Oral Presentation Abstracts

1. Pediatric Hand Fractures: Epidemiology and Patterns of Management
Rebecca Hartley, MD; Josh Lam, MD; Ceilidh Anne Kinlin, MScPT; Karen Hulin-Poli, MScOT; Robertson Harrop, MD, MSc, FRCS, FACS; Franki O.G. Fraulin, MD, FRCS
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Introduction: Pediatric hand fractures are frequent and occur in predictable, age-dependent patterns. While common, only a low proportion of these fractures require surgical intervention. The purpose of this study was to characterize the types of hand fractures managed by Pediatric Plastic surgeons at one centre.

Materials & Methods: Data was collected retrospectively through chart review over one calendar year at a large tertiary pediatric centre. Patients were included in this study if they were under 18 years of age and had a hand fracture (defined as distal to the carpus). Patient demographics were recorded from medical health records and each fracture was detailed individually by using the hospital's picture archiving and communication system. Statistical analysis, using the chi-square test, was performed using patient demographics or fracture characteristics as the independent variable and surgical intervention (defined as any reduction or internal fixation) as the dependent variable with a p-value of <0.05.

Results: The 608 charts reviewed identified 559 fractures in 514 patients. Of these, 68.3% patients were male. The incidence of hand fracture was 91.2 per 100,000 per year. The most common bone fractured was the proximal phalanx (31.9%), the majority of fractures occurred in the little finger (45.3%), and there were 260 epiphyseal fractures (46.3%). The mechanism of injury (MOI) and type of fracture depended upon patient age:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Most Common MOI</th>
<th>Most Common Fracture Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool (0-5 yr)</td>
<td>Crush (19/38, 50%)</td>
<td>Salter-Harris II (18/38, 47%)</td>
</tr>
<tr>
<td>Primary (6-11 yr)</td>
<td>Ball Games &amp; Falls (86/159, 54%)</td>
<td>Salter-Harris II (80/159, 50%)</td>
</tr>
<tr>
<td>Secondary (12-17 yr)</td>
<td>Ball Games (157/362, 43%)</td>
<td>Avulsion (95/362, 26%)</td>
</tr>
</tbody>
</table>

Most patients sustained low energy closed injuries and only a small proportion of injuries involved multiple fractures (8.1%). The majority of fractures were managed non-operatively, with only 10.2% requiring surgery. Chi-square analysis revealed fractures with displacement greater than 2 millimeters, comminution, intra-articular component, angulation greater than 15 degrees in the anterior-posterior or lateral planes, rotation, and open component were significant.

Conclusions: Even though pediatric hand fractures are common, the overwhelming majority of pediatric hand fractures referred to hand specialists did not require surgery. Modifying risk factors to prevent pediatric hand fractures are difficult and we propose that efforts should instead be focused on identifying which of these fractures will require surgery.
2. What About the Children? Incidence of Radial Nerve Palsy in Pediatric Humeral Shaft Fractures
Maureen A O'Shaughnessy, MD; Todd Milbrandt, MD; Laura Lewallen, MD; Kapil Mehrotra, MD; A Noelle Larson, MD
Mayo Clinic, Rochester, MN

**Introduction:** Humeral shaft fractures complicated by radial nerve palsy continue to be an important injury in the adult population with an average incidence of 11.8%; debate is ongoing regarding their optimal management. In the pediatric population, humeral shaft fractures are less common and little information exists regarding the incidence or management of radial nerve palsy in pediatric humeral shaft fractures. This study aims to evaluate incidence and outcomes of radial nerve palsy in pediatric humeral shaft fractures.

**Methods:** IRB-approved retrospective study reviewed pediatric patients treated for humeral shaft fracture between 1996-2016. At latest follow up data including fracture characteristics, operative vs nonoperative management, complications and outcomes were recorded.

**Results:** The series includes 100 patients (32 female, 68 male) with average age at injury of 10 (range 0-17). Average follow up was 34 months (range 2-181) excluding 7 patients deceased from inciting trauma. Fractures in this series were 65 type AO 12A, 13 type 12B and 2 type 12C. Location included proximal (6), middle (72), middle/distal junction (6) and distal third (16). Final fracture treatment consisted of nonoperative (70 patients) and operative (30) management. Humeral shaft fractures complicated by radial nerve palsy continue to be an important injury in the adult population with an average incidence of 11.8%; debate is ongoing regarding their optimal management. Overall, any nerve injury was noted in 8/100 patients including radial (5), ulnar (1), median (1) and mixed radial, ulnar and median nerve symptoms (1) giving an overall incidence of radial nerve palsy of 6%. 8/8 patients with nerve injury had closed injuries. 3/8 patients with nerve injury underwent closed reduction and fixation with flexible nailing. All were treated expectantly with no patient undergoing operative nerve exploration in this series. Incidence of nerve palsy was slightly higher in males (8.8%) vs females (6.4%). Average age of patients with nerve lesion was slightly higher (14 vs 10 years old). Nerve injury was noted in fractures only in the middle, middle/distal, or distal location with no injuries in the proximal third. Nerve recovery was noted in 8/8 patients at an average time to full recovery of 133 days (range 2-378). Average time to onset of recovery was 47 days (range 0.25-145). Median and ulnar nerve palsies showed earlier recovery with average onset of recovery 1 day (range 0.25-2) and average full recovery 3 days (range 2-4).

**Discussion and conclusion:** This study is significant as it is the first to define the incidence (6%) and outcomes (full recovery in all) of radial nerve palsy in pediatric humeral shaft fractures.
3. A Retrospective Review of 10 Years of Pediatric Both Bone Forearm Fractures: Comparison of Single Bone versus Both Bone Fixation

Tyler Keller, MD; Ashley Miller, MD; Kevin J. Little, MD
University of Cincinnati, Cincinnati, OH

Introduction: Both bone forearm shaft fractures are among the most common bony injuries in children. These fractures require operative treatment when a loss of reduction occurs during casting or the fracture is determined to be grossly unstable at the time of initial reduction. This study compares the treatment outcomes of fixation of both the radius and ulna to just the radius or ulna. Additionally, this study compares plate and screw fixation to elastic stabilized intramedullary nail fixation.

Methods: This retrospective study investigates patients under the age of 18 years undergoing operative fixation of both bone forearm fractures between 2003 and 2013 at our single institution. Fracture location of both the radius and ulna was compared (Image 1). Comparative analysis of time to union, complication rate, tourniquet time and overall cost of treatment were examined across different fixation types. Excluded were patients with concurrent unstable ligamentous injury (ex: Monteggia fractures), ipsilateral humerus fracture, percutaneous fixation fractures, as well as patients with incomplete follow-up data.

Results: A total of 401 patients were included in the study, of which 333 patients (83.0%) received fixation of both bones, while 68 (17.0%) received single bone fixation (Figure 1). Zone 2 radius and zone 3 ulna fractures were the most frequent location (Figure 2). Patients undergoing single bone fixation had a shorter time to radiographic union compared to both bone fixation (126.7 days vs 155.1 days; p < 0.001) (Figure 3), a shorter tourniquet time (24.4 versus 38.8 minutes; p = 0.0167) and hospital encounter cost was $11,383.24 compared to $18,517.95 for the single bone fixation and both bone fixation, respectively (p<0.0001). Zone 1 fractures of the ulna had significantly higher times to union than fractures at other locations (p=0.0043). Neither the complication rates (21.0% single bone versus 18.9% both bone; p = 0.367), nor the rate of revision procedures (8% single bone, 3.3% both bone; p=0.367) were significantly different between fixation groups.

Discussion and conclusion: The most recent literature relating to single bone fixation of pediatric both bone forearm fractures remains controversial. This study demonstrates that single bone fixation may have a shorter time to union, similar complication rates, shorter operative time and less overall cost than similar patients with both bone fixation. Intraoperative assessment of stability after fixation of one bone remains the best criteria for determination of suitable patients for single bone fixation.

Image 1
<table>
<thead>
<tr>
<th>Fixation Type</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius only ESIN</td>
<td>39</td>
<td>9.73</td>
</tr>
<tr>
<td>Ulna only ESIN</td>
<td>30</td>
<td>7.48</td>
</tr>
<tr>
<td>Radius only plate</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>Radius and ulna ESIN</td>
<td>284</td>
<td>70.82</td>
</tr>
<tr>
<td>Radius and ulna plate</td>
<td>33</td>
<td>8.23</td>
</tr>
<tr>
<td>&quot;Other&quot; hybrid construct</td>
<td>9</td>
<td>2.24</td>
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</table>

Figure 1

<table>
<thead>
<tr>
<th>Radius Fracture Zone</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>4.49</td>
</tr>
<tr>
<td>2</td>
<td>153</td>
<td>38.15</td>
</tr>
<tr>
<td>3</td>
<td>131</td>
<td>32.67</td>
</tr>
<tr>
<td>4</td>
<td>83</td>
<td>20.7</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>3.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ulna fracture zone</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>2.24</td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>10.22</td>
</tr>
<tr>
<td>3</td>
<td>237</td>
<td>59.1</td>
</tr>
<tr>
<td>4</td>
<td>79</td>
<td>19.7</td>
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<tr>
<td>5</td>
<td>35</td>
<td>8.73</td>
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</table>

Figure 2

<table>
<thead>
<tr>
<th>Fixation Type</th>
<th>N</th>
<th>Mean</th>
<th>Lower 95% CL for Mean</th>
<th>Upper 95% CL for Mean</th>
<th>Median</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius only ESIN</td>
<td>36</td>
<td>171.72</td>
<td>165.30</td>
<td>178.12</td>
<td>168.35</td>
<td>126.11</td>
</tr>
<tr>
<td>Ulna only ESIN</td>
<td>29</td>
<td>144.72</td>
<td>136.89</td>
<td>152.55</td>
<td>141.29</td>
<td>122.42</td>
</tr>
<tr>
<td>Radius only plate</td>
<td>5</td>
<td>86.8</td>
<td>80.54</td>
<td>93.06</td>
<td>82.95</td>
<td>57.78</td>
</tr>
<tr>
<td>Radius + Ulna ESIN</td>
<td>271</td>
<td>149</td>
<td>134</td>
<td>164</td>
<td>147</td>
<td>125.44</td>
</tr>
<tr>
<td>Radius + Ulna Plate</td>
<td>29</td>
<td>162.76</td>
<td>152.22</td>
<td>173.31</td>
<td>162.76</td>
<td>98.68</td>
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<tr>
<td>Other</td>
<td>9</td>
<td>315.11</td>
<td>312.69</td>
<td>317.53</td>
<td>316.9</td>
<td>263.34</td>
</tr>
</tbody>
</table>

Figure 3
4. Salter-Harris Fractures of the Distal Phalanx: is it Time to Define Optimal Surgical Treatment?
Waleed Gibreel, MBBS; Ali Charafeddine, MD; Karim Bakri, MBBS
Mayo Clinic, Department of Plastic Surgery, Rochester, MN

Introduction: Salter-Harris (SH) fractures of the distal phalanx with or without evidence of nail bed laceration (NBL) are frequently undertreated. We sought to review our experience and propose a treatment algorithm.

Material and Methods: A retrospective review of patients with SH fractures of the DP treated between 2004 and 2016.

Results: Seventy patients (74% male) were treated for 72 SH fractures at a mean±SD age of 11.3±3.7 years. Median follow-up was 6 weeks [IQR 4-12.6]. The right hand was involved in 43 fractures. The thumb was the most commonly involved (n=21), followed by long (n=18), ring (n=17), small (n=9), and index (n=7). Sport-related injuries accounted for 39 (54%) fractures. SH 2 was the most common (n=50) followed by SH 3 (n=12) and SH 1 (n=10). Eighty percent presented within 24 hours of injury. Forty-Two (58%) fractures had at least one clinical finding suggestive of NBL (CFSNBL). CFSNBL were subungual hematoma (n=16), subluxation of proximal nail plate (n=13), laceration proximal to the eponychial fold (n=12), oozing of blood from underneath the nail plate (n=4), eponychial fold laceration (n=3), and near total/total nail plate avulsion (n=2). Among 42 fractures with CFSNBL, surgical exploration was undertaken in 38 fractures. At exploration, NBL was found in 31 (82%) fractures and soft tissue interposition in 18 (47%) (Table1). Fractures without CFSNBL (n=30) were treated with closed reduction and splinting (CS) (n=24) and closed reduction and percutaneous pinning (PP) (n=6). Fractures with CFSNBL (n=42) were treated with open reduction (OR) and splinting (n=25), OR and PP (n=13), CS (n=4). Excellent results were obtained with few unfavorable outcomes (nail plate deformity in 5, premature physeal closure in 5, abnormal DIPJ ROM in 5, and non-union in 1). Infectious complications occurred in 6 patients (Table2)

Conclusions: The high rate of NBL and soft tissue interposition in fractures with CFSNBL mandates surgical exploration and repair of the nailbed. Excellent outcomes could be achieved via early recognition and initiation of clinical finding-based treatment algorithm. (Figure1)

Table 1: Predictive value of each clinical finding suggestive of nail bed laceration for the actual presence of nail bed laceration and soft tissue interposition at nail bed surgical exploration. PPV: positive predictive value.

<table>
<thead>
<tr>
<th>Clinical finding suggestive of nail bed laceration</th>
<th>Number of fractures</th>
<th>Nail bed exploration</th>
<th>Presence of nail bed laceration at exploration (PPV)</th>
<th>Soft tissue interposition (PPV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-ungual hematoma</td>
<td>16</td>
<td>14</td>
<td>12 (86%)</td>
<td>6 (43%)</td>
</tr>
<tr>
<td>Laceration proximal to the eponychial fold</td>
<td>12</td>
<td>12</td>
<td>9 (75%)</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>Subluxation of proximal nail plate</td>
<td>13</td>
<td>11</td>
<td>9 (82%)</td>
<td>4 (36%)</td>
</tr>
<tr>
<td>Oozing of blood from underneath the nail plate</td>
<td>4</td>
<td>4</td>
<td>4 (100%)</td>
<td>2 (50%)</td>
</tr>
<tr>
<td>Eponychial fold laceration</td>
<td>3</td>
<td>3</td>
<td>2 (67%)</td>
<td>2 (67%)</td>
</tr>
<tr>
<td>Near total/total nail plate avulsion</td>
<td>2</td>
<td>2</td>
<td>2 (100%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Injury from</th>
<th>Finger involved</th>
<th>Fracture type</th>
<th>Feeling suggestive of SNL</th>
<th>N/I at exploration</th>
<th>Repair of M&amp;O</th>
<th>Nail bed infection?</th>
<th>Type of infectious complication</th>
<th>Percent of presentation</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Male</td>
<td>Long</td>
<td>SI 1</td>
<td>Subungal lacerations</td>
<td>Yes</td>
<td>Pain mg</td>
<td>Yes</td>
<td>Gomco cut</td>
<td>No</td>
<td>Osteomyelitis</td>
<td>Yes</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
<tr>
<td>31</td>
<td>Male</td>
<td>Long</td>
<td>SI 1</td>
<td>Acute dry lacerations</td>
<td>Yes</td>
<td>Pain mg</td>
<td>Yes</td>
<td>Gomco cut</td>
<td>No</td>
<td>Osteomyelitis</td>
<td>No</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
<tr>
<td>33</td>
<td>Male</td>
<td>Small</td>
<td>SI 2</td>
<td>Lacerated field .</td>
<td>Yes</td>
<td>Splinting</td>
<td>Yes</td>
<td>Gomco cut</td>
<td>No</td>
<td>Osteomyelitis</td>
<td>Yes</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>Long</td>
<td>SI 2</td>
<td>Subungal lacerations</td>
<td>Yes</td>
<td>Healing</td>
<td>Yes</td>
<td>Gomco cut</td>
<td>No</td>
<td>Osteomyelitis</td>
<td>Yes</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
<tr>
<td>14</td>
<td>Male</td>
<td>Ring</td>
<td>SI 2</td>
<td>Subungal lacerations</td>
<td>Yes</td>
<td>Pain mg</td>
<td>No</td>
<td>Gomco cut</td>
<td>No</td>
<td>Osteomyelitis</td>
<td>Yes</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
<tr>
<td>35</td>
<td>Male</td>
<td>Long</td>
<td>SI 3</td>
<td>No findings</td>
<td>NA</td>
<td>Splinter</td>
<td>NA</td>
<td>Gomco cut</td>
<td>No</td>
<td>Perforation with subsequent collection</td>
<td>No</td>
<td>M&amp;O + IV AAI</td>
<td>Resolution</td>
</tr>
</tbody>
</table>

Figure 1: The proposed treatment algorithm. PIP: proximal interphalangeal joint. DIP: Distal interphalangeal joint.

Clinical and radiographic evidence SI fracture

Fractures with clinical findings suggestive of nail bed laceration

- Administration of IV antibiotics
- Remove all of the nail plate
- Irrigation and débridement
- Nail bed examination
- Repair of nail bed lacerations
- Elevate impacted soft tissue
- Replace the nail plate under the eponychial fold
- Reduce fracture and assess reduction stability

Stable

Unstable

Splint

Perforation plucking

Fractures without clinical findings suggestive of nail bed laceration

- No need for antibiotics
- Reduce fracture and assess reduction stability

Stable

Unstable

Splint

Perforation plucking

* Oral antibiotics are continued for 7 days. Need for longer course is determined at the 1-week follow-up visit.
** Replace the nail plate to act as a splint and facilitate nail plate reattachment and stable débridement. When the nail plate is not available, you may use a biologic splint or an aluminum splint.

