more than one-third of the articular surface.

Methods: Forty-nine patients with a mallet fracture involving more than one-third of the articular surface, but without dislocation of the distal interphalangeal (DIP) joint were reviewed. The DIP joint dislocation is defined when the anterior neck-head line of the middle phalanx is located posteriorly compared to the anterior tip of distal phalanx base in the lateral view (Fig. 71-1) the DIP joint was defined Twenty-six cases were treated using...
extension block pinning (surgery group) and 23 were treated non-operatively (non-operative group). At the final follow-up, extension lag and flexion of the DIP joint of the affected digit were measured. DIP joint pain was rated using a visual analogue scale and the overall clinical outcomes were graded using Crawford’s criteria. Complications, including nail deformity and dorsal prominence, were also assessed. The rate of DIP joint subluxation, fracture fragment size, and time to union were radiographically evaluated.

**Results:** Mean extension lag and flexion of the DIP joint, and mean visual analogue pain scores were not significantly different between the two groups. Outcomes as assessed using Crawford’s criteria in the surgery group were as follows: excellent for 5, good for 12, fair for 6, and poor for 3. Outcomes in the non-operative group were excellent for 2, good for 11, fair for 8, and poor for 2, which were not significantly different. Moreover, the frequency of nail deformity or dorsal prominence did not exhibit any significant intergroup difference (Table 71-1). The rate of DIP subluxation and mean fracture fragment size were not significantly different between the two groups. All the fractures had united by 3 months after injury in both groups, although the time to union was 1.5 weeks longer in the non-operative group.

**Summary Points:**

- The clinical outcomes do not significantly differ between extension block pinning and non-operative management for mallet fractures involving more than one-third of the articular surface regardless of the presence of joint subluxation as long as those with dislocation excluded.

**Table 71-1: Clinical Outcomes**

<table>
<thead>
<tr>
<th></th>
<th>Surgery group (n = 26)</th>
<th>Non-operative group (n = 23)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension lag (°)</td>
<td>5 (range, 0 — 20)</td>
<td>8 (range, 0 — 25)</td>
<td>0.23</td>
</tr>
<tr>
<td>Flexion (°)</td>
<td>73 (range, 55 — 90)</td>
<td>78 (range, 65 — 90)</td>
<td>0.11</td>
</tr>
<tr>
<td>VAS (points)</td>
<td>1.5 (range, 0 — 5)</td>
<td>0.9 (range, 0 — 3)</td>
<td>0.36</td>
</tr>
<tr>
<td>Crawford criteria</td>
<td>5/12/6/3</td>
<td>3/11/8/2</td>
<td>0.81</td>
</tr>
<tr>
<td>Presence of nail deformity</td>
<td>2</td>
<td>0</td>
<td>0.49</td>
</tr>
<tr>
<td>Dorsal prominence</td>
<td>13/10/3</td>
<td>9/11/3</td>
<td>0.74</td>
</tr>
</tbody>
</table>

**Figure 71-1:** The DIP joint dislocation is defined when the anterior neck-head line of the middle phalanx is located posteriorly compared to the anterior tip of distal phalanx base in the lateral view.
The lateral aspect of the dorsal ridge is a reliable radiographic landmark on the scaphoid, providing surgeons with a convenient starting point to achieve consistent and successful results.

Figure 72-1: Posterolateral radiographic image of screw placed proximal to the lateral aspect of the dorsal ridge of the scaphoid. Custom-made reflective, spherical markers mounted to drill bits and place into the scaphoid and the lunate for real-time capture by infrared cameras can be seen as well.

Table 72-1: Clinical, Radiographic, and Real-time Capture of Movement between Scaphoid and Lunate

<table>
<thead>
<tr>
<th>Position in scaphoid</th>
<th>Manual Movement by exam</th>
<th>Radiographic Change in diastasis (mm)</th>
<th>Real-time capture (diastasis)</th>
<th>Real-time capture (rotation) Change in Euler angles²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal (15)</td>
<td>2</td>
<td>0.492</td>
<td>0.422</td>
<td>1.584</td>
</tr>
<tr>
<td>Distal (16)</td>
<td>13</td>
<td>1.717</td>
<td>1.557</td>
<td>5.694</td>
</tr>
<tr>
<td>P value</td>
<td>&lt; 0.001*</td>
<td>0.012*</td>
<td>0.035*</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