Post-operative care:
- Follow up at 1 week, 4 weeks, and 8 weeks with clinical and radiographic (x-ray) examination at each visit
- Early referral to hand therapy (ideally at the 1-week follow-up)
- At 1 week: Exchange the initial splint for one that allows PIP joint movement
- At 4 weeks: A bare DIP joint exercise. Wear custom made splint during night as needed for comfort
5. Pediatric Hand Fractures: Predicting Which Fractures Require Specialized Care by a Hand Surgeon
Rebecca L Hartley, MD; Ceilidh Anne Kinlin, MScPT; Josh Lam, MD; Karen Hulin-Poli, MScOT; Claire Temple-Oberle, MD, MSc, FRCSC; Rob Harrop, MD, MSc, FRCSC, FACS; Frankie OG Fraulin, MD, FRCSC
University of Calgary, Calgary, AB, Canada

Introduction: Most pediatric hand fractures can be managed non-operatively without consequence. There are no evidence-based guidelines to identify which fractures will require specialized care by a hand surgeon and current referral systems are based on primary care discretion. Our study's purpose is to determine which pediatric hand fractures require specialized care by a hand surgeon.

Materials & Methods: A retrospective chart review was conducted on all patients referred to plastic surgeons at a large tertiary pediatric hospital in 2013 with a diagnosis of a hand fracture. Patients' medical charts and radiographs were examined and data was collected into categories derived from both the literature and expert opinion. The fractures were then divided into two categories: metacarpal (MC) and phalangeal. Univariate analysis screened the categories for significant variables (screening cut-off p-value<0.2). We performed a logistic regression using the significant variables from the univariate screening as our independent (predictor) variables and "requiring specialized care by a hand surgeon" as our dependent (outcome) variable (defined as fractures that needed reduction, surgery or more than 3 follow-up visits by a hand surgeon). Goodness of fit testing for the model as well as beta values for the predictor variables were calculated with a p-value<0.05.

Results: 608 charts were reviewed, identifying 559 fractures, 185 MC (33.1%) and 374 phalangeal (66.9%). Management of all fractures included: immobilization alone (369, 66.0%), closed reduction and immobilization (119, 21.3%), surgical intervention in the operating room (57, 10.2%) and surgical intervention in the emergency department (14, 2.5%). The MC logistic regression model explained 85.9% of the observed outcomes with a Hosmer and Lemeshow test (HL) value of 0.869. Displacement (p-value 0.016, beta 1.638) and rotation (0.012, 2.199) were important predictors. The phalangeal logistic regression model explained 83.2% of observed outcomes with a HL value of 0.284. Condylar involvement (0.016, 1.290), displacement over 2 millimeters (0.042, 0.694), anterior-posterior angulation over 15 degrees (0.012, 1.238), and lateral angulation over 15 degrees (0.036, 0.955) were important predictors.

Discussion: Relatively few variables predict whether pediatric hand fractures will require specialized care by a hand surgeon. Knowledge of these variables will be an essential first step in devising strategies to better manage pediatric hand fractures. This data will be used to develop a clinical prediction tool and management pathway for pediatric hand fractures.
Introduction:
In July 2015, the first bilateral pediatric hand transplant was performed on an eight-year-old patient already on immunosuppression for a renal transplant earlier in life. Here we present his clinical outcome one year after transplantation.

Methods:
Using a multi-team approach, the hand transplant procedure was successfully performed in ten hours. Our rejection protocol included 2mm skin biopsies performed weekly for eight weeks, then monthly starting three months after transplantation, then quarterly for second year. We obtained his outcomes from his clinical visits with the surgical team, nephrology, infectious disease, neuropsychology and occupational therapy.

Results:
The patient had several episodes of Banff grades I and II rejection episodes treated with topical tacrolimus and betamethasone and grade III rejection treated with solumedrol. Two months after transplant, immunosuppression regimen was changed to sirolimus in addition to tacrolimus prednisone and MMF due to rising creatinine with concerns of calcineurin inhibitor toxicity. Currently, patient is able to perform most activities of daily living independently: dress himself, brush his teeth, wipe after toileting, use utensils during meals and write with marker. Transcranial magnetic stimulation showed cortical representation of hand motor activity consistent with high degree of neuroplasticity. To address concerns regarding attention and impulse control that may impact his recovery, behavior modifications such as frequent breaks during therapy, using positive rewards and improving sleep in spite of demanding schedules were made to improve his motivation. His support system at home remained robust and responsive.

Conclusion:
Not only has the first pediatric transplant patient demonstrated full compliance with treatment and rehabilitation, he gained ability to perform activities of daily living and independence from caregivers. The patient was re-integrated to school at 10 months post operatively.
7. Pediatric Ganglion Cysts: A Single Surgeon Experience
Joseph Meyerson, MD¹; Linda Pan, BS¹; Maya Spaeth, MD²; Gregory Pearson, MD¹
¹The Ohio State University, Columbus, OH ²Nationwide Childrens, Columbus, OH

**Background:** Ganglion cysts are the most common type of soft tissue tumors of the hand. In the pediatric population, monitoring may be appropriate unless cysts are painful, interfering with range of motion or parental concerns exist. Reported recurrence rates after surgical removal of pediatric ganglion cysts varies widely in the literature. Notably recurrence rates are higher for children than adults, ranging from as low as 6% to as high as 35%.

**Methods:** A retrospective review of a single pediatric hand surgeon’s patients undergoing excision of primary and recurrent ganglion cysts was examined from 2010-2015. Variables measured included patient age at diagnosis of ganglion cyst, time to presentation, location of cyst, hand dominance, previous therapy, previous surgery, length of surgery, tourniquet time, length of follow up, any associated complications, and recurrence of cyst.

**Results:** Ninety-six patients were identified with an average age of diagnosis 10.2 years, age at surgery 11.8 years and 84.8% were right handed. Females made up of 72.9% of the patients. Cysts were right-sided in 43.8% of cases. Indications for surgery: 95.8% for pain or decreased range of motion, 4.2% for cosmetic or parental concern. Seventy-five percent of the cases were dorsally located with the remaining 24.2% being volar. Of the 96 patients, four complications occurred: 2 dysthesias, 1 infection, 1 hypertrophic scar and 5 recurrences (5.3%). Tourniquet time was on average 9.8 minutes longer for cases that resulted in recurrence. Multivariate analysis of the data demonstrated a 35% increased risk of recurrence with patients who had a previous aspiration (p<0.0378).

**Conclusions:** This is the largest series reported of a single pediatric hand surgeon’s outcomes of pediatric wrist ganglion cysts. Our recurrence rate of 5.3% is low for a pediatric population indicating potential merit in this surgeon’s operative and postoperative techniques. This study parallels reports in the literature with a predilection of cysts in females and higher rates of volar cysts in pediatric cases compared to adults. Previous studies indicate observation as an appropriate first line treatment in pediatric patients. Symptomatic cysts or cysts remaining longer than one year should be considered for excision, which were the vast majority of our study. We demonstrate significantly increased rates of recurrence when a cyst had been previously aspirated possibly from scarring and disruption of planes resulting in difficult dissection, increased tourniquet times and incomplete excision.
8. Pediatric Elbow Arthroscopy: Indications and Complications

Steven M. Andelman, MD; Kristen M. Meier, MD, MS; Joung Heon Kim, BS1; William J Rubenstein, BS1; Michael R. Hausman, MD

Mount Sinai School of Medicine, New York, NY

Introduction
Elbow arthroscopy is a safe and effective means by which to treat a variety of pathologic conditions of the elbow. While well described in the adult population, significantly less is known regarding the indications and safety of elbow arthroscopy in the pediatric patient. Previous publications have suggested the primary role for pediatric elbow arthroscopy is in the treatment of osteochondritis dessicans. We present a retrospective review of the indications and complications for pediatric elbow arthroscopy and demonstrate the increasing role of this minimally invasive technique in treating an expanding array of pediatric elbow pathology.

Methods
A retrospective review was performed of arthroscopic elbow surgeries on patients less than eighteen years old by a single surgeon at a single institution from 2001-2015. Standard and accepted arthroscopic techniques were utilized. The age at date of surgery, gender of patient, indication for surgery, and any associated complications were recorded.

Results
55 arthroscopic elbow surgeries in 51 patients (51 elbows) were available for review. Table One provides an overview of the average age at time of surgery, indication for surgery, and associated surgical complications. The most common indications for intervention were arthroscopic contracture release for post-traumatic arthrofibrosis (26/55, 47.3%), arthroscopic-assisted closed reduction and percutaneous pinning for elbow fracture (10/55, 18.2%), arthroscopic treatment of osteochondritis dessicans (10/55, 18.2%), diagnostic arthroscopy for elbow instability (5/55, 9.1%), arthroscopic release for snapping plica (3/55, 5.5%), and arthroscopic debridement of the ulnohumeral joint (1/55, 1.8%). Four arthroscopic contracture releases were performed as staged, planned procedures in two patients (three in one patient, one in another). An overall complication rate of 20.0% (11/55) was identified, 7.3% (4/55) of which were categorized as minor complications while 12.7% (7/55) of which were categorized as major complications.

Discussion/Conclusion
Elbow arthroscopy is a safe and minimally invasive surgical technique that can be utilized to treat an expanding array of elbow pathology in the pediatric population. While previous literature has suggested the primary role for pediatric elbow arthroscopy is in treatment of osteochondritis dessicans, we demonstrate the increasing role of arthroscopy in the treatment of post-traumatic arthrofibrosis, fracture fixation, and in the diagnosis and treatment of soft tissue pathology.
Conjoined Versus Isolated Shoulder Tendon Transfers in Brachial Plexus Birth Palsy
William Smith, MD1; Dustin Greenhill, MD1; Scott Kozin, MD2; Dan Zlotolow, MD2
1Temple University Hospital, Philadelphia, PA; 2Shriners Hospital for Children Philadelphia, Philadelphia, PA

Background:
In children with brachial plexus birth palsy (BPBP) undergoing tendon transfers to augment shoulder external rotation, it is unclear whether transfer of the latissimus dorsi with its conjoined teres major tendon (cLT) versus isolated teres major tendon transfer (iTM) yield different outcomes.

Methods:
Records of patients with BPBP who underwent shoulder tendon transfers to augment external rotation were retrospectively reviewed. Transfer type (cLT or iTM) was considered indiscriminate by virtue of surgeon preference. Modified Mallet Scale (mMS) and Active Movement Scale (AMS) scores were recorded. Patients with <12 months follow-up, C7 or lower palsy, humeral osteotomy, shoulder procedure(s) within 8 months, microsurgery within one year, or recurrent glenohumeral subluxation confirmed by postoperative imaging were excluded. Matched cohorts were identified within each tendon transfer group to yield similar preoperative shoulder function and glenohumeral alignment status. Outcomes for all tendon transfers as well as differences between cLT and iTM cohorts were analyzed.

Results:
Among 121 cLT and 34 iTM transfers, matching cohorts yielded 28 patients (14 cLT and 14 iTM) for study inclusion. Average age at time of transfer was 2.2±1.0 years. Follow-up averaged 2.3±1.9 years. There were no statistically significant preoperative differences between cohorts, thus matching criteria were validated. Regardless of tendon(s) transferred, mMS external rotation improved (2.14 to 3.75, p<0.0001) while mMS internal rotation decreased (3.80 to 2.96, p=0.008). When comparing cohorts, cLT produced a greater improvement than iTM in mMS external rotation (2.0 versus 1.2, p=0.01). Loss of midline function (defined as mMS external rotation <3) occurred in five cLT and two iTM patients.

Conclusion:
Both cLT or iTM transfer are effective at augmenting shoulder external rotation in children with C5-C6 BPBP. Furthermore, cLT transfers may be superior in most patients given a larger improvement in external rotation. However, both techniques slightly decrease shoulder internal rotation. Given that more total cLT patients lost midline function, iTM transfer can still be considered when limited midline function is a concern.
Objective: To determine whether PROMIS Depression, Physical Function, and Pain Interference scores at presentation for hand specialty care varied according to the type of symptomatic condition.

Methods: This cross-sectional evaluation analyzed 2,009 consecutive outpatient clinic visits of adult patients presenting to a tertiary hand clinic for an upper extremity condition from 10/2/2015-12/30/2015. All patients completed electronic PROMIS Depression (higher scores = more depression), Physical Function (higher scores = better function), and Pain Interference (higher scores = more pain) modules at their visit. Kruskal-Wallis Chi-square analyses were performed with post-hoc comparisons using the Mann-Whitney U test for differences in PROMIS scores for each health domain according to diagnosis.

Results: Depression, Physical Function, and Pain Interference scores significantly differed between patient groups according to diagnosis (Depression: p<0.001; Physical Function: p<0.001; Pain Interference: p<0.001). Patients with nerve compression syndromes had the highest Depression (median 49.9) and Pain Interference scores (median 61.5) and the lowest Physical Function scores (median: 42.0), while patients presenting with ganglion cysts had the lowest Depression (45.6) and Pain Interference scores (55.8), and the highest Physical Function scores (50.0) (Table1). Assuming moderate effect size change (0.5) to be clinically relevant, patients with nerve compression syndromes had worse physical function than patients with ganglion cysts, hand fractures, and trigger finger.

Conclusions: PROMIS Depression, Physical Function, and Pain Interference scores vary significantly according to the diagnosis prompting presentation for specialty hand care. While patients presenting with nerve compression syndromes demonstrated PROMIS health domain scores with the most negative implications, further studies including additional validated health measures should be performed to determine if these apparent disparities remain consistent.

Table 1. Medians (25-75%) of PROMIS CATs by hand condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Physical Function</th>
<th>Pain Interference</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTS/CuTS</td>
<td>42.0 (35.3-49.7)</td>
<td>61.5 (56.0-66.9)</td>
<td>49.9 (41.5-58.6)</td>
</tr>
<tr>
<td>1st CMC OA</td>
<td>44.7 (37.4-50.5)</td>
<td>59.9 (54.5-64.3)</td>
<td>47.6 (39.3-53.7)</td>
</tr>
<tr>
<td>Trigger Finger</td>
<td>46.5 (39.4-51.3)</td>
<td>59.0 (54.3-64.4)</td>
<td>46.1 (38.9-52.2)</td>
</tr>
<tr>
<td>Hand Fx</td>
<td>48.6 (40.1-54.0)</td>
<td>56.9 (52.2-62.9)</td>
<td>45.7 (34.2-55.0)</td>
</tr>
<tr>
<td>Ganglion</td>
<td>50.0 (43.3-57.0)</td>
<td>55.8 (50.1-60.1)</td>
<td>45.6 (34.2-51.0)</td>
</tr>
</tbody>
</table>

Figure 1. Means of PROMIS Physical Function by hand condition
11 Restoration of Finger Flexion in Children Using Functioning Free Gracilis Transfer
Mohamed Mostafa Kotb, MD;
Orth, Hand and Reconstrucrive Microsurgery Unit, Orthopedic Deptment, Assiut University Hospital,
Assiut, Egypt

Introduction:
Finger flexion is yet the most difficult task to achieve in upper limb reconstruction. Patients and methods: A study on 30 Children were operated upon for restoration of finger flexion via free vascularized gracilis muscle transfer. The mean follow up period was 71.87 months (about 6 years). The mean age: 7.83 years (range 4 to 12 years). 13 of the children were girls (57%). 14 cases (60%) were operated upon by FFMT before one year has passed since the incident. 14 cases had Volkman's ischemic contracture, 6 cases OBPP, 2 cases traumatic muscle loss, one case post tumor excision. FFMT was the first operation in 7 children (30.4%). All muscles harvested were with skin monitors. 16/18 muscles restoring finger flexion only were anastomosed to the ulnar artery or a side branch of it. 3/5 muscles restoring elbow and finger flexion were anastomosed to the thoracodorsal a.

Results:
24 autotransplants survived (80%). Clinical active motion started after the operation by a mean of 4m. The mean total active range of finger flexion very highly significantly increased from a preoperative 10.47° (4.36%) to 141.96° (64%) (of the available passive ROM). In cases of Volkmann’s ischaemic contracture best results are obtained when the patient is operated within 6 months from the incident injury. 73.9% of the cases had M0 active power grade before the operation. 78.2% of the cases reached M4 muscle power grade at late follow up. 51.4% of the cases, had further reconstruction during the follow up period 65.7% of the patients, are probably still in need for further reconstructive procedures. Tenolysis was the most frequently done operation after FFMT. 88% of the children in this series had other operation(s) besides that for FFMT.
12 Effect of alternating inter-manual training on hand shaping during grasp in children with unilateral spastic cerebral palsy
Aviva Wolff, EdD, OTR, CHT\textsuperscript{1}; Howard Hillstrom, PhD\textsuperscript{1}; Andrew Gordon, PhD\textsuperscript{2}
\textsuperscript{1}Hospital for Special Surgery, New York, NY; \textsuperscript{2}Teachers College Columbia University, New York, NY

Introduction
Children with unilateral spastic cerebral palsy (USCP) demonstrate impairment in grasp control in the affected hand. This study tests the effect of alternating inter-manual training (AIM), a novel form of inter-manual training, on hand-shaping, a component of reach-to-grasp, in children with USCP.

Materials and Methods
Two groups of children (n=20, ages 6-18 years) with USCP were age matched to 2 practice groups: AIM training group and control group (CON). All subjects grasped a rectangle, convex, or concave shape during 3-dimensional motion capture analysis. For each shape, data were collected in a single session during 3 phases: pre-test (10 trials), training-test (the last 10 of 25 training trials), and post-test (10 trials). In the training phase, the AIM group reached, grasped, and lifted each shape in an alternating fashion first with the less affected hand followed by the affected hand. The control group alternated lifts with a sham object (rubber ball). A visuomotor efficiency index (VME) was calculated to quantify hand shaping during reach-to-grasp (100=perfect discrimination). The VME, derived from all hand joint angles at multiple intervals throughout reach, provides temporal-spatial information on the evolution of hand posture discrimination between shapes. VME and kinematics were analyzed with two-way repeated measures ANOVA and pairwise post-hoc between group comparisons.

Results
Compared to controls, the AIM group demonstrated improvement in VME maximum (AIM=88±8, CON=72±11, p= 0.001) and the number of joints differentiated at object contact (AIM =6±1, CON=2±1, p=0.012), indicating better shaping while receiving alternating input from the less affected hand. No improvement was noted in VME at deceleration prior to object contact in either group. Gains in the number of joints differentiated were maintained at post-testing (AIM=5±1, CON=4±1, p=0.005).

Conclusion
Findings of improved hand-shaping at the end of the movement support proof-of-concept that subjects can use AIM training to utilize information from the less-affected hand to inform hand-shaping in the affected hand. This approach may be a useful paradigm to increase grasp control in children with USCP.
13 Does Age Contribute to Outcomes for Elbow Release in Arthrogryposis?
Christopher Richards, MD, MS; Dan Zlotolow, MD; Rey Natividad Ramirez, MD;
1Cooper University Hospital, Camden, NJ; 2Shriners Hospital for Children Philadelphia, Philadelphia, PA

Introduction
Up to 25% of children with arthrogryposis have an elbow extension contracture that limits hand to mouth for functions such as eating. Posterior elbow release, triceps lengthening, and ulnar nerve transposition (posterior elbow release) has been shown to improve passive elbow flexion, with previous literature suggesting good results at an average of 3 years of age. No consensus exists regarding timing of surgery. This study looks at the effect of age at the time of surgery on the outcome of posterior elbow release.

Methods
This study is a retrospective chart review of consecutive patients with arthrogryposis who underwent a posterior elbow release for an elbow extension contracture between 2007 and 2014 at one institution. Out of 62 procedures in 44 patients, 20 procedures in 14 patients had a minimum follow-up longer than of 2 years and were included in the study. Of the six patients who had bilateral posterior elbow releases, all of them were done within 8 months of each other and within the same year of life. Patients were divided into 3 groups based on their age at the time of surgery: <2 years old, 2-3 years old and >3 years old. T-tests were used to compare the pre- and post-operative passive arcs of motion.

Results
The average pre-operative arc of motion was 16° (0°-30°) for the children younger than 2, 33.5° (5°-60°) for the children 2-3 and 45° (25°-80°) for the children older than 3. These differences were not statistically significant between cohorts. Children >3 years old also developed on average a 6.7° flexion contracture, shifting their pre-operative arc of motion into more flexion. The average post-operative arc of motion was 88.2° (70°-103°) for the children younger than 2, 60° (15°-85°) for the children 2-3 and 54.33° (23°-70°) for the children older than 3. There was a statistically significant difference in the post-operative arc of motion between the children less than 2 years old and both the children 2-3 years old and older than 3 years old. The difference between the 2-3 and >3 year old cohorts were not significant.

Conclusion
Children who underwent posterior elbow release prior to the age of 2 had a statistically significant increase in their post-operative passive arc of elbow motion compared to older children. The results were better and more predictable. Restoring passive elbow flexion should therefore be an early priority of the treatment plan for children with arthrogryposis.
Multiple Enchondromas of the Hand in Children: Long Term Follow up of Mean 15.4 years
Assaf Kadar, MD; Steven L. Moran, MD
Mayo Clinic, Rochester, MN

Background
Multiple enchondromatosis of bone, termed Ollier's disease, or Maffucci syndrome when associated with hemangiomas, is a rare disease that can affect the pediatric hand. This condition often causes a finger mass, deformity, pain and possible pathological fractures, and has been associated with malignant transformation to chondrosarcoma. The aim of our study is to describe the long term sequela of multiple enchondromatosis of the hand in the pediatric population, specifically the rates of malignant transformation, tumor recurrence, rates of pathological fracture, and phalangeal growth arrest.

Methods
We examined a total of 127 phalanxes and metacarpals in 15 pediatric patients who were treated in our institute. Only patients with follow up of at least 4 years were included. We retrospectively reviewed patients' chart and hand radiograph for symptoms including pathological fractures, indications for surgery, and postoperative complications including tumor recurrence, and malignant transformation. We assessed phalangeal growth arrest with radiographs and normalized phalangeal growth charts.

Results
Mean age of diagnosis was 5.8 years and mean follow up time was 15.4 years. Pathological fractures were common at 46% of pediatric patients, but ceased to occur once reaching adulthood. Outcomes of pathological fractures were excellent, regardless of treatment. Malignant transformation was very rare (0.7% of lesions) and did not occur during childhood. 80% of patients underwent surgical treatment of curettage and bone graft for the lesion, yet recurrence was common and affected 33% of treated patients. Phalangeal Growth arrest was the most common long term sequela and affected 11% of phalanxes and metacarpals. This sequela was significantly more prevalent in patients who had surgical excision of the tumor.

Conclusions
Our findings reassure that malignant transformation of enchondromatosis of the hand is rare and even rarer in the pediatric population. Pathological fracture is a common, but has excellent outcomes. When considering surgery, parents should be counseled about the possibility of phalangeal growth arrest and recurrence of the lesion.
16 Intramedullary Venous Drainage System for Distal Finger Tip Replantations
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Introduction
The number of venous anastomosis performed in fingertip replantations is one of the most important factors affecting the success of the fingertip replantation. Vascular anastomosis especially venous anastomosis is difficult in Tamai zone-1 level of fingertip amputations, because of the small vessel diameters, and venous anastomosis often can not be done. To overcome this problem many arterial only replantation techniques have been described in the literature including arteriovenous anastomosis, creating arteriovenous or venocutaneous fistula, manual milking and massage, puncturing, fish mouth incision and using medicinal leeches. The medullary cavity of the distal phalanx has been shown to be a reliable way for venous return in the fingertip. In this study, we described the venous drainage system that we developed to use in distal fingertip replantations and we evaluated the results of our patients using this system between 2008-2013.

Patients and Methods
24 fingertips of 22 patients with tamai zone 1 fingertip amputations that appropriate vein could not be found for venous anastomosis were included in this study. In all replantations venous return was maintained only with using intramedullary venous drainage system that we described in this study.

System & Surgical Technique
Intramedullary venous drainage system was created drilling 0.1 mm holes on a standard 18G needle, in a circular manner with one hole drilled in every 0.5 cm rotating 90 degrees. By drilling the holes along the length of the needle, a connection was created between the medullary cavity of the amputated part and the medullary cavity of distal/middle phalanx of the affected finger. This system was used for venous return and bone stabilization in all cases (figure 1).

Result
Complete replantation success was achieved in 21 of 24 fingertips (88%), partial necrosis was observed in one case (4%) and complete necrosis was observed in 2 cases (8%). Venous congestion was observed in 4 cases in early postoperative period and in all cases it disappeared following washing the inside of the needle with heparinized saline solution. We did not observe any partial or complete necrosis due to venous congestion.

Conclusion
We think that the venous drainage system we developed is a good alternative in maintaining the venous return of tamai zone 1 fingertip replantation’s if venous anastomosis cannot be established properly using standard technique. This technique eliminates the need of blood transfusions especially in multiple finger replantation’s. Figure 1.
17 Comparison of Patient-Reported Outcomes after Traumatic Upper Extremity Amputation: Replantation versus Prosthetic Rehabilitation

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1University of Washington, Seattle, WA, 2The University of Michigan, Ann Arbor, MI, 3Union Memorial Hospital, Baltimore, MD; 4Curtis National Hand Center, Baltimore, MD; 5Northwestern University, Chicago, IL

Purpose:
After major upper extremity amputation, replantation is generally attempted based upon the assumption that patient outcomes for a successfully replanted limb exceed those for revision amputation and prosthetic rehabilitation. There is sparse data demonstrating superior task-based functional outcomes for patients undergoing replantation, but to our knowledge there are no studies directly comparing patient-reported outcomes. It increasingly apparent that a patient’s perception of his or her function is an important measure of outcome after loss of an upper extremity, and that functional testing and physician assessment may not align with the patient experience. It is the goal of this study to compare upper extremity replantation versus revision amputation with prosthetic rehabilitation using the DASH and MHQ instruments, two validated measures of patient-reported upper extremity outcomes.

Methods:
At each of three collaborating major replantation centers, patients with a history of traumatic, unilateral, upper extremity amputation between the radiocarpal and elbow joint (inclusive) were identified. This included patients who underwent successful replantation, and those who underwent revision amputation and attempted prosthetic rehabilitation. Those who could be contacted and agreed to participate completed the DASH and MHQ instruments. Intergroup comparison was completed for aggregate DASH score, aggregate MHQ score on the injured side, and each of the MHQ component sub-scales including overall function, ADLs, pain, appearance, and patient satisfaction.

Results:
22 amputees who underwent prosthetic rehabilitation and 9 patients who had successful replantation were included. Aggregate MHQ score for the affected extremity was significantly better for the Replantation group compared to the Prosthetic Rehabilitation group (47.2 vs. 35.1, p<0.05). Amongst the component MHQ sub-scales, significant advantages to replantation were demonstrated with respect to overall function (41.1 vs. 19.7, p=0.03), ADLs (28.3 vs. 6.0, p=0.03), and patient satisfaction (46.0 vs. 24.4, p=0.03). DASH score was more favorable in Replantation patients (24.6 vs. 39.8), though this difference fell short of statistical significance (p=0.08).

Conclusions:
After upper extremity amputation, patients who underwent successful replantation reported superior outcomes with respect to overall function, ADLs, and patient satisfaction, compared to patients who underwent revision amputation followed by prosthetic rehabilitation. This offers some justification for the considerable effort and expenditure required on the part of the patient, surgeon, and payer to complete this heroic reconstruction. Assessment of patient reported outcomes is a critical part of evaluating the success of surgical treatment, and future outcomes studies should include the DASH and MHQ.
18 Patients Transferred for Upper Extremity Amputation: Do All Level I Trauma Centers Participate?
Shantum Misra, BA1, Suzanne C. Wilkens, MD2; Neal C. Chen, MD3; Kyle R Eberlin, MD3
1George Washington University School of Medicine and Health Sciences, Washington, DC; 2Harvard University, Boston, MA; 3Massachusetts General Hospital, Cambridge, MA

INTRODUCTION:
Level I trauma centers are required to provide hand surgery and microsurgery capability 24 hours a day. We hypothesize that patients are transferred to our center for management of upper extremity amputations despite the availability of approved, closer level I facilities.

MATERIALS & METHODS:
Medical records were reviewed from October 2010 to June 2015 to evaluate patients transferred to our level I institution for upper extremity amputation. Patients who presented with an ICD-9 code demonstrating amputation of an upper extremity were included. Patient demographics, type and presence of medical insurance, injured extremity, dominant extremity, number of extremity amputations, trauma designation of transferring facility, and zip code of transferring facility were recorded. Patients from 6 states were transferred to our facility and distances from each patient’s transferring facility to all 13 level I trauma centers in these 6 states was computed by compiling straight-line distances from the zip code of the transferring facility to the zip code of each level I trauma center.

RESULTS:
Out of 261 patients with eligible ICD-9 codes transferred, 250 (91.2% male, 8.8% female) had available data. Of these, patients were transferred from hospitals in 6 surrounding states: Massachusetts (163), Maine (31), Vermont (7), New Hampshire (21), Rhode Island (27), and Connecticut (1). For 112 patients our hospital was the nearest level I trauma center, however for the remaining 138 patients other trauma facilities were located closer to the referring hospital and were bypassed to get to our hospital. Among these 138 patients, an unpaired student t-test showed that the mean distance of the transferring facility to the nearest level I trauma center (mean= 30 miles; SD= 27 miles) was significantly different from the mean distance of the transferring hospital to our facility as a more distant level I trauma center (72 miles; SD= 60 miles) ($P< 0.001$). An average of 4 (range 1 – 10) level I trauma centers were bypassed before patients arrived at our center.

CONCLUSION:
55% of patients transferred for upper extremity amputation from 6 surrounding states had a level I trauma center closer to their injury than our institution. Patients with upper extremity amputations are referred to our regional center despite the proximity of closer level I trauma centers. This suggests that regional microsurgical expertise is recognized and may be independent of ACS trauma accreditation.

Distance of transport from transferring facility (A); Trauma designation of transferring facility (B, n= 74)
19 Proximal Interphalangeal Joint Arthroplasty in Young Patients; An Analysis of 305 Consecutive Primary Arthroplasties

Eric R. Wagner, MD; William Robinson, MD; Matthew Houdek, MD; Steven L. Moran, MD; Marco Rizzo, MD
Mayo Clinic, Rochester, MN

Purpose: The purpose of this investigation was to assess the correlation between a young age and outcomes after PIP arthroplasty.

Methods: 305 consecutive primary PIP arthroplasties were performed in over a 14-year period, with an average age of 60 years (16-88). There were 129 arthroplasties performed in patients <60 years of age. In these younger patients (compared to patients over 60), surgical diagnoses included inflammatory arthritis (36% vs. 30%), osteoarthritis (35% vs. 53%), and post-traumatic arthritis (29% vs. 17%). Implant utilized in younger patients (vs. older patients) were pyrocarbon (64% vs. 63%), silicone (7% vs. 8%), and surface replacing arthroplasty (SRA, 29% vs. 30%). Both the younger and older groups have 3% laborers.

Results: Overall, there were 55 (18%) PIP arthroplasties that required revision surgery, including 33 (26%) in young patients (<60 years) at a mean 1.4 years. Risk of revision surgery was associated with younger ages (p=0.002). The 2, 5, and 10-year implant survival rates for the patients <60 years were 80%, 71%, and 71%, respectively, which was worse than the older patients (HR 2.10, p=0.006, Figure 1). Patients younger than 50 years had an increased risk of revision surgery (HR 1.88, p=0.04). Amongst the these younger patients (<60 years), a diagnosis of post-traumatic arthritis increased the risk for revision surgery (Table 1). The use of silicone implants decreased the risk of revision surgery (Figure 1). Complications in the younger patients included dislocation (n=13), infection (n=6), intraoperative fracture (n=9), and postoperative fracture (n=1). The risk of dislocation was increased in younger patients (p=0.02). Amongst the young patients, use of a silicone implant decreased the risk of dislocation (p<0.001). In unrevised patients at a mean 5.3 years follow-up (1-12), preoperative to postoperative pain levels significantly improved in patients <60 years (p<0.001). PIP total arc of motion did not significantly improve from 38° preoperatively to 37° postoperatively (p=0.71), and there was no significant change in grip or pinch strength. Older patients had improved PIP motion compared to patients younger than 60 years (p=0.045), but no differences in pain or pinch strength.

Summary Points: Younger age leads to worse outcomes after PIP arthroplasty, particularly in the setting of post-traumatic arthritis. Silicone implants have improved rates of revision and complications in patients <60 years. However, PIP arthroplasty predictably relieves pain and preserves motion with low complications in these younger patients.
Table I: Hazard Ratios for Implant Failure in PIP Arthroplasty in Patients Younger than 60 Years of Age

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone</td>
<td>&lt;0.01</td>
<td>--</td>
<td>*p = 0.01</td>
</tr>
<tr>
<td>Pyrocarbon</td>
<td>1.21</td>
<td>0.60 – 2.59</td>
<td>p = 0.60</td>
</tr>
<tr>
<td>SRA</td>
<td>1.22</td>
<td>0.57 – 2.47</td>
<td>p = 0.59</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>0.88</td>
<td>0.40 – 1.80</td>
<td>p = 0.73</td>
</tr>
<tr>
<td>Post-Traumatic Arthritis</td>
<td>2.63</td>
<td>1.30 – 5.25</td>
<td>*p = 0.008</td>
</tr>
<tr>
<td>Inflammatory Arthritis</td>
<td>0.73</td>
<td>0.35 – 1.46</td>
<td>p = 0.38</td>
</tr>
<tr>
<td>Preoperative Instability</td>
<td>1.07</td>
<td>0.43 – 2.33</td>
<td>p = 0.88</td>
</tr>
<tr>
<td>Female</td>
<td>0.72</td>
<td>0.36 – 1.51</td>
<td>p = 0.37</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>0.32</td>
<td>0.02 – 1.49</td>
<td>p = 0.18</td>
</tr>
<tr>
<td>Bone Graft</td>
<td>0.94</td>
<td>0.15 – 5.11</td>
<td>p = 0.93</td>
</tr>
<tr>
<td>Laborer</td>
<td>1.32</td>
<td>0.07 – 6.18</td>
<td>p = 0.79</td>
</tr>
<tr>
<td>Index Finger</td>
<td>0.92</td>
<td>0.37 – 1.99</td>
<td>p = 0.83</td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>0.72</td>
<td>0.36 – 1.44</td>
<td>p = 0.35</td>
</tr>
<tr>
<td>BMI</td>
<td>1.05</td>
<td>0.99 – 1.11</td>
<td>p = 0.11</td>
</tr>
</tbody>
</table>

Diagram: Age <60 Years by Diagnosis, Age <60 Years by Occupation, Age <60 Years by Implant, Age <60 Years by Gender.
Introduction
Arthritis at the distal interphalangeal (DIP) joint often results in pain and deformity. Arthrodesis of the DIP joint is commonly performed for symptomatic arthritis that has not responded adequately to nonoperative treatment. DIP fusion results in a motionless joint and carries the risk of malunion, nonunion, and implant-related complications. We hypothesize that an alternative technique involving an open dorsal cheilectomy and DIP joint debridement would result in adequate pain relief while preserving joint motion and avoiding the potential complications associated with DIP arthrodesis. We retrospectively analyzed the outcomes of 78 patients who underwent an open dorsal cheilectomy and debridement of the DIP joint for symptomatic osteoarthritis of the DIP joint.