1Relative to lateral aspect of the dorsal ridge
2Scaphoid in respect to lunate
*Indicates significance at P ≤ 0.05 using Mann-Whitney U test

Summary Points:
- Compared to the gold standard motion capture measurements, the surgeon’s clinical estimates and occupational therapist’s goniometer measurements had both poor precision and accuracy for HTER and poor precision for GHCB.
- Surgeon-estimated HTER and Mallet ER scores were poorly correlated, which calls into questions the accuracy of Mallet score measurements.
- Motion capture is an important tool with improved accuracy and precision of shoulder motion measurements and should be considered for routine clinical care for patients with BPBP.

This research was supported by a 2015 Basic Science Grant from the American Foundation for Surgery of the Hand.

**PAPER 73**

Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 • 1:30–1:35 PM
Evaluation/Diagnosis

Comparison of Surgeon and Therapist Shoulder Motion Measurements to Motion Capture Measurements
N/A - not a clinical study

Ross Chafetz, DPT, MPH
Stephanie A. Russo, MD, PhD

Luisa M. Rodriguez, OTR/L
Dan A. Zlotolow, MD
Scott H. Kozin, MD
James G. Richards, PhD

COI: There is no financial information to disclose.

Hypothesis: During office visits, joint ranges of motion are often measured by surgeons using a visual estimate or therapists using a goniometer. This study aimed to assess the accuracy of these measures, and the hypotheses were: (1) poor agreement and (2) poor precision between humerothoracic external rotation (HTER) and glenohumeral cross-body adduction (GHCB) when measured by a surgeon’s clinical estimate, an occupational therapist’s goniometer, and a motion capture system’s measurements in children with brachial plexus birth palsy (BPBP), and (3) poor correlation between HTER measured by motion capture and external rotation (ER) Mallet classification score.

Methods: Twenty-six children (9.9±3.2 years) with BPBP participated in this study. A pediatric hand surgeon visually estimated each child’s passive HTER and passive GHCB during the patient’s clinical visit. An occupational therapist measured the same parameters using a goniometer while motion capture (Vicon, Oxford, UK) measurements of thorax, scapula, and humerus orientations were simultaneously collected. One-way ANOVAs were completed to test for differences between measurement techniques. Bland-Altman plots were created to look at precision and agreement across measurements, and Spearman rho correlation was used exam the relationship between motion capture and Mallet Scale scores.

Results: Comparison of clinical estimates, goniometer measurements and motion capture measurements demonstrated no significant differences (P = 0.751) for GHCB, while all HTER measures were significantly different from each other (P < 0.02). The GHCB comparisons exhibited good accuracy with the Bland-Altman plots with the mean difference near zero, but poor precision with a minimum of 20° deviations from neutral (Fig. 73-1). For HTER, there was poor precision and accuracy (Fig. 73-1). Considering precision using motion capture as the gold standard, both goniometer measurements and clinical estimates overestimated HTER by 9° and 24° respectively (mean differences). There was also poor accuracy, with the smallest 95% CI across all comparisons being +24°. External rotation position Mallet scores correlated with surgeon estimates of HTER (r = -0.43, P = 0.02), but not motion capture (r = -0.24, P = 0.229).

Figure 73-1: Selected Bland-Altman graphs comparing motion capture measurements to occupational therapist’s goniometer measurements for glenohumeral (Gr) cross-body adduction (CBA) and humerothoracic (HT) external rotation.

**BIBLIOGRAPHY**


PAPER 74

Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 ● 1:37–1:42 PM
Treatment; Surgical Technique; Prognosis/Outcomes

Post-operative Complications Following Distal Biceps Tendon Repairs: A Prospective Study
Level 4 Evidence

Jonas L. Matzon, MD
Sreeram Penna, MBBS, MRCS
Dennis P. Martin, BS
Pedro Beredjiklian, MD

COI: Ownership Interest: Matador Medical, Dimension Orthotics LLC, Wright Medical (Beredjiklian)

Hypothesis: The reported incidence of post-operative complications following distal biceps tendon repairs (DBTR) has been largely determined by retrospective and small prospective studies.1–4 We hypothesized that a large prospective cohort study of DBTRs performed at our institution would demonstrate similar complication rates.