Materials and Methods
There were seventy women and eight men with a mean age of 64 years (range, 52-74 years). The dominant hand was involved in 59 patients. The most common fingers were the middle (36 patients) and index (33 patients). Preoperative radiographic assessment demonstrated Kellgren and Lawrence grade 3 osteoarthritis in 44 patients and grade 4 in 34 patients. In all patients, through a lazy “S” incision over the dorsal DIP joint, an arthrotomy was performed on each side of the extensor tendon and debridement of the joint was performed removing osteophytes from the DIP joint, while preserving the insertion of the extensor mechanism. At completion, the DIP joint was immobilized in an extension splint. At 4 weeks postoperatively, the splint was removed and physical therapy was initiated for active range of motion. At the final follow-up pain level, satisfaction and DIP joint range of motion were assessed.

Results
The mean final follow-up was 37 months (range, 24 to 62 months). All clinical parameters demonstrated statistically significant improvement at final follow-up. Mean patient pain VAS scores improved from 8.3 preoperatively to 1.2 postoperatively. Patient satisfaction scores significantly improved by an average of 7 points. Mean flexion contracture of the DIP joint significantly improved from 11.4° preoperatively to 4.6° postoperatively. There were no postoperative infections or tendon rupture. Six patients experienced mild extensor tendon weakness at the DIP joint. No patients required additional surgery. No other complications were encountered.

Conclusions
Open dorsal cheilectomy and debridement of the DIP joint in patients with symptomatic DIP joint osteoarthritis is a safe and reliable alternative procedure. This surgical technique provides pain relief while preserving DIP joint motion.
21 Proximal Interphalangeal Arthroplasty According to Finger; Do Border Digits Perform Worse Than Middle Digits?
Eric R. Wagner, MD; William Robinson, MD; John Weston, MD; Steven L. Moran, MD; Marco Rizzo, MD
Mayo Clinic, Rochester, MN

Purpose:
Although it is traditionally thought proximal interphalangeal (PIP) arthroplasties perform worse on border (2nd or 5th) digits, there is a paucity of studies examining this thought. The purpose of this investigation was to assess the correlation between border digits and outcomes after PIP arthroplasty.

Methods:
Over a 14 year period, 110 consecutive primary PIP arthroplasties were performed on border digits, either the 2nd (n=75) or 5th (n=35). This was compared to 195 arthroplasties performed in either the 3rd (n=122) or 4th (n=73) non-border digits. Demographics of border (vs. non-border) arthroplasties include 68% female (vs. 77%), average age of 60 years (vs. 60), with diagnoses of inflammatory arthritis (25% vs. 30%), osteoarthritis (57% vs. 53%), and post-traumatic arthritis (18% vs. 17%). Implants utilized included pyrocarbon (65% vs. 63%), silicone (5% vs. 7%) and SRA (30% vs. 30%).

Results:
There were 20 PIP arthroplasties in the border digits (13 in 2nd, 7 in 5th) that required revision surgery at a mean 0.7 years postoperatively. Etiologies include pain and stiffness (n=10), dislocation (n=6) implant fracture (n=1), and infection (n=3). Risk of revision surgery was not associated with border digit (HR 1.04, p=0.88). The 2, 5, and 10-year implant survival rates for the border digits were 83%, 81%, and 81%, respectively, which was not different from the non-border digits (Figure 1). Amongst border digits, younger patients and those requiring bone grafting had increased risks of implant failure (Table 1). Silicone implants had improved implant survival compared to pyrocarbon or SRA (Figure 1). Diagnosis did not influence risk of revision surgery. Complications in the border digits included dislocation (n=6), infection (n=6), intraoperative fracture (n=6), and postoperative fracture (n=1). The risk of dislocation was not different in border versus non-border digits. In unrevised border digits at a mean 4.8 years follow-up (1-11), preoperative to postoperative pain levels significantly improved border digit arthroplasties (p<0.001). PIP total arc of motion did not improve from 38o preoperatively to 36o postoperatively (p=0.71), with no improvements in pinch or grip strength. Non-border digits had better PIP arc of motion (46o) compared to border digits (p=0.03).

Conclusions:
PIP arthroplasty performed in border digits had similar outcomes to those performed in non-border digits. Implant choice and diagnosis do not effect these outcomes. However, these border digit arthroplasties have worse PIP motion. However, PIP arthroplasty performed in border digits results in predictable pain relief, preservation of range of motion, with low complications.
Table 1: Hazard Ratios for Implant Failure in PIP Arthroplasty in Border Digits

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrocarbon</td>
<td>1.40</td>
<td>0.56 – 3.95</td>
<td>0.48</td>
</tr>
<tr>
<td>Silicone</td>
<td>0.86</td>
<td>0.05 – 4.16</td>
<td>0.88</td>
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<tr>
<td>SIA</td>
<td>0.72</td>
<td>0.23 – 1.85</td>
<td>0.51</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>1.16</td>
<td>0.48 – 2.95</td>
<td>0.75</td>
</tr>
<tr>
<td>Post-Traumatic Arthritis</td>
<td>2.03</td>
<td>0.72 – 5.07</td>
<td>0.17</td>
</tr>
<tr>
<td>Inflammatory Arthritis</td>
<td>0.32</td>
<td>0.05 – 1.09</td>
<td>0.07</td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>0.80</td>
<td>0.33 – 1.94</td>
<td>0.61</td>
</tr>
<tr>
<td>Age at Surgery</td>
<td>0.99</td>
<td>0.96 – 1.02</td>
<td>0.56</td>
</tr>
<tr>
<td>Bone Graft</td>
<td>&lt;0.01</td>
<td>--------</td>
<td>0.12</td>
</tr>
<tr>
<td>Preoperative Instability</td>
<td>&lt;0.01</td>
<td>--------</td>
<td>0.34</td>
</tr>
<tr>
<td>Female</td>
<td>1.58</td>
<td>0.61 – 4.87</td>
<td>0.36</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>1.72</td>
<td>0.27 – 5.96</td>
<td>0.50</td>
</tr>
<tr>
<td>BMI</td>
<td>1.00</td>
<td>0.07 – 8.73</td>
<td>0.98</td>
</tr>
</tbody>
</table>
22 Biomechanical Comparison of subsidence of Trapeziectomy and Suture Button Suspension plasty versus Trapeziectomy and FCR Ligamentous Reconstruction for Thumb Carpometacarpal Arthritis

Benjamin Zellner, MD; Hani Matloub, MD; Cameron Best, MD; Monica Ramirez, MD; Samita Goyal, MD; Mei Wang, PhD
Medical College of Wisconsin, Milwaukee, WI

Purpose:
Central to the treatment of thumb carpometacarpal arthritis is trapeziectomy, removing the articular surface on one side of the joint. Many advocate ligamentous suspension of the thumb metacarpal using various methods. A common method, FCR autograft suspension (LRTI) and a more novel method, suspension button (SB), have both demonstrated good results to date. Our goal was to compare the subsidence and real-time motion of a suspension button and an FCR LRTI.

Methods:
Six fresh frozen match pairs of human forearms were used. Open trapeziectomy was performed in all specimens. Specimens were randomly assigned to one treatment group and the contralateral limb was used for the other procedure. The capsule was closed in similar fashion. A lateral pinch model was used via cyclic pinch for 1000 cycles at 2Hz via loading of the FPL, adductor pollicis and APL tendons. Fluoroscopic measurements of the scapho-metacarpal height were taken before and after pinch simulation. In addition, a unique method of evaluation (real time motion analysis) was performed during the pinch simulation.

Results:
Student t-test evaluation showed no significant difference between the groups in post scapho-metacarpal space after 1000 cycles in fluoroscopic evaluation. Pre-trapeziectomy scaphometacarpal space was not significantly different between the groups. The subsidence in the FCR group was 3.13 +/- 1.70mm and for the SB group was 2.85 +/- 2.25mm for a p value of 0.21. In flexion the subsidence of the thumb measured 2.22 +/- 1.79mm in the FCR specimens changed and 1.80 +/- 1.30mm in the suspension button specimens for a p-value of 0.32. In extension the subsidence of the thumb measured 1.47mm +/- 1.10 in the FCR specimens changed and 1.57 +/- 1.10mm in the suspension button specimens for a p-value of 0.45.

Conclusion:
Biomechanical evaluation using a lateral pinch model demonstrated no significant difference in subsidence on fluoroscopy and real time motion analysis between the tightrope and suspension button groups.
23 Outcomes after PIP Arthroplasty Dislocation; an analysis of 28 consecutive cases
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Mayo Clinic, Rochester, MN

Purpose: There remains a paucity of information regarding the treatment outcomes of dislocation after proximal phalangeal (PIP) arthroplasty. The purpose of this study was to assess the outcomes of surgical and nonoperative treatment modalities for PIP arthroplasty dislocations.

Methods: Out of 380 PIP arthroplasties collected in a single institution's total joints registry, there were 28 (7%) dislocations, including 8% of all non-constrained arthroplasties (total n=345). Demographics for those who suffered a dislocation included 75% females and mean age of 55 years. Eight dislocations involved border digits, with diagnoses including osteoarthritis (n=8), inflammatory arthritis (n=9), and post-traumatic arthritis (n=11). Only non-constrained implants, including pyrocarbon (n=22) and surface replacing arthroplasty (SRA, n=6), experienced dislocations. The analysis included treatment of dislocations after primary (n=21) and revision (n=7) PIP arthroplasty. Dislocation was defined as radiographic evidence of PIP prosthetic dislocation diagnosed by a fellowship trained hand surgeon.

Results: Out of the 28 dislocations, the initial treatments included 4 closed reduction and splinting, 15 revision arthroplasties, 1 PIP arthrodesis, 2 soft tissue procedures, and 1 amputation. Additionally, 5 patients chose to have treatment for their PIP dislocations. Of the 4 that underwent closed reduction and splinting, all failed nonoperative management secondary to recurrent instability and eventually required either soft tissue (ST) stabilization (n=1) or revision arthroplasty combined with stabilization procedures (n=3). Ultimately, 17 underwent revision arthroplasty and 4 underwent soft tissue stabilization procedures. All 4 of those who underwent ST procedures had recurrent instability, with 3 requiring revision procedures. Of the 17 revision arthroplasties, 5 (29%) had repeat instability, with 4 (24%) requiring revision surgery. Components used in revision PIP arthroplasty included pyrocarbon (n=9), SRA (n=1) and silicone (n=7). Patients who underwent ST procedures had an increased risk of repeat instability (p<0.01) and revision surgery for instability (p=0.049) compared to revision arthroplasty. After revision arthroplasty, the 2 and 5 years survival-free of repeat instability was 72%, while the 2 and 5 year survival free of re-revision surgery was 62%. There was no difference in repeat instability when comparing the 3 components.

Conclusion: Treatment of PIP dislocation is a very technically challenging endeavor, with high rates of repeat instability requiring repeat intervention. Closed reduction with splinting and soft tissue stabilization procedures have an increased risk of failure compared to revision arthroplasty.
Introduction:
Wrist fusion is a common procedure indicated for degenerative wrist arthritis, traditionally performed using Iliac crest bone graft (ICBG). Wrist fusion using demineralized bone matrix (DMB) spares ICBG donor site morbidity. Literature describing fusion procedures using DMB is scarce, and the fusion rates using DMB for wrist fusion have never been reported. This study assessed the rate of successful fusion using DMB in wrist fusion procedures. Furthermore, use of DMB in fusion procedures is often avoided due to the presumed high cost. We performed a cost comparison analysis using a specific DBM (Allomatrix®) compared with conventional ICBG in wrist fusion procedures.

Materials & Methods:
All patients undergoing partial or total wrist fusion over a six year period in a single surgeon’s practice were reviewed. Data collected included: Demographics, risk factors for non-union, operative procedures performed, length of stay, time to union, and complications. Bony union was confirmed clinically and using CT imaging (82% of patients) and plain film radiography (12% of patients). To compare costs associated with using DBM, a matched group of 10 ICBG fusion patients were compared with 10 DBM fusion patients. We compared Direct costs (operative time, operative supplies, intraoperative imaging, nursing, PACU, overnight stay), and Indirect costs (overhead expenses of administration, finances, heating).

Results:
Forty patients underwent partial (27.5%) or total (72.5%) wrist fusion using DBM. 45% had risk factors for non-union. All patients except one achieved union at 5.2 weeks post-operatively for a non-union rate of 2.5%. When comparing the DBM to the ICBG group, all DBM patients except those requiring admission for medical comorbidities were treated with outpatient surgery whereas all ICBG patients required admission. Mean operative time for the DBM group was 113 minutes versus 136 minutes for the ICBG group (p = 0.04). For patients undergoing a wrist fusion procedure alone, mean operative time for the DBM group was 90.1 minutes versus 138.3 minutes for the ICBG group (p = 0.003). Average time to union was 5.2 weeks for the DBM group versus 5.9 weeks for the ICBG group (p = 0.51). Mean costs for the DBM group were $2239.71 versus $4033.66 for the ICBG group.

Conclusions:
Demineralized bone matrix is an effective bone substitute in achieving bony union in patients undergoing wrist fusion. Although the cost of DBM is significant, a reduction in operative time and an ability to do surgery as an outpatient makes the use of DBM cost-effective.
The Diagnostic Clinical Value of Thumb Metacarpal Grind, Pressure-Shear, Flexion and Extension Tests for Carpometacarpal Osteoarthritis

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University of Pittsburgh Medical Center, Pittsburgh, PA

Background:
Thumb carpometacarpal (CMC) joint osteoarthritis (OA) is a frequent cause of thumb pain associated with functional disability. It is the second most common site of arthritis in the hand, and is considered the most common site requiring surgery for pain relief and increased function. Thumb CMC OA commonly affects post-menopausal females and young male manual laborers. There is limited data on the sensitivity and specificity of the different physical examination tests that attempt to differentiate CMC joint OA from other sources of pain surrounding the base of the thumb and radial side wrist joint.

Purpose of the Study:
To compare the diagnostic value of the Grind test, metacarpal Flexion, metacarpal Extension and pressure-shear tests for CMC OA of the thumb and compare these results with the Eaton classification system.

Methods:
Radiological evaluation was used as the gold standard. One hundred twenty seven thumbs from 104 patients were included in the study. The grind test, metacarpal flexion, metacarpal extension and Pressure-Shear tests and radiographic evaluation over a 12 month period of time were performed by a certified hand surgeon. The sensitivity, specificity, and predictive values of each test were calculated for the primary outcome of diagnosing thumb CMC OA. In a secondary analysis of cases with thumb CMC OA, polychoric correlation coefficients were used to assess how well each test correlated with severity as defined by Eaton and Littler stage.

Results:
The overall diagnostic accuracy of the thumb metacarpal Grind, Pressure-Shear, Flexion, and Extension test were 70%, 98%, 47%, and 55%, respectively, for the primary outcome of diagnosing thumb CMC OA. For the same outcome, the sensitivities (with 95% confidence intervals) of thumb metacarpal Grind, Pressure-Shear, Flexion and Extension tests were 64% (54-73), 99% (95-100), 36 (27-46) and 46% (36-56), respectively. The specificities of thumb metacarpal Grind, Pressure-Shear, Flexion and Extension tests were 100% (78-100), 95% (77-100), 100% (78-100), and 100% (78-100), respectively. For the secondary outcome of thumb CMC arthritis severity, polychoric correlation coefficients for the grind, Pressure-shear, flexion, and extension tests were 0.33, 0.12, 0.25, and 0.36, respectively.

Conclusion:
For the diagnosis of thumb CMC OA, the metacarpal Pressure-Shear test was superior overall in terms of diagnostic accuracy and sensitivity, while having comparable specificity to the other tests. The Extension test appeared to correlate most strongly with severity of CMC OA cases.
Outcomes of Stage III Thumb Carpometacarpal Joint Osteoarthritis Treated With Arthroscopic Fusion

Esther Chow, MD
United Christian Hospital, Hong Kong, Hong Kong

Introduction
The thumb carpometacarpal joint (CMCJ) is one of the most common site of pathology in the hand. When conservative treatment fails, surgical treatment is recommended. However, there are variety of surgical options including ligament reconstruction tendon interposition, osteotomy, fusion and arthroplasty. With the advancement in hand arthroscopy, the use of arthroscopic assisted treatment has become more popular. However, no previous studies had reported on the results of arthroscopic fusion for Eaton III Thumb CMCJ Osteoarthritis. This study prospectively evaluate the subjective and objective results of Eaton stage III thumb CMCJ osteoarthritis treated with arthroscopic fusion.

Materials and Methods
From March 2013 to March 2016, Nine patients with Eaton Stage III thumb CMCJ osteoarthritis were treated with arthroscopic fusion. They were evaluated objectively with grip strength, pinch strength, range of motion and Kapandji score. They were also evaluated subjectively with Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and the visual analog scores (VAS) for pain. These were assessed before surgery, 3 months after surgery and 6 months after surgery. The radiographs were assessed at the latest follow-up.

Results
The average age was 64.3 years old. All nine patients were female. The pre-treatment VAS was average 5.8; the pre-treatment average DASH was 44.8. The average change in VAS and DASH was -3.8 and -4.27 at 3 months; -4.8 and -14.8 at 6 months. The change in Grip and pinch strength was +0.45kg, -0.15kg at 3 months; +4.0kg and +0.45kg at 6 months. There was one case of pseudoarthrosis. There were no wound complications and no implant related complications.

Conclusion
Arthroscopic fusion is a feasible treatment option for Stage III thumb CMCJ osteoarthritis. It provides excellent pain relief and improves hand function as early as 12 weeks after the surgery. This treatment also proved to have improved the grip strength and pinch strength at 6 months after the surgery.
The Impact of Age on Metacarpophalangeal Arthroplasty; An Analysis of 689 Consecutive Arthroplasties
Eric R. Wagner, MD; William Robinson, MD; John Weston, MD; Steven L. Moran, MD; Marco Rizzo, MD
Mayo Clinic, Rochester, MN

Purpose:
The purpose of this investigation was to assess the association between a young age and MCP arthroplasty outcomes.

Methods:
689 consecutive primary MCP arthroplasties were performed in over a 14-year period, with an average age of 60 years (14-88). There were 283 arthroplasties performed in patients <60 years of age. Comparing these younger patients to patients >60 years, there were similar preoperative diagnoses and implants utilized in the two age groups. Additionally, in the younger vs. older group, there 2% (vs. 3%) were laborers in the young group.

Results:
50 MCP arthroplasties that required revision surgery, including 35 in young patients (<60 years) at a mean 4.6 years for recurrent ulnar deviation and pain (n=7), dislocation (n=27), and implant loosening (n=1). Risk of revision surgery was associated with younger ages (HR 0.97, p=0.001). The 2, 5, and 10-year implant survival rates for the patients <60 years were 97%, 91%, and 81%, respectively, which was worse than older patients (97%, 97%, 94%, HR 3.13, p<0.001). Patients younger than 55 year had an even higher risk of revision surgery (HR 3.47, p<0.001) (Figure 1). There was no difference when comparing age brackets under 60 years. Amongst the patients younger than 60 years, the use of silicone implants decreased the risk of revision surgery (Table 1). Surgical diagnosis and laborer did not impact revision surgery risk in all patients or younger patients (Figure 2). Complications in the younger patients included dislocation (n=36), infection (n=2), intraoperative (n=13) and postoperative (n=4) fractures. 65 fingers had recurrent ulnar deviation. The risk of dislocation was increased in younger patients overall and in those subgrouped under 60 years (p<0.001). In these younger patients, use of silicone decreased the risk of dislocation. In unrevised patients at a mean 6.0 years follow-up (1-16), preoperative to postoperative pain levels significantly improved in patients <60 years (p<0.001). MCP total arc of motion did not significantly improve from 38° preoperatively to 41° postoperatively (p=0.30), and there was significant improvement in pinch or grip strength. Patients > 60 had improved MCP arc of motion compared to younger patients (p=0.01).

Conclusion:
MCP arthroplasty in patients younger than 60 years have worse outcomes, independent of their occupation or diagnosis. Silicone implants have improved outcomes in younger patients. However, MCP arthroplasty predictably relieves pain and preserves motion with relatively low complications in these younger patients.
Table 1: Hazard Ratios for Implant Failure in MCP Arthroplasty in Patients Younger than 60 Years of Age

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>95% Confidence Interval</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone</td>
<td>0.27</td>
<td>0.09 – 0.64</td>
<td>*p = 0.002</td>
</tr>
<tr>
<td>Pyrocarbon</td>
<td>1.78</td>
<td>0.90 – 3.61</td>
<td>p = 0.10</td>
</tr>
<tr>
<td>SRA</td>
<td>1.77</td>
<td>0.77 – 3.70</td>
<td>p = 0.17</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>1.99</td>
<td>0.47 – 5.68</td>
<td>p = 0.30</td>
</tr>
<tr>
<td>Post-Traumatic Arthritis</td>
<td>1.02</td>
<td>0.16 – 3.39</td>
<td>p = 0.98</td>
</tr>
<tr>
<td>Inflammatory Arthritis</td>
<td>0.67</td>
<td>0.28 – 2.00</td>
<td>p = 0.44</td>
</tr>
<tr>
<td>Dominant Hand</td>
<td>2.01</td>
<td>0.99 – 4.44</td>
<td>p = 0.054</td>
</tr>
<tr>
<td>Female</td>
<td>2.16</td>
<td>0.65 – 13.34</td>
<td>p = 0.24</td>
</tr>
<tr>
<td>Preoperative Instability</td>
<td>1.66</td>
<td>0.76 – 3.37</td>
<td>p = 0.41</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>1.20</td>
<td>0.35 – 3.09</td>
<td>p = 0.74</td>
</tr>
<tr>
<td>Bone Graft</td>
<td>2.55</td>
<td>0.87 – 6.02</td>
<td>p = 0.08</td>
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<tr>
<td>Laborer</td>
<td>1.85</td>
<td>0.10 – 8.66</td>
<td>p = 0.58</td>
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<tr>
<td>BMI</td>
<td>1.06</td>
<td>0.96 – 34.79</td>
<td>p = 0.96</td>
</tr>
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</table>
Introduction:
Radiocarpal (RC) arthroscopic findings have already been compared with MRI and/or arteriogram (AG) for its diagnostic ability of TFCC injury. Recently introduced distal radioulnar joint (DRUJ) arthroscopy has advanced diagnostic ability of arthroscopy for TFCC injuries. The purpose of this study was to compare the diagnosing ability of both RC and DRUJ arthroscopies with preoperative MRI and arthrogram on peripheral TFCC injuries.

Materials & Methods:
We retrospectively reviewed 140 consecutive TFCC injury patients. All patients underwent MRI (1.5T, Fat suppression T1WI, GRE T2*WI) and arthrogram (die into the RC joint, DRUJ) preoperatively, then RC and DRUJ arthroscopy was performed. We used Palmer’s classification for RC joint findings and evaluated whether the fovea avulsion of the radio-ulnar ligament existed on DRUJ arthroscopy or not. We examined the sensitivity, specificity and accuracy of MRI and arthrogram for diagnosis of peripheral TFCC injuries (1B tear and foveal avulsion) compared with those of RC and DRUJ arthroscopic findings.

Results:
RC arthroscopy demonstrated that there were 1A tear in 16, 1B tear in 107, 1C tear in 1, and Class 2 in 30. DRUJ arthroscopy revealed 32 fovea avulsion. MRI demonstrated no 1A, 1B in 44, no 1C and Class 2 in 4 and AG demonstrated 1A in 11, 1B in 103, no 1C and Class 2 in 5. MRI indicated fovea avulsion in 84 wrists, while AG in 44, respectively. For the diagnosis of 1B peripheral tear, the sensitivity, specificity and accuracy of MRI and arthrogram were 39% / 93% / 52% and 86% / 69% / 82% respectively. For the diagnosis of fovea avulsion, sensitivity, specificity and accuracy of MRI and arthrogram were 81% / 46% / 54% and 56% / 75% / 71% respectively.

Conclusion:
For Palmer 1B peripheral tear, MRI indicated high specificity with low sensitivity, while AG demonstrated high sensitivity with low specificity. MRI cannot detect small 1B tear, while AG might misdiagnose the prestyloid recess as 1B tear. For fovea avulsion, MRI indicated high sensitivity with low specificity, while AG demonstrated high specificity with low sensitivity. Rich fat tissue in the origin of the radio-ulnar ligament origin might be misdiagnosed as a fovea avulsion on MRI, while scar tissue prevented the contrast agent into the fovea that leaded AG findings less sensitive. Even MRI is more popular, AG still has an important role to cover the weakness of MRI.
"Diamond" Stress View Radiograph for Pre-Operative Evaluation of Thumb Metacarpophalangeal Joint Hyperextension Laxity
Paul Austin Henkel, DO1; Jeffrey A Marchessault, MD; 1Wellmont Holston Valley Medical Center, Kingsport, TN; 2Lincoln Memorial University-DeBusk College of Osteopathic Medicine, Kingsport, TN

Introduction:
Thumb metacarpophalangeal (MCP) joint hyperextension deformity is relatively common in patients with carpometacarpal (CMC) arthritis. It is generally recommended that thumb MCP joint hyperextension greater than 30 degrees be addressed during CMC arthroplasty by MCP arthrodesis or capsulodesis. However, accurate clinical measurement of MCP hyperextension is difficult using standard finger goniometers. The purpose of this study was to compare goniometer measurement and a novel stress radiograph technique of the thumb MCP joint to intra-operative stress radiographs of patients undergoing thumb CMC arthroplasty to validate a pre-operative measurement of MCP joint hyperlaxity.

Materials & Methods:
Local IRB approval was obtained. Exclusion criteria included previous thumb surgery. All enrolled patients electing to undergo thumb CMC arthroplasty by a single surgeon were clinically measured for MCP joint hyperlaxity using a standard finger goniometer. The patients were then instructed to form a “diamond” between their hands to stress the MCP joint of both thumbs into hyperextension during the pre-operative radiographic evaluation of the thumb. The radiographic angle of both thumb MCP joints was measured blinded to the other measurements. All thumb MCP joints were then manually stressed in the operating room, under anesthesia, to remove pain as a variable. The intra-operative MCP stress view was considered the gold standard. The differences between the goniometer and intra-operative stress view, and “diamond” view to the intra-operative stress view were compared for statistical significance using Pearson Correlation and paired sample t-test.

Results:
Fifty-seven thumb examinations in 30 patients, averaging 61 years of age, were completed. Goniometer, “diamond” view, and intra-operative measurements were averaged for the left thumb and right thumb in each group. Pearson correlations at the .01 level were statistically significant (p<.05) when comparing the goniometer and “diamond” measurements to the intra-operative measurements. Paired sample t-test significance of p>.53 between the “diamond” view and intra-operative measurement was consistent that the two views were inter-changeable. Conversely, paired sample t-test significance of p<0.001 showed the goniometer measurement was statistically different from the intra-operative view.

Conclusions:
The thumb hyperextension “diamond” stress radiograph accurately measures MCP joint hyperlaxity, providing objective evidence to patients being counseled on CMC arthroplasty. Goniometer measurement of thumb MCP joint hyperextension does not reliably measure MCP hyperlaxity compared to patients under anesthesia.
Reduction of the Thumb-tip Trajectory Area after Trapeziometacarpal Joint Fusion: a Cadaveric Study
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1Clinical Research Center, International University of Health and Welfare, Tokyo, Japan; 2Department of orthopaedic surgery, Keio University, Tokyo, Japan; 3National Institute of Advanced Industrial Science and Technology, Digital Human Research Center, Tokyo, Japan

INTRODUCTION: There is no biomechanical study examining reduced area of the thumb-tip trajectory after the thumb trapeziometacarpal (TMC) joint fusion. We investigated how large area of the thumb-tip trajectory decreased after the TMC joint fusion.

METHODS: 6 fresh-frozen cadavers were used in this study. Three optical markers were fixed directly to the bones by stainless steel wires drilled into the scaphoid, trapezium, metacarpal, proximal phalanx, and distal phalanx of the thumb and 6 optical markers were fixed to the base of the custom-built experimental apparatus. Four extrinsic tendons (FPL, EPL, EPB, APB) were pulled independently by computer-controlled serve motors. Tension by the servo motors was applied to the distal tendons of 4 extrinsic thumb muscles, while tension by static weight was applied to 4 intrinsic muscles (APB, FPB, AdD, OP) through Nylon stitches representing the direction of each muscle. Thumb motion was measured under six different intrinsic muscle tensions, 0.00N, 0.98N, 1.96N, 2.94N, 3.92N, and 4.90N, before and after the TMC fixation with pins. The motions of these markers were recorded by a motion capture system (OptiTrack Flex 13; Natural Point, Inc.)(Fig. 1). Surface geometries of the markers and bones created from the CT images were fit into the marker trajectories from the motion capture system to reconstruct the 3-dimensional bone motion.

RESULTS: Fig. 2 shows the area of the thumb-tip trajectories for six different tensions of the APB, when the FPL was pulled before (Fig. 2A) and after (Fig. 2B) the TMC joint fixation. Figure 3 demonstrates the superimposed trajectories. This figure clearly indicates that the fingertip trajectory area was extremely smaller after the TMC fusion. Trajectory area was limited to approximately 30% of the original area after the TMC joint was fixed.

DISCUSSION: TMC fusion provides stability of the thumb, while resulting in decrease of the range of motion of the thumb. Despite the marked decrease in motion, subjective functional complaints may be minimal. In this study, we revealed how the area of thumb-tip trajectory decreased after the TMC joint fixation compared with before fixation. The trajectory area decreased to approximately 30% of original area after the TMC joint fusion. We consider that this technique and result of this study will be useful for understanding thumb motion after the TMC arthrodesis.
31 Prevalence of Radiocarpal and Midcarpal Arthritis
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Thomas Jefferson University Hospital, Philadelphia, PA

Introduction:
Radiocarpal and midcarpal osteoarthritis (RC/MC OA) are debilitating degenerative diseases, and their prevalence is poorly defined. While the most common forms of arthritis have traditionally been considered to be scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC), not all forms of OA fit these patterns. The goals of our study were to 1) to elucidate the prevalence and patterns of RC/MC OA; and 2) to evaluate the reliability of a modified carpal zone-specific typing of this degenerative condition.

Methods:
We searched the radiology database at a single institution for Current Procedural Terminology (CPT) codes 73100 and 73110 to identify all patients who had wrist radiographs for any reason. Visualization of both the mid-carpal and radio-carpal joints on a minimum of 2 views was required for inclusion. All radiographs were classified according to the SLAC and SNAC patterns and a modified carpal zone-specific classification system (Figure 1). The prevalence and types of RC/MC OA were tabulated, and observer reliability of these patterns were calculated between four hand surgeons.

Results:
1,007 patient x-rays were reviewed. The overall prevalence of RC/MC OA in this population was found to be 5.4%. The prevalence among women was 3.5% and among men was 9%. The average age of the patients with RC/MC OA was 65 years (range 23-96). Twelve patients (21%) had degenerative changes consistent with SLAC pattern (1 Type 1, 8 Type 2, 2 Type 3 and 1 Type 4) while 6 patients (11%) had changes consistent with SNAC pattern (4 Type 1, 1 Type 2 and 1 Type 3). The remainder (69%) had RC/MC OA patterns which did not fit the SLAC/SNAC classification schemes (Table 1). Logistic regression demonstrated that male gender and increasing age were predisposing factors to arthritis (p < 0.001). The kappa coefficients for inter and intra-observer reliability for the carpal zone typing of degenerative changes were 0.69 and 0.86.

Conclusion:
Overall, the prevalence of RC/MC OA in this study was 5.4%. Contrary to the conventional wisdom, the SLAC and SNAC degenerative patterns were not the most common forms of arthritis. The more common, non-typical patterns may be better defined by denoting the zone of carpal joint involvement.

Table 1: Radiocarpal and Midcarpal Zones of Degenerative Changes
TABLE 2:

<table>
<thead>
<tr>
<th>RADIOCARPAL or MIDCARPAL ARTHRITIC ZONE</th>
<th>OCCURRENCE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26 (67)</td>
</tr>
<tr>
<td>2</td>
<td>15 (15)</td>
</tr>
<tr>
<td>3</td>
<td>17 (17)</td>
</tr>
<tr>
<td>4</td>
<td>4 (10)</td>
</tr>
<tr>
<td>5</td>
<td>4 (10)</td>
</tr>
<tr>
<td>6</td>
<td>2 (5)</td>
</tr>
<tr>
<td>7</td>
<td>2 (5)</td>
</tr>
</tbody>
</table>
Introduction:
Partial wrist denervation (PWD) and total wrist denervation (TWD) are minimally invasive options to treat chronic pain related to articular degeneration or chronic instability. Herein, we report a comparative study of the efficacy and outcomes between these procedures.

Methods:
The medical records of all patients who underwent PWD or TWD at the Portland VA Medical Center from 1999 through 2015 were reviewed. Patients who underwent a concomitant wrist procedure at the time of denervation were excluded. Patients that required further wrist surgery for pain were classified as treatment failures. Patients who died or were lost to follow-up were considered successes if they had not undergone salvage surgery. For the remaining patients, mini-DASH scores were calculated at the most recent follow-up.

Results:
Ninety-six patients (93 males and 3 females) met inclusion criteria. The predominant diagnoses were: carpal arthritis, scaphoid nonunion, SLAC, Keinbock, STT arthritis, and sequelae of prior distal radius fracture. Twenty-nine patients underwent PWD between 1999 to mid-2008 and 67 underwent TWD between late-2008 to 2015. Four PWD (12.9%) and 16 TWD (23.9 %) went on to require additional surgery. A trend towards failure was observed in younger patients and the diagnosis of SLAC wrist; these results were not statistically significant (P>0.05). The average time to failure was 9.2 years (95% CI 7.3-11.1 years) for PWD and 3.9 years (95% CI 3.4-4.5 years) for TWD (P <0.0001). Mini-DASH scores were obtained for 60 patients, 19 had PWD at an average follow-up of 11.9 years (range 7.8-17.0 years) and 41 had TWD at an average follow-up of 5 years (range 0.1-11.9 years). The average mini-DASH score for PWD was 30.7 and 30.5 for TWD; this difference was not statistically significant (P=0.76).