Methods: All patients undergoing a primary DBTR by a surgeon from our institution were followed prospectively. The repair technique, post-operative protocol, and follow-up intervals were determined by the individual surgeons’ protocols. At each visit, the surgeon evaluated the patient for any complication, which included infection, wound dehiscence, sensory nerve injury, motor nerve injury, heterotopic ossification, re-rupture, and others. Demographic and surgical data was collected. Descriptive statistics were performed.

Results: Sixty patients (59 male, 1 female) underwent 60 distal biceps repairs by 25 orthopaedic surgeons over the course of 6 months. The mean age of the patients was 47 years (Range: 28 - 62), and the mean Body Mass Index (BMI) was 32 (Range: 23 to 54). Surgical techniques included one-incision tension-slide (33 cases), two-incision Modigliani (26 cases), two-incision Modified Boyd Anderson (26 cases), and one-incision suture anchor (1 case). The average time to surgery was 2.9 weeks (Median: 2, Range: 0.5 - 10), the average post-operative length of immobilization was 1.5 weeks (Range: 0 - 4), and the average follow-up was 12 weeks (Range: 6 - 27). The overall complication rate was 23%. There were 14 sensory nerve injuries: 8 lateral antebrachial cutaneous nerves, 2 superficial radial nerves, 1 non-specific hand numbness, and 3 non-specific forearm numbness. Thirteen of 14 sensory nerve injuries occurred with single-incision techniques (38% of one-incision cases vs 4% of two-incision cases). While there was not a single infection, 1 patient had wound blisters, and 1 patient developed olecranon bursitis. Finally, 1 patient re-ruptured his biceps tendon, which required revision surgery.

Summary Points:
- Patients treated with a one-incision technique have a higher rate of complication than those treated with a two-incision technique.
- Sensory nerve injury, specifically to the lateral antebrachial cutaneous nerve, is the most common complication.
- The prospective incidence of complications is similar to that obtained retrospectively and reported in the literature.

BIBLIOGRAPHY


PAPER 75

Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 ● 1:44–1:49 PM
Treatment; Prognosis/Outcomes; Basic Science

Randomized, Placebo-controlled Clinical Trial Evaluating Ketotifen Fumarate in Reduction of Post-traumatic Elbow Joint Contracture
Level 2 Evidence

Prism S. Schneider, MD, PhD, FRCS
Nicholas Mohtadi, MD, MSc, FRCS
Tolulope Sajobi, PhD
Meng Wang, MSc
Alexandra Garven, BSc
Kevin A. Hildebrand, MD, FRCS

Grant support received from: American Foundation for Surgery of the Hand

COI: There is no financial information to disclose.

Hypothesis: Post-traumatic joint contractures (PTJC) are a significant complication following intra-articular injuries. Our research has established that a myofibробlast-mast cell-neuropetide axis underlies the joint capsule fibrosis that limits motion of the human elbow and a rabbit knee model of PTJC.1–3 In our rabbit model, we have established that Ketotifen Fumarate (KF), a mast cell stabilizer, prevents growth factor release and decreased contracture severity by 50% concomitant with decreased measures of fibrosis.2–4 We hypothesized that oral KF would decrease elbow PTJC severity, compared with placebo, in patients with intra-articular elbow fractures and/or dislocations.

Methods: A randomized, placebo-controlled clinical trial comparing 6-weeks of oral KF 5 mg twice daily to a lactose placebo in patients sustaining distal humerus (AO/OTA 13) and proximal radius +/- ulna (AO/OTA 21) fractures. The primary outcome measure was flexion-extension range of motion (ROM) arc at 12-weeks post-injury. Secondary outcomes included the Disabilities of the Arm, Hand and Shoulder (DASH) score, complication rate, and fracture healing. Statistical analysis consisted of chi-square for categorical variables and ANOVA for continuous variables. Multiple linear regression based on robust estimators was used to assess the adjusted effect of KF.

Results: 145 participants were randomized (76 KF, 69 placebo). There were no significant differences between the two groups for baseline characteristics including age, sex, side of injury, hand dominance, pre-injury work status, time to randomization, injury types, and operation; all P > 0.05 (Table 75-1). The 12-week follow up rate was 88% in the KF group and 89% in the placebo group. There was no significant difference between the treatment groups in the primary outcome measure, serious adverse event rates, or (re) operation rates; P > 0.05. But there was a significant difference between operative and non-operative groups on extension-flexion arc of motion (P = 0.03). Fracture healing at the time of analysis found 48% of participants in each group had achieved union.