Conclusion:
Wrist denervation is an efficacious treatment for chronic wrist pain with a 79% overall rate of success in preventing or delaying progression to salvage surgery.1,2 In our study, neither treatment was statistically superior. However, better pain relief and an increased time to treatment failure was observed in those undergoing partial wrist denervation. The overall failure rate for PWD was 12.9% (mean time to failure 9.2 years) and was 23.9% (mean time to failure 3.9 years) for TWD. Patients greater than 50 years-old and those who suffered from arthritis demonstrated reduced rates of failure and salvage surgery regardless of denervation method. Even for patients who may ultimately fail, denervation may provide durable and meaningful pain reduction.
INTRODUCTION:
Ulnar sided wrist pain can be a daunting problem for hand surgeons. Pisiform pathology, including pisotriquetral arthritis, fracture or instability, may be the culprit. At our institution pisiformectomy has been clinically found to have good outcomes, with formal review lacking. This study reviews the long term outcomes of patients treated with pisiformectomy, focusing on need for and time to revision procedure.

METHODS:
IRB-approved retrospective study was performed over a 27 year period (1988-2015) of all patients undergoing pisiformectomy. At latest follow up, data including range of motion, grip strength, complications and need for revision surgery were recorded.

RESULTS:
The series includes 61 wrists in 60 patients (45 female, 15 male) with an average age at surgery of 46 (range 18 to 74). Average follow up was 98 months (8.2 years) (range 3-288 months). The main diagnosis in this series was pisotriquetral degenerative arthritis (idiopathic osteoarthritis 81%, post-traumatic arthritis 13%, inflammatory arthritis 6%); no patients had pisotriquetral instability. 63% of patients had documentation of failed nonoperative management (splinting, injections, and immobilization). Surgery consisted of open pisiformectomy in all patients. Patients underwent concomitant procedures in about half of cases (48%). Most common procedures included TFCC/DRUJ debridement or repair (12), diagnostic arthroscopy (10), synovectomy (5), Guyon’s canal release (4) and CMC procedure (4). Two complications were noted (3%); a postoperative ulnar nerve palsy (resolved with observation) and symptomatic retained suture (taken for operative removal). 4 patients required repeat surgery which included removal of symptomatic suture and FCU debridement (1), volar ganglion excision (1), DRUJ stabilization procedure (1) and four-corner fusion (1). Average time to revision surgery was 92 months (range 15-177). The majority of the patients in the series did not require revision procedures for pain or instability at average follow up of 98 months (range 3-288). At final follow up, average flexion to extension arc was 81% (expressed as percent of contralateral), radioulnar deviation arc was 88% and average grip strength was 89%.

CONCLUSIONS:
Pisiformectomy is a reliable motion preserving procedure with low complication rates for patients with chronic ulnar sided wrist pain related to pisotriquetral arthritis or instability. In this series, 66% of patients experienced pain relief and did not require further procedures at an average of 8.2 years of follow up. The significance of these results better enable surgeons to give time estimates and expectations regarding pain control following pisiformectomy.
34 Ulnar Shortening Osteotomy: Is it Necessary to Create Ulnar Neutral Variance?
Loukia K. Papatheodorou, MD; Joel V. Ferreira, MD; Mark E. Baratz, MD; Dean G. Sotereanos, MD
University of Pittsburgh, Pittsburgh, PA

Introduction
Ulnar shortening osteotomy (USO) is commonly performed for surgical treatment of ulnar impaction syndrome. Although the recommended amount of ulnar shortening varies in the literature, most studies advocate between neutral and 2 mm of negative ulnar variance. However, with increasing amounts of shortening, biomechanical and long-term clinical studies have shown an increased risk of developing distal radioulnar joint (DRUJ) arthritis. The purpose of the study was to determine if a limited step-cut USO of 2-3 mm would provide symptom resolution in the treatment of ulnar impaction syndrome regardless of pre-operative ulnar variance.

Materials and Methods
We retrospectively reviewed 164 consecutive patients who treated with a limited step-cut USO for ulnar impaction syndrome between 2000-2010. Eighty-eight patients were female and seventy-six were male with a mean age of 36.8 years. Idiopathic ulnar impaction syndrome was diagnosed in 116 patients, while a post-traumatic etiology was seen in the remaining 48 patients. In all cases a limited step-cut USO of 2-3 mm was performed. Ulnar variance was assessed radiographically pre- and post-operatively with the pronated grip view. The mean pre-operative ulnar variance was +3.5 mm (range, +1 mm to +6 mm). Wrist radiographs were assessed post-operatively for evidence of degenerative changes or osteophyte formation at the DRUJ at final follow-up.

Results
The mean follow-up was 62.4 months. Union of the osteotomy was achieved with a mean time of 8.2 weeks (range, 5-18 weeks) and at a rate of 98.78% (162/164 cases). There were two cases of nonunion which both went on to heal with revision surgery utilizing autologous iliac crest bone graft. The mean post-operative ulnar variance was +0.2 mm (range, -1 mm to +1.5 mm). In all patients, pain, range of motion, grip strength and Modified Mayo Wrist Score significantly improved postoperatively regardless of the postoperative ulnar variance (negative, neutral, positive). Hardware removal was performed in twelve patients due to persistent plate-related symptoms (7.3%). At final follow-up, asymptomatic degenerative changes at the DRUJ occurred in nine of the 164 patients (5.5%).

Conclusions
A limited step-cut USO of 2-3 mm provides excellent union rates and good to excellent functional results, regardless of pre-operative ulnar variance. Limiting the amount of shortening to 2-3 mm results in lower rates of degenerative changes seen at the DRUJ compared to previous literature. The limited ulnar shortening minimizes the rate of DRUJ articular incongruity and diminishes development of DRUJ arthritis.
Purpose:
The outcomes of upper extremity small joint arthroplasty in young patients has yet to be examined. The purpose of this investigation was to define the association between a young age and outcomes after TWA.

Methods:
Using our institution's total joint registry, 445 consecutive primary TWA arthroplasties were performed at our institution from 1974 to 2013. The average age was 57 years (16-83). There were 261 arthroplasties performed in patients <60 years of age. In these younger patients, the surgical diagnoses included osteoarthritis (3%), inflammatory arthritis (91%), and post-traumatic arthritis (PTA, 7%). The implants in this study included Remotions (n=19), Biax (n=99), Volz (n=10), Meuli (n=91), Universal (n=4), and Swanson (n=38). Cement was used in 215 (82%), while 27 (10%) required augmentation with bone graft.

Results:
Overall, there were 110 (25%) TWA arthroplasties that required revision surgery at a mean of 5.4 years postoperatively. In the young patients (<60 years), 81 (31%) required revision surgery at a mean 5.6 years postoperatively for loosening (n=36), component fracture (n=6), infection (n=7), wrist instability (n=20), and other (n=12). Risk of revision surgery was not associated with age taken as a continuous variable (p=0.44), but there was an increased risk of revision surgery when comparing those younger than 60 to those older than 60 years (HR 1.61, p=0.02). The 5, 10, and 20-year implant survival rates for the patients <60 years were 80%, 70%, and 60%, respectively, which was significantly lower the older patients (Figure 1). Amongst the these younger patients, the risk for revision surgery was increased in osteoarthritis, but this was not significant (Figure 1). Swanson implants had improved implant survival (Table 1). In the younger patients, there were 4 intraoperative complications involving fracture in the younger patients. Postoperative complications in the younger patients included dislocation (n=24), infection (n=13), postoperative fractures (n=11), implant loosening (n=41), recurrent subluxation (n=17) heterotopic ossification (n=5), tendon/ligament injury (n=12), and wear (n=6). The risk of carpal component loosening was increased in patients younger than 60 years, while dislocation and fractures were not.

Conclusions:
Younger age lead to slightly higher rate of revision surgery and complications, particularly implant loosening after total wrist arthroplasty. Swanson implants performed better in this younger population. These findings help when counseling patients, estimating risk, and potentially evaluating risk in health policy.
Table 1: Hazard Ratios for TWA Implant Failure in Patients Younger than 60 years

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>1.03</td>
<td>0.95 – 1.12</td>
<td>p = 0.44</td>
</tr>
<tr>
<td>Female</td>
<td>1.09</td>
<td>0.66 – 1.89</td>
<td>p = 0.76</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>2.03</td>
<td>0.50 – 5.48</td>
<td>p = 0.28</td>
</tr>
<tr>
<td>Inflammatory Arthritis</td>
<td>0.93</td>
<td>0.48 – 2.10</td>
<td>p = 0.85</td>
</tr>
<tr>
<td>Post-traumatic Arthritis</td>
<td>0.82</td>
<td>0.29 – 1.84</td>
<td>p = 0.66</td>
</tr>
<tr>
<td>Tourniquet Time</td>
<td>1.00</td>
<td>0.99 – 1.01</td>
<td>p = 0.84</td>
</tr>
<tr>
<td>Operative Time</td>
<td>1.01</td>
<td>1.00 – 1.01</td>
<td>p = 0.17</td>
</tr>
<tr>
<td>Prop Instability</td>
<td>1.83</td>
<td>0.30 – 5.88</td>
<td>p = 0.44</td>
</tr>
<tr>
<td>Remotion</td>
<td>2.23</td>
<td>0.77 – 5.11</td>
<td>p = 0.13</td>
</tr>
<tr>
<td>Bix</td>
<td>0.81</td>
<td>0.51 – 1.28</td>
<td>p = 0.27</td>
</tr>
<tr>
<td>Volz</td>
<td>0.61</td>
<td>0.10 – 1.92</td>
<td>p = 0.45</td>
</tr>
<tr>
<td>Meuli</td>
<td>1.47</td>
<td>0.95 – 2.28</td>
<td>p = 0.09</td>
</tr>
<tr>
<td>Universal</td>
<td>3.73</td>
<td>0.61 – 12.07</td>
<td>p = 0.13</td>
</tr>
<tr>
<td>Swanson</td>
<td>0.50</td>
<td>0.22 – 0.99</td>
<td>*p = 0.04</td>
</tr>
<tr>
<td>Bone Craft</td>
<td>1.50</td>
<td>0.70 – 2.85</td>
<td>p = 0.27</td>
</tr>
<tr>
<td>Cemented Implant</td>
<td>0.90</td>
<td>0.51 – 1.73</td>
<td>p = 0.74</td>
</tr>
</tbody>
</table>
36 Complex Combined Thermal-crush Hand Trauma. Our 10 years Experience.
Dinu Iuliu Dumitrascu, MD PhD¹; Alexandru Georgescu, Prof, MD; PhD²
¹UMF Cluj, Cluj-Napoca, Romania; ²Plastic Surgery and Reconstructive Microsurgery Clinic, UMF Iuliu Hatieganu, Cluj Napoca, Romania

Introduction
Even rare, the combined thermal and crush injury is present in our service. The etiology of the trauma is especially due to misuse of industrial equipment. The cumulative insult results in a complex trauma that usually not only affects the skin but also nerves, muscles, tendons, vessels and even bone.

Materials and Methods
A total of 24 patients (mean age 46) were included in the study. 16 patients were female and 8 men. The etiology was a combined crush and burn injury sustained with heat press (flat or rotary). The patients were admitted from 2006 to 2016. All patients had skin defects that needed coverage with skin grafts or flaps. 15 patients had dorsal or palmar tendon injury, 8 had interosseous muscle injury and 3 had fractures in the hand. Defect coverage was obtained using skin grafts, pedicled flaps, perforator pedicled flaps or free flaps.

Results
In 8 cases free flaps were used to cover the defects. In 10 cases the coverage was achieved with the use of perforator pedicled flaps. In 2 cases, skin grafting and fascial pedicled flaps were used. In 4 cases, only skin grafting was necessary to achieve a good coverage. If needed, osteosynthesis and tendon grafting were performed.

Conclusions
Due to the complex injury mechanism, the tissue destruction is difficult to estimate. Usually a treatment in successive stages is mandatory. A good debridement is paramount in order to obtain a good result. If possible, we prefer the coverage with perforator flaps instead of free flaps due to early postoperative mobilization and shorter operative time.
37 Micro-CT Study of the Intraosseous Vascularity of the Scaphoid
Mohamed Morsy, MD1,2; Nick A van Alphen, MD1; Alexis T Laungani, MD1; Assaf Kadar, MD1; Steven L Moran, MD1
1Mayo Clinic, Rochester, MN; 2Assiut University, Assiut, Egypt

Introduction:
Avascular necrosis of the proximal pole of the scaphoid is a commonly anticipated complication following scaphoid fractures. The purpose of this study was to use micro-CT to demonstrate the intraosseous vascularity of the scaphoid within a three dimensional orientation to identify areas of greatest perfusion, and define vascular “safe-zones” for surgical intervention.

Methods:
Twelve upper extremities were injected with a lead-based contrast agent (Microfil MV-117, Flow Tech, Carver, MA, USA) under a physiologic pressure of 140 mmHg, monitored by a pressure monitor. The Scaphoids were harvested and scanned using a micro-CT scanner. The intraosseous vascularity was incorporated into a 3D rendering (figure 1). Vessel number, diameter, distribution and pattern were evaluated and analyzed.

Results:
Four scaphoids (33.33%) received one vessel to the proximal pole and waist. Five (41.67%) received two vessels and three (25%) received three vessels. Those vessels entered the scaphoid at the dorsal ridge proximal to the level of the mid-waist in three specimens (25%), at the level of the mid-waist in six (50%) and distal to the level of the mid-waist in three (25%). As for the distal pole, three specimens (25%) received one vessel to the distal pole, five (41.67%) received two vessels and four (33.33%) received three vessels. Nutrient vessels entered the distal pole from the volar side in five specimens (41.67%), from the dorsal side in one (8.33%) and from both the volar and dorsal side in six (50%). A vascular density 3D model was created by mirroring the intraosseous vascularity of all the twelve specimens onto one image (figure 2). This showed the areas of potential vascularity, and was used to suggest an optimal position for instrumentation of the scaphoid respecting the intraosseous vasculature (Figure 3).

Discussion and Conclusion:
Results of this study suggest that the scaphoid's proximal pole and waist receive vascularity exclusively from vessels entering through the dorsal ridge, which conforms to the data from previous studies. However, the distal pole showed variability in the vessel entry, being exclusively volar, dorsal or from both sides. The generated 3D intraosseous vascular model allowed us to suggest a “safe-zone” for surgical intervention and instrumentation. The results of this study suggest screw placement slightly ulnar and dorsal to the long axis of the scaphoid.
Vascularized Dorsal Capsular Bone Grafting for Proximal Pole Scaphoid Nonunions with AVN
Seth D Dodds, MD1; Shannon Fitzpatrick, MD2; Cynthia Tsai, BS2
1University of Miami, Miami, FL, 2Yale University, New Haven, CT

Introduction:
Fracture fixation is frequently tenuous when the scaphoid proximal pole is a small avascular nonunited fragment. We hypothesized that the addition of scaphocapitate screw fixation to standard scaphoid screw nonunion repairs would improve healing rates.

Methods:
We retrospectively reviewed ten patients with scaphoid proximal pole fracture nonunions that were treated with a vascularized dorsal capsular graft as described by Sotereanos(1), scaphoid screw fixation, and temporary scaphocapitate fixation. Two patients were lost to final follow-up. Scaphoid proximal pole nonunions were debrided and bone grafted with cancellous autograft. A dorsal trough was created in the scaphoid for the dorsal capsular vascularized bone graft. The scaphoid nonunion was then secured with a scaphoid screw placed down the central axis of the scaphoid. Next, percutaneous scaphocapitate fixation of the midcarpal was performed to reduce flexion forces at the fracture site. All patients were prescribed an ultrasound bone stimulator until there was radiographic evidence of healing, defined as >50% bone bridging on CT scan.

Results:
Our case series included eight males and two females with an average age of 22.5. All patients had proximal pole fractures of the scaphoid with avascular necrosis as diagnosed on CT scan based on bone density. The average time to radiographic union for patients with proximal pole necrosis was 5.5 months, with 2 patients taking up to a year to heal before removal of their scaphocapitate screws. The average wrist flex/ext for patients was 42.5/47.5 after scaphocapitate screw removal compared to pre-op flex/ext of 45.0/36.7. Healing was confirmed on CT scan in 8 of 10 patients, in the other 2 patients healing was confirmed on radiographs and intra-operative fluoroscopy at the time of screw removal. Complications included 2 patients with radial sensory nerve hypersensitivity that did not completely resolve related to the scaphocapitate screw insertion and/or subsequent removal.

Conclusions:
While we did achieve healing in all of our patients, we recognize that the time to union was lengthy in this group. In fact, one patient, who took over a year to heal, had a CT scan at six months showing no more than 25% bridging bone. Prior series(1) without scaphocapitate screw fixation found 8 of 10 proximal pole nonunions with AVN healed, but no other complications. Vascularized, dorsal capsular grafting with temporary scaphocapitate fixation creates a powerful combination of surgical treatment for a very challenging subset of scaphoid proximal pole fracture nonunions with avascular necrosis.
39 Is Free Vascularized Bone Grafting Superior for Scaphoid Nonunion?
William Aibinder, MD; Eric R. Wagner, MD; Allen Bishop, MD; Alexander Y. Shin, MD
Mayo Clinic, Rochester, MN

INTRODUCTION:
Symptomatic scaphoid nonunion occurs in 10 to 15% of fractures. Nonvascularized bone grafting (NVBG), and pedicled and free vascularized bone grafts (VBG) have been employed with variable success. Regarding VBG, while the traditional 1,2-intercompartment supraretinacular artery (1,2-ICSRA) distal radius bone graft is limited by its pedicle, the free medical femoral condyle (MFC) graft permits greater deformity correction. We thus sought to compare our institution’s experience using NVBG via structural iliac crest bone graft (ICBG), 1,2-ICSRA, and MFC grafts to treat scaphoid nonunions.

MATERIALS AND METHODS:
We performed a retrospective review between 2000 and 2013 of all scaphoid nonunions treated at our institution. After excluding patients with less than 6 months of follow-up were excluded, there were 35 that underwent ICBG, 43 that underwent 1,2-ICSRA, and 41 that underwent MFC bone grafting. Mean time to follow-up was 16 months (range 6 to 164). Patients that underwent reoperation prior to 6 months were included. Mean age at surgery was 24 years (range 11 to 66). Males comprised 87% and the dominant extremity was involved in 60% of cases. Tobacco use was noted in 21% of subjects. Outcomes included time to healing, range of motion, complications, and reoperations.

RESULTS:
Union rates and mean time to union were 69% and 20 weeks for ICBG, 71% and 45 weeks for 1,2-ICSRA, and 95% and 16 weeks for MFC, respectively. The use of an MFC graft, absence of tobacco use, younger age, and male gender were correlated with healing (p = 0.004, 0.002, 0.005, and 0.01, respectively). Time from injury to surgery did not affect healing (p = 0.30). There was no significant difference between the 3 groups in regards to change in wrist flexion, wrist extension, radial deviation, ulnar deviation, and grip strength. There were 28 overall reoperations, including 26% in the ICBG group, 15% in the 1,2-ICSRA group, and 32% in the MFC group.

CONCLUSIONS:
The use of a free vascularized MFC graft has demonstrated promising results in the literature. This comparative study demonstrates superior union rates with a more rapid time to union compared to NVBG and pedicled dorsal distal radius VBG. Clinical outcomes are similar, and when excluding reoperation for hardware removal, the reoperation rates are not dissimilar. In cases of symptomatic scaphoid nonunion with osteonecrosis and carpal collapse, the MFC is a viable and reliable surgical option, even as salvage for prior failed structure grafting procedures.
40 Internal Bone Grafting Technique for the Treatment of Scaphoid Non-Unions
Hasan Utkan Aydin, MD; Sunil T. Thirkannad, MD
Christine M Kleinert Institute for Hand and Microsurgery, Louisville, KY

Introduction:
Scaphoid fracture is the second most common fracture of the upper extremity after distal radius fractures, and approximately 5%-10% of undisplaced scaphoid fractures may eventually progress to non-union. The excision of pseudoarthrosis and fibrous scar tissues surrounding the fracture has been so far regarded as one of the important steps in management of scaphoid fractures. We propose a technique where the curettage of the non-union and fibrous tissue was performed through a drill hole on the scaphoid and the bone graft was packed using this drill hole before fixation with a headless compression screw. The aim of this study is to investigate the clinical and radiological outcomes of the internal bone grafting technique performed at our institution.

Materials & Methods:
A retrospective chart review was done investigating all patients who presented to the clinic with scaphoid non-unions between 2006 and 2014. Patients with humpback deformity, avascular necrosis, carpal instability, and osteoarthritis were excluded.

Results:
A total of 14 patients (13 male and 1 female; average age, 37.5 years; range 21-64 years) meeting the set criteria were identified. The average follow up time was 12.2 months (range 2-52 months). Twelve of 14 patients achieved union evidenced by clinical examination and imaging. Two patients demonstrated failure of union (Less than 25% bridging callus on computed tomography scan).

Conclusions:
Internal bone grafting is a versatile and technically uncomplicated method, which can be applied successfully in selected cases. This technique allows for the external fibrocartilaginous shell to be preserved, which closely resembles original surface of an uninjured scaphoid.
**41 Scaphoid Nonunions with Segmental Defects Treated with Locking Plate Fixation and Pure Cancellous Grafting: First Clinical Report**

Scott G. Edwards, MD;  
*Department of Orthopaedic Surgery, The CORE Institute, Phoenix, AZ*

**BACKGROUND:**
Scaphoid nonunions have traditionally been treated with headless screw or pin fixation with vascular or non-vascular corticocancellous graft to add structural integrity. Volar locking plates may offer several advantages over headless screws for fixation for scaphoid nonunion management: (1) preserved intraosseous vascularity; (2) increased surface area for bony healing; and (3) maintenance of a gap for pure cancellous grafts. Cancellous grafts have been proposed by many investigators as being physiologically superior to corticocancellous grafts. Vacularized grafts carry the added burden of increased costs and morbidity over non-vascularized grafts. Scaphoid volar locking plates may allow for cancellous grafts to be used as opposed to the more invasive, expensive and perhaps less physiologic grafting options.

**METHODS:**
27 consecutive patients were prospectively enrolled that met inclusion criteria of having an established scaphoid nonunion with segmental defect or bone loss with or without the presence of avascular necrosis. In addition to routine radiographs, all patient were assessed by MRI for vascular status. All patients were treated with locked volar plating with cancellous graft from the distal radius and/or olecranon. SNAC II-IV were excluded. Patients were immobilized until radiographic evidence of bony healing which was confirmed on CT scan. Time to healing was recorded as well as preoperative and postoperative motion, grip strengths, analog pain scores, and DASH scores.

**RESULTS:**
22 males and 5 females with a mean age of 33.2 years were enrolled. The mean time from initial injury was 72 months (range: 14 weeks to 28 years). 9 patients presented with proximal pole nonunion, 7 of which had AVN. Mean follow up was 19 months (range 9 to 24 months). 3 patients failed previous scaphoid fracture fixation with headless screws. At the final follow up, all patients demonstrated bony healing. Mean time for bony healing was 84 days (range: 46 to 196 days). Mean grip strengths increased 14% and was 87% of the contralateral side, mean DASH scores increased 32.4 points, and motion remained relatively unchanged from the preoperative measurements. Mean operative time was 42 minutes.

**CONCLUSIONS:**
Locked volar plate fixation with cancellous graft compare favorably to previous reports of more traditional techniques that involve vascularized or non-vascularized corticocancellous grafting. Avascular necrosis does not appear to be a contraindication to this procedure, in fact success healing can be expected. This technique may offer faster and more predictable union with less morbidity, expense, and expertise required.
42 Biomechanical Analysis of Screw Trajectory in the Reduction and Association of the Scaphoid and Lunate (RASL) Procedure
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Introduction:
The reduction and association of the scaphoid and lunate (RASL) procedure is a technique for treating scapholunate (SL) ligament disruptions, achieving sufficient functional outcomes and restoring proper wrist kinematics to prevent the development of scapholunate advanced collapse. The goal of this cadaveric study was to determine if placement of the screw affects the ability of the SL joint to withstand mechanical force, thereby providing insight into the importance of screw trajectory in the outcome of the RASL procedure.

Methods:
The RASL procedure was performed by the senior author on 27 fresh-frozen cadaveric wrists after complete disruption of the SL ligament. Using fluoroscopic guidance, a headless compression screw was placed either distal (15 screws) or proximal (12 screws) to the scaphoid waist and into the dorsal (13 screws) or volar (14 screws) aspect of the lunate. Specimens were mounted onto a custom-made jig and the wrist was subjected to repeated cycles of transcarpal axial force, increasing in a step-wise fashion from 100N to 200N, covering the spectrum of physiologic compression forces during clenched-fist motion. Failure was defined as any amount of diastasis between the scaphoid and lunate, as determined using radiographs between each force interval, direct visual inspection, and real-time infrared camera displacement monitoring using a Vicon Nexus motion capture system. Statistical significance was determined by a two-tailed t test or Fisher's exact test setting a confidence level of 95% (α ≤ 0.05).

Results:
The average cadaver age was 52 (range 18-64). No specimens were reported to have used steroids, have a history of fragility fractures, or osteoporosis. Cadaver age (p=0.082), BMI (p=0.958), physical activity level (p = 0.596), smoking status (p=0.678), gender (p=0.695), and hand dominance (p=0.695) were not significant predictors of failure for the procedure. When examining screw trajectory, placement in the dorsal versus volar poles of the lunate (p=0.706) were not significant predictors of failure. However, screw placement distal to the scaphoid waist was significantly (p<0.001) associated with failure of the RASL procedure.

Conclusion:
This study offers the first biomechanical analysis of treatment of a SL ligament rupture with the RASL procedure. The results presented here suggest screw placement proximal to the scaphoid waist is optimal for success of the RASL procedure, and that accurate positioning in the lunate does not affect the outcome of the RASL. The scaphoid waist is a reliable radiographic landmark, providing surgeons with the means to achieve a consistent successful screw starting point.
43 Infection Rates in Open Hand Fractures: Can Treatment Be Delayed?
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Introduction:
The purpose of this study was to retrospectively evaluate rates of nonunion and compare the infection rates in two groups of open hand fractures (immediate operative treatment versus delayed operative treatment). We hypothesized that the delayed treatment group would have similar rates of infection and nonunion.

Materials & Methods:
A level one trauma center claims database was queried using the International Classification of Diseases (ICD-9) codes for open fractures including both phalanx and metacarpal fractures for patients presenting to the emergency department (ED). Open fractures were treated either with immediate operative treatment or with delayed operative treatment (>24 hours) by a fellowship trained hand surgeon. The groups were then compared as delayed versus immediate treatment groups through a retrospective chart review.

Results:
One hundred and twenty nine patients with open hand fractures met the study eligibility criteria. There were 105 males and 24 females with an average age of 42.7 years. Of the 129 open hand fractures, 58 had delayed treatment and 71 received immediate treatment. Follow-up was similar between groups (p=0.74) and, on average, was 6 months (std dev=7.5 months). On average, there was only one phalange or metacarpal fractured, but ranged up to 4 digits involved. Both the delayed and immediate surgical treatment groups had associated soft tissue injuries in 62% of cases (37/58 and 43/71, respectively; p=0.71). The infection rate among those that were delayed was 9% (5 of 58) compared to 14% (10 of 71) that received immediate treatment (p=.34). There were no cases of nonunion in the delayed treatment group, but 9 cases in the immediate treatment group (13%; 9 of 71) (p<0.01). Eighteen (25%) of the immediate treatment group had reoperation, compared to 8 (14%) of the delayed treatment group (p=0.11). When adjusted for severity of injury, the occurrence of a washout in the ER, and the immediate treatment with antibiotics, there was not a statistically significant difference in the rate of infection (OR=0.32, 95% CI: 0.07-1.44; p=0.14) or reoperation (OR=0.50, 95% CI: 0.15-1.63; p=0.25) between groups.

Conclusion:
We sought to compare immediate versus delayed operative treatment of patients presenting with open hand fractures. When adjusted for case mix, delayed treatment was associated with lower rates of infection, but the decrease was not statistically significant. Delayed treatment was associated with lower rates of nonunion of open hand fractures when compared to immediate operative treatment.
**44 Kirschner wire infection rates in hand fractures**

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**Introduction**

Kirschner wires (K-wires) are a commonly used method for fracture fixation. There is little evidence looking specifically at infection rates with their use. Literature ranges between 6-20% have been reported. We aimed to compare infection rates over time between buried and exposed K wires in various hand fractures in our unit.

**Materials and methods**

Retrospective review of patients with hand fractures treated with K wires from Day Surgery database. We compared two groups; group (A) 104 adult patients (April 2010-March 2011), group (B) 47 patients (October 2015-January 2016). All acute, closed fractures suitable for K-wire fixation were included. Parameters looked at were: location of fracture, digits involved, number of wires, length of time for wire removal, age, gender, smoking, medical history of Diabetes Mellitus. Statistic analysis by paired t-tests, chi-squared and relative risk.

**Results**

Group A- a total of 202 K wires were used, Male / Female ratio was 82/22. We observed an 8.8% infection rate (3 cases) with buried and 10% (7 cases) with exposed K wires. Total infection rate in group A was 10.4%. Group B- a total of 83 K-wires used, male/female ratio was 40/7 and infection rates were 16.7% (2 cases) with buried and 8.6% (3 cases) with exposed K wires. Total infection rate was 10.6%. The mean age in both groups was 33 and mean time for K-wire removal was 4 weeks. All the infected cases involved a localized skin and percutaneous tissue infection with no osteomyelitis. There was no significant difference in infection rates between buried and exposed K-wires in both group A and group B, and also none when comparing infection rates between the two groups (χ² = 1.05, p= 0.305). Length of time for K-wire removal and smoking history were not significant. There was a significant difference in infection rates with diabetic patients compared to non-diabetics p<0.05 (χ² = 2.03, P= 0.03).

**Conclusion**

Compared to the literature, in our practice- exposed wires do not increase infection rates compared to buried. We remove wires earlier than that stated in literature (4 weeks mean compared to 6.5 weeks mean). A history of diabetes significantly increased infection rates with K-wire use. We therefore conclude that there is no need to bury K-wires in view of avoiding infections in hand fractures treated with K wires.
45 Infection Rates of Buried vs. Exposed Kirschner Wires in Phalangeal, Metacarpal, and Distal Radius Fractures
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Introduction:
Kirschner wires (K-wires) are commonly used by hand surgeons for temporary fixation of unstable fractures. To decrease risk of infection, some surgeons bury K-wires subcutaneously rather than leaving them exposed through the skin. However, studies comparing these two techniques have shown conflicting results. Our goal was to determine if there is a difference in infection rates between exposed and buried K-wires when used to treat phalanx, metacarpal, and distal radius fractures.

Methods:
We conducted a retrospective review identifying all patients over 16 years of age at our institution who underwent fixation of phalanx, metacarpal or distal radius fractures with K-wires between 2007 and 2015. We recorded patient demographic data as well as location of fracture, number of K-wires used, whether K-wires were buried or left exposed, and duration of K-wire placement. Infectious complications were separated into five groups based on treatment: 1) oral antibiotics, 2) oral antibiotics + early pin removal, 3) IV antibiotics without early pin removal, 4) IV antibiotics with early pin removal and 5) IV antibiotics + surgical debridement. Data was analyzed using equal variance t-test, chi-square test, Fisher's exact test, or unequal variance t-test, as appropriate.

Results:
Six hundred and ninety five patients met the inclusion criteria. Surgeons buried K-wires in 207 (29.78%) patients, and left K-wires exposed in the remaining 488 (70.22%) patients. Infections occurred in 80 exposed K wire cases (16.4%) and 19 buried K wire cases (9.2%) resulting in a statistically significant relative risk of infection for patients with exposed K-wires of 1.79 (95% CI: 1.11-2.87; p=0.01). Subgroup analysis based on fracture location revealed a statistically significant increased risk of infection for exposed pins when used in metacarpal fractures (RR= 2.25; 95% CI: 1.13-4.49; p=0.02).

Conclusion:
Patients with exposed K-wires for fixation of phalanx, metacarpal, or distal radius fractures were more likely to be treated for a pin site infection than those with K-wires buried beneath the skin. Metacarpal fractures treated with exposed K-wires were 2.25 times as likely to get a post-operative infection. To decrease infection rates when pinning hand and wrist fractures, particularly metacarpal fractures, surgeons should consider burying K-wires beneath the skin subcutaneously.
Scaphoid fractures can be successfully treated with cast immobilization in most cases; however, there is an estimated 5-15% nonunion rate with these fractures. More proximal fractures have a higher risk of avascular necrosis (AVN) given the more limited blood supply of this region. The results of the 1,2 ICSRA vascularized graft for scaphoid non-unions has had varying success in the literature, ranging from 27% to 100%. When we look closer at the published articles, there is substantial inconsistency in the fractures that are being treated, modalities for assessing healing, and fixation methods used. We hypothesized that small proximal pole scaphoid fractures could be managed successfully with fixation achieved by using a 1,2 ICSRA vascularized graft and a smaller diameter (≤ 2.5 mm diameter) compression screw.

Methods
This is a retrospective case series of 12 patients with ultra-small proximal pole scaphoid fracture nonunions that were treated at our institution with 1,2 ICSRA vascularized grafts and compression screws. Calculations of the size of the proximal pole fragment relative to the total scaphoid were performed using Posterior-Anterior Scaphoid view radiographs with the wrist in ulnar deviation and flat on the cassette. Analyses were repeated three times per subject, and the average ratio of proximal pole fragment relative to the entire scaphoid was calculated. We reviewed medical records, radiographs, and CT scans of these 12 patients. CT scans that were performed after an average of 12 weeks were ultimately used to confirm union of the scaphoid fractures.

Results
12/12 (100%) scaphoid fractures healed at an average of 11.45 weeks as shown by CT scan. The mean proximal pole fragment size was 18% (range 7-27%) of the entire scaphoid.