Summary Points:
- Patients requiring surgical treatment, as a surrogate for increased injury severity, demonstrated increased PTJC.
- The greater loss of motion at 12 weeks in the operative sub-group will inform future Phase III multi-centre injury inclusion criteria to elbow fractures or dislocations requiring surgical treatment.
Several measures of safety were compiled that confirmed the safety of Ketotifen in elbow fractures or dislocations.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ketotifen</th>
<th>Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age — years, mean (SD)</td>
<td>46.7 (18.3)</td>
<td>44.4 (13)</td>
</tr>
<tr>
<td>Sex — female (%)</td>
<td>41 (54)</td>
<td>29 (42)</td>
</tr>
<tr>
<td>Side of Injury — right (%)</td>
<td>32 (42)</td>
<td>26 (38)</td>
</tr>
<tr>
<td>Hand dominance — right (%)</td>
<td>63 (83)</td>
<td>56 (81)</td>
</tr>
<tr>
<td>Work status — employed (%)</td>
<td>56 (74)</td>
<td>52 (75)</td>
</tr>
<tr>
<td>Injury to randomization — days, mean (SD)</td>
<td>3.7 (2.1)</td>
<td>3.7 (2.1)</td>
</tr>
<tr>
<td>Injury Fracture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 13 (distal humerus):</td>
<td>11:51</td>
<td>7:48</td>
</tr>
<tr>
<td>Type 21 (proximal radius +/- ulna)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury Dislocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Operation — yes (%)</td>
<td>34 (45)</td>
<td>31 (45)</td>
</tr>
</tbody>
</table>

This research was supported by a 2012 Clinical Research Grant from the American Foundation for Surgery of the Hand.

BIBLIOGRAPHY

PAPER 76
Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 • 1:51–1:56 PM
Evaluation/Diagnosis; Treatment
Prospective Evaluation of Single Corticosteroid Injection in Radial Tunnel Syndrome
Level 4 Evidence
Joseph Marchese, MD, MPH
Jennifer Morrisi Wolf, MD
Katy Coyle, RN, BSN
Mark Cote, PhD

COI: Salary: Deputy Editor, The Journal of Hand Surgery (Wolf)

Hypothesis: Radial tunnel syndrome, or compression of the posterior interosseous nerve (PIN), is a diagnosis of exclusion, without clearly defined examination findings or diagnostic tests. We evaluated the utility of a single corticosteroid injection at the PIN in the proximal forearm as a diagnostic measure of radial tunnel syndrome. We hypothesized that corticosteroid injection would serve as a diagnostic and therapeutic measure for PIN compression.

Methods: Based on an a priori power analysis, 40 patients (13 men and 27 women) were prospectively enrolled from the practice of a single orthopaedic hand surgeon after the diagnosis of radial tunnel syndrome was made based on clinical findings including pain with deep palpation over the PIN. The primary outcomes measure was the quick-Disabilities of the Arm, Shoulder, and Hand (quickDASH) instrument. Consented patients also completed a demographic questionnaire and a Visual Analog Scale (VAS) for pain. Each patient was then treated with a single corticosteroid injection placed at the proximal forearm at the area of maximal tenderness, using betamethasone. Patient followup occurred at 2 weeks, 3 months, and one year. Failure of injection and progression to radial tunnel surgery were measured as additional outcomes.

Results: The cohort had a mean age of 49 years and an average BMI of 29. The right side was involved in 30/40 (25%). Outcomes based on quickDASH and VAS scores showed a significant decline from baseline, with quick-DASH decreasing from 49 to 31, and VAS from 6.7 to 3.7 at 52 weeks. During the time period of the study, 10/40 patients (25%) failed conservative treatment and went on to surgery for decompression of the PIN.

Summary Points:
- Radial tunnel syndrome or PIN nerve compression typically presents with lateral elbow and forearm pain without sensory or motor changes.
- Prospective evaluation of corticosteroid injection demonstrated improvement in standardized outcomes measures of pain and function at one year in 75% of patients presenting with symptoms of radial tunnel syndrome.
- Conservative management with injection can be used as a diagnostic and therapeutical modality in the management of radial tunnel syndrome.

BIBLIOGRAPHY

PAPER 77
Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 • 1:58–2:03 PM
Surgical Technique
Augmented Reality-enhanced Elbow Arthroscopy
N/A - not a clinical study
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Hypothesis: Elbow arthroscopy with superimposed bone and nerve visualization based on CT and MRI data is attainable. Accuracy of the resulting augmented reality enhancement to standard arthroscopic technique is acceptable using lens distortion parameters estimated from the calibration pattern.

Methods:
- Experiment 1. We obtained bone and nerve data from CT and MRI scans of a healthy volunteer’s elbow using software (VoTracer; Riken, Wako, Japan) and created a full-size stereolithographic model using a 3D printer. Elbow arthroscopy was performed on this model with computer graphics (CG) superimposed onto the arthroscopic video images. The loci of these data were adjusted with a position tracking device (MicronTracker 3; ClaroNav, Toronto, Canada) that uses real-time stereoscopic vision to detect and track specifically marked objects.
**Results:** We superimposed the CG onto the elbow arthroscopy video images for both the full-size 3D model and the monkey (Fig. 77-1). The arthroscopic view was initially quite different from the superimposed CG due to lens distortion. However, we corrected the CG position and shape to match the arthroscopic view using lens distortion parameters estimated from the calibration pattern (Fig. 77-2). Ultimately, the AR position and shape errors were limited to 2.3 mm at a 1-cm scope—object distance.

**Summary Points:**
- The technological integration of AR into arthroscopy succeeded as a feasibility study and demonstrated acceptable accuracy.
- With further iteration and refinement, the capability of AR-enhanced arthroscopic visualization has the potential to be a transformative technology.
- This technique will contribute to reducing the possibility of serious complications associated with elbow arthroscopy.

**Figure 77-1:** (A) Configuration of augmented reality arthroscopy system. (B) Bones and nerves rendered in 3-dimensional computer graphics. (C) Medial portal view.

**Figure 77-2:** Correction of augmented reality lens distortion, (A) before and (B) after.

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**PAPER 78 WITHDRAWN**

Clinical Paper Session 11
Elbow/Shoulder — Saturday, September 9, 2017 • 2:05–2:10 PM
Treatment; Surgical Technique

**Ulnar Nerve Complications Following Ulnar Collateral Ligament Reconstruction of the Elbow: A Systematic Review**

Level 4 Evidence

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**C0I:** There is no financial information to disclose.

**Hypothesis:** Ulnar nerve complications following ulnar collateral ligament reconstruction (UCLR) of the elbow will vary as a function of surgical approach, graft fixation techniques and ulnar nerve management strategies.

**Methods:** Systematic review of the literature was completed using the MEDLINE, PubMed, and Ovid databases. UCLR case series that contained complications data were included. Ulnar neuropathy was defined as any symptoms or objective sensory and/or motor deficit(s) following surgery.

**Results:** Seventeen articles (n = 1518 cases) met inclusion criteria. The average rate of postoperative ulnar neuropathy was 12.0% overall following any UCLR procedure, and 0.8% of cases required reoperation to address ulnar neuropathy. The surgical approach associated with the highest rate of neuropathy was detachment of flexor pronator mass (21.9%) [versus muscle retraction (15.9%) and muscle splitting (3.9%)]. The fixation technique associated with the highest rate of neuropathy was the modified Jobe (16.9%) [versus DANE TJ (9.1%), figure of 8 (9.0%), interference screw (5.0%), docking technique (3.3%), hybrid suture anchor-bone tunnel (2.9%), and modified docking (2.5%)]. Concomitant ulnar nerve transposition was associated with a higher neuropathy rate (16.1%) compared to no handling of the ulnar nerve (3.9%). Among cases with concomitant transposition performed, submuscular transposition resulted in a higher rate of reoperation for ulnar neuropathy (12.7%) compared to subcutaneous transposition (0.0%).

**Summary Points:**
- 12.0% of UCLR surgeries result in postoperative ulnar nerve complications.
- UCLR techniques associated with the highest rates of neuropathy are detachment of the flexor pronator mass, modified Jobe fixation, and concomitant ulnar nerve transposition.
- This data may help guide surgeons on ways to minimize ulnar nerve complications following this procedure.

**BIBLIOGRAPHY**