Conclusion
The 1,2 ICSRA vascularized graft and compression screw is an effective operation for patients with very small proximal pole scaphoid fractures. Previous studies have unsuccessfully used this surgery for waist fractures and have included a mix of patients treated with Kirschner wires and screws. The benefit of this study is that we included only patients with proximal pole fractures and included only patients treated with a compression screw and were able to show the success of the proposed operation.
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Introduction
The abnormal contour of the dorsal cortex of the distal radius provide difficulties in discerning screw penetration on standard lateral radiographs and may result in soft tissue injuries. The skyline and carpal-shoot through views are additional views described to improve dorsal cortex visibility. This study is a cadaveric analysis evaluating sensitivities in detecting screw protrusion when using skyline and carpal shoot-through views intraoperatively.

Materials and Methods
Seven fresh frozen human cadavers’ arms were instrumented with volar locking plate. Following instrumentation, a dorsal dissection of the wrist was performed to detect screw penetration. Protruding screws were replaced with screws of the appropriate length and deemed as baseline. Screws were then sequentially lengthened by 2mm and 4mm. Skyline and carpal shoot through views were obtained at baseline, 2mm, and 4mm. The images were randomized and compiled into an untimed survey asking orthopaedic surgeons to determine if screws were penetrating through the dorsal cortex based on radiographs provided.

Results
Sensitivities for the skyline and carpal shoot-through views were 75% and 86% respectively for 2mm protrusions, and 76% and 89% respectively for 4mm screw protrusions. Specificities were 85% and 84% for the skyline and shoot-thought views respectively.

Conclusion
The skyline and carpal shoot-through views are more sensitive at detecting screw protrusions compared to historic controls and should be added to intraoperative protocols and may decrease the incidence of screw protrusion resulting in soft tissue injuries.
The Effect of Orthopedic Hardware on Patient and Surgical Team Scatter Radiation Exposure Utilizing Mini C-arm in a Simulated Wrist Fracture Fixation Model

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Introduction:
The use of fluoroscopic imaging in orthopedic surgery has become more commonplace over the last few decades. Occupational risk of routine, increased use of fluoroscopy is due to the unknown effects of chronic low-level radiation exposure. The mini-C-arm is commonly used in upper extremity surgery and is generally perceived as safe. Studies have investigated radiation scatter in the past, but to our knowledge no studies have compared the effect of absence or presence of orthopedic hardware (plates/screws/retractors) in the fluoroscopy field with respect to changes in the intensity, direction of scatter, and degree of radiation exposure to the patient and surgical team. Furthermore, there is limited literature describing alteration in scatter exposure with changing the orientation of the mini-C-arm. The goal of this study was to determine if the presence of orthopedic hardware increases scatter radiation exposure to the patient and surgical team when using mini-C-arm in the horizontal and vertical positions.

Materials and Methods:
4 trials were conducted using a lamb limb specimen and a standard mini-C-arm to simulate a forearm/wrist fracture fixation scenario. Trials 1 and 2 tested scatter with no metal on the field and with the mini-c-arm in the vertical and horizontal position. Trials 3 and 4 tested scatter radiation with a 6 hole 3.5 mm LCDCP plate attached to the specimen in the standard fashion with 6 cortical screws and a self-retaining retractor with mini-C-arm in vertical and horizontal positions. We used a parallel plate radiation detector to measure scatter directed at the region of the eyes, thyroid, chest, hands (surgeon only) and gonads of the patient and surgical staff. Comparisons were made using scatter percentage (scatter/direct beam x 100).

Results:
The patient, scrub technician, circulating nurse, and anesthesiologist were exposed to no detectable scatter radiation. However, the presence of orthopedic hardware in the fluoroscopy field produced a substantial 181-fold increase in scatter radiation exposure to first assistant’s eyes (0.016% v 2.893%) in the horizontal mini-c-arm position trials. Exposure to the surgeon’s hands was increased in the horizontal position with the presence of orthopedic hardware.

Conclusion:
Orthopedic hardware in the fluoroscopy field increases radiation scatter exposure to a degree that may place the first assistant’s yearly eye exposure in excess of the current International Commission on Radiological Protection (ICRP) limit. We advise to always wear lead aprons, thyroid shields, and leaded glasses when working in close proximity to the operative field.
49 Patient Demographics and Complications Following Operative Treatment Distal Radius Fractures: A Review of 260,953 Cases
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Introduction:
Distal radius fractures (DRFs) are becoming more prevalent as the population ages, with an estimated prevalence of 6% in women by age 80. The purpose of this study was to investigate the relationship between comorbidities and complication rates after operative fixation of DRFs in the Medicare population.

Materials & Methods:
We identified all Medicare patients treated for DRFs between 2005-2012 by cross-referencing the corresponding CPT and ICD-9 codes. ORIF patients were stratified by diagnoses of osteoporosis, type 2 diabetes (T2DM), tobacco-use, obesity, and male gender. Outcomes evaluated were 90d rates of surgical-site infections (SSIs), osteomyelitis, wound complications (WC), nerve injury (NI), compartment syndrome, medical complications, 1-year rates of malunion, distal radio-ulnar joint instability (DRUJ) instability, and complex regional pain syndrome (CRPS). Odds ratios and confidence intervals were determined and chi-squared tests for association conducted between each risk factor and outcome of interest with statistical significance set at p<0.05.

Results:
260,953 patients were treated for DRFs with an incidence of 5.97 per 10,000 Medicare patients. 43.3% of this population underwent ORIF, of which 22.6% had osteoporosis, 20.2% T2DM, 11.38% used tobacco, 7.05% were obese, and 15.4% were male. A diagnosis of osteoporosis was associated with significantly increased odds of SSIs, WC, malunion, and medical complications. T2DM was associated with significantly increased odds of SSIs, osteomyelitis, WC, NI, diagnosis of malunion, and medical complications. Tobacco use disorder was significantly associated with increased odds of SSIs, osteomyelitis, WC, NI, CRPS, diagnosis and treatment of malunion, DRUJ dislocation, treatment for DRUJ instability, and medical complications. Obesity was associated with significantly increased odds of SSIs, osteomyelitis, WC, NI, diagnosis and treatment of malunion, treatment for DRUJ instability, and medical complications. Male gender was associated with significantly increased odds of SSIs, osteomyelitis, WC, NI, diagnosis and treatment of malunion, DRUJ dislocation, DRUJ instability.

Conclusions:
To our knowledge, this is the largest study evaluating demographics and complication rates in Medicare patients undergoing ORIF for DRFs. Each patient variable was associated with increased risk of SSI. T2DM, obesity, smoking, and male gender each relate with increased risk of infection, nerve injury, wound complications, and malunion. In conclusion, patient demographics should be closely examined when determining treatment for distal radius fractures in order to optimize patient outcomes.
Can We Identify a Threshold for Acceptable Radiographic Parameters of Distal Radius Fractures in Patients Over 65 Years Old?
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Introduction:
Distal radius fractures are common in older adults. Evidence supports that in patients over 65 years old, malalignment on imaging does not necessarily translate into poor outcomes. Older patients, as a group, appear to tolerate a greater degree of anatomic deformity than their younger counterparts. The purpose of this study was to identify the acceptable threshold for radiographic parameters following distal radius fractures (DRF) in patients over 65 years old according to a patient-rated pain and disability outcome measure.

Methods:
A prospective cohort of 190 older adults (≥ 65 years old) with DRF were recruited from a tertiary care referral center. The influence of specific radiographic parameters (ulnar variance (UV), radial inclination (RI), and volar/dorsal tilt) on 1 year Patient-Rated Wrist Evaluation (PRWE) scores was investigated. The odds ratio (OR) of a poor PRWE outcome at various alignment thresholds was calculated with 95% confidence intervals.

Results:
The majority of the cohort (n=158, 83%) had a good PRWE outcome (14.4 +/- 19.5, mean +/- SD) despite malalignment on radiographs. Average radiographic parameters for our cohort were an UV of 1.9mm +/- 1.9mm (+/-SD), RI of 18.7° +/- 5.9° (+/-SD) and dorsal tilt of 4.5° +/- 11.9° (+/-SD). The OR of a poor PRWE outcome was not significant for UV. The OR of a poor outcome was significant for RI ≤ 20° (OR 3.6, 95% CI 1.5-8.7) and dorsal tilt ≥ 15° (OR 5.3, 95% CI 1.0-27.8).

Conclusion:
Our study provides new discrete thresholds for acceptable radiographic parameters following DRF in a cohort ≥65 years old according to a validated patient-rated outcome measure. This information can be used to counsel older patients on their increased likelihood of a poor outcome with RI ≤ 20° or a dorsal tilt ≥ 15°.
Effects of Volar Tilt, Wrist Extension, and Plate Position on Contact Between Flexor Pollicis Longus Tendon and Volar Plate

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Introduction
Flexor pollicis longus (FPL) rupture is a known complication after volar plate fixation. Plates positioned closer to the watershed line have been shown to have a higher incidence of FPL rupture. However, the effect of wrist extension and volar tilt has not been investigated with an in vivo model. Our objective was to evaluate the effect of distal radius malreduction, plate position and wrist extension on contact between FPL and volar plate. We hypothesized that following volar plate application; loss of native volar tilt and distal plate position will increase contact between the FPL tendon and the volar locking plate at lower degrees of wrist extension.

Materials & Methods
A volar locking plate (Acu-Loc Distal Radius Plate System standard; Acumed, Beaverton, OR) was applied on 6 fresh frozen cadavers. The FPL tendon and the plate were wrapped with conductive wire and circuit conductivity was monitored at various degrees of wrist extension. A lateral wrist radiograph was obtained upon circuit closure, indicating tendon-plate contact. Baseline measurements were taken prior to an osteotomy at 3 different plate positions, Soong grade 0, 1, and 2. A dorsal extra-articular osteotomy was made and WristJack external fixator (Agee WristJack; Hand Biomechanics Lab, Inc, Sacramento, CA) was applied to enable reproducible degrees of malreduction at +5°, 0°, -5°, -10°, -15° and -20°. Degree of contact was measured in all malreduction angles at 3 plate positions using lateral radiographs of the wrist. Data were analyzed using two-way repeated measures ANOVA (alpha=0.05) followed by post-hoc paired t-tests.

Results
Summary of all results are depicted on FPL/plate contact chart (Figure 1). Loss of volar tilt and plate positioning were two independent risk factors determining contact between plate and tendon. Significantly less wrist extension was required for a full contact in malreduced wrists (p<0.001) as well as in distally placed volar plates (p =0.02) (Graph 1). Plates placed in Soong grade 2 had the highest range of contact (p < 0.001).

Conclusion
In addition to plate position, fracture malreduction and degree of wrist extension help determine contact between FPL and plate. This study demonstrates contact, which does not predict the risk of rupture. FPL/plate contact chart generated in this study may be used to assess the risk of rupture at the clinical setting.
Figure 1. Wrist range of motion with maximum degree of extension before FPL plate contact. Green depicts no contact between plate and FPL tendon, while red represents contact. Horizontal break signifies neutral wrist position.

Graph 1. Mean angle of wrist extension at FPL/Plate contact displayed by degree of malreduction and plate position. Error bars represent the standard error of the mean. Contact between FPL tendon and volar plate occurred at significantly less wrist extension with loss of volar tilt (p<0.001, all pairwise comparisons p < 0.005) and distally placed volar plate (p < 0.02), with Grade 2 placement resulting in the most significant reduction in extension across all degrees of malreduction (p < 0.001).
52 When is it Safe to Drive After Distal Radius Fracture Fixation
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Introduction:
One of the most common patient concerns following surgical fixation of the distal radius is when they can resume driving. This decision has important medical, legal and safety considerations, but there are no evidence based guidelines to assist the surgeon. The purpose of this study was to determine when patients who underwent volar plating of the distal radius can safely return to driving.

Materials and Methods:
Patients who had undergone volar plating of a distal radius fracture were prospectively enrolled. Their driving skills were evaluated at approximately 2 and 4 weeks post surgery by an independent driving rehabilitation specialist. The exam was performed on a closed course and all basic functions of vehicle operation and driving skill were evaluated. Successful completion indicated they would pass a Pennsylvania Department of Transportation Driving Evaluation. Additionally, the patient’s hand function was evaluated by a certified hand therapist and through patient reported pain VAS scores.

Results:
Twenty four patients were enrolled. Seventeen of the 24 (70%) passed on the first try (average of 19.4 days from surgery), another 4 (16.7%) on the second try (at an average of 31.3 days from surgery), and 3 did not complete the second exam. Patients who failed relied too exclusively on their non-operative hand, were not able to control the steering wheel with two hands, and reported pain and insecurity when using the operative hand. Of those who passed the second attempt, pain was universally attributed to the first failure. Fifteen patients reported return to independent driving prior to the first exam at an average of 11.27 days from surgery. Of the 7 patients who failed, all but one reported they could control the car in an emergency, yet 2 reported they would not feel safe with daily driving. Common difficulties included managing the ignition, fastening a seatbelt and quick turning of the steering wheel. Maximum pain while driving, on the VAS scale, was 2.4/10 among those who failed compared to 1.3 among those who passed.

Conclusion:
The majority of patients were able to safely return to driving within 3 weeks of surgery. Pain was the primary limiting factor affecting driving ability. Safe return to driving may be warranted within 3 weeks of distal radius volar plate fixation.
53 Biomechanical Assessment of the Dorsal Spanning Bridge Plate in Distal Radius Fracture Fixation: Implications for Immediate Weight-Bearing

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Introduction

Treatment of high-energy comminuted distal radius fractures remains a difficult challenge, especially in the setting of polytrauma patients with multiple injuries who require use of the upper extremity for mobilization. We sought to compare the biomechanical stability of the 2.4 mm spanning dorsal bridge plate to a standard volar distal radius locking plate in a distal radius fracture model, during simulated crutch weight-bearing.

Methods

Five paired cadaveric specimens were each mounted to a crutch handle for the hand and potted proximally in the forearm (Fig. 1). A standard 1 cm dorsal wedge osteotomy was created in the metaphysis to simulate an unstable distal radius fracture with dorsal comminution. The fracture was fixated with either a volar distal radius locking plate (VLP) or a dorsal spanning bridge plate (DBP) with fixation in the index metacarpal distally and the radius proximally. Optical motion tracking sensors were attached to the proximal and distal segments. All specimens were mounted to a servohydraulic test frame and loaded in compression at 1 mm/s until failure. Failure was defined as 2 mm of gap site displacement.

Results

The volar locking plate construct was significantly more stable to axial load in a crutch weight-bearing model than a 2.4 mm dorsal spanning bridge plate. The failure load to displace the fracture by 2 mm was 493 ± 123 N for the VLP constructs compared to 332 ± 138 N for the DBP constructs (p < 0.01). Stiffness did not significantly differ (p=0.07) between the constructs (DBP: 32.4 ± 17.2 N/mm vs. VLP: 51.4 ± 26.0 N/mm). Consistent failure mechanisms were observed in the two groups. In the dorsal bridge plates, the wrist flexed with progressive axial loading, causing the plate to bend (Figure 2). For the volar plate specimens, failure occurred with axial compression of the fracture site and dorsal collapse.

Conclusion and Discussion

The dorsal spanning bridge plate was less stable to axial load than standard volar distal radius locking plates in our crutch weight-bearing model for distal radius fractures. Based on our results, the 2.4 mm dorsal bridge plate remains a good option for highly comminuted intra-articular distal radius fractures but may not offer advantages in early weight-bearing or transfer in polytrauma patients. A stiffer, thicker 3.5 mm dorsal spanning plate may be considered if the goal is early crutch weight-bearing through the injured extremity.
Distal radius fracture patients show declined ability of dynamic body balancing

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Background

Fragility fractures of the distal radius are associated with an increased risk of future hip and spine fracture, thus the importance of body balancing ability and bone quality is well acknowledged for falls and secondary fracture prevention. Here, we assessed the body balancing ability, grip strength and bone quality of patients with distal radius fractures who underwent surgery.

Methods

This study is a prospective multicenter study, approved by IRA. Subjects are 94 women (age > 45-year-old) with distal radius fractures as first fragility fracture, who underwent surgery in registered hospitals from January to December in 2015. Two weeks after surgery, body balancing ability was measured by four methods, Functional Reach Test (FRT), Timed Up and Go test (TUG), 2 Step test (2ST) and Timed Unipedal Stance test with eye open (TUS). 2S is the score which maximum length of double stride divided by own height. Grip strength on the non-fracture side (GS) and bone density (T-score) were also measured at the same time point. Statistical analysis was performed by Student’s t test to compare with Japanese normative values and p < 0.05 was considered as significant.

Results

FRT is 29.6 cm in 40s (p = 0.03), 31.1 cm in 50s (p = 0.002), 32.5 cm in 60s (p < 0.001) and 28.2 cm in 70s (p < 0.001). TUG is 7.7 seconds (S) in 50s (p < 0.001), 7.1S in 60s (p = 0.002) and 8.1S in 70s (p = 0.004). 2ST is 1.40 in 40s, 1.32 in 50s (p = 0.003), 1.29 in 60s (p < 0.001), 1.21 in 70s (p < 0.001) and 1.02 in 80s (p = 0.01). TUS was 55S in 60s (p < 0.001). GS was 20.9 kg in 50s, 19.3 kg in 60s and 18.2 kg in 80s. Only 25% of subjects showed lower T-score than -2.5.

Summary

The patients with distal radius fractures in 50s, 60s and 70s showed significantly lower body balancing ability, especially during dynamic motion like FRT, TUG, 2ST. GS was also significantly lower in 50s, 60s and 80s. 75% of patients did not show osteoporotic status. It is compatible to the fact that distal radius fractures are tend to be primary fragility fracture and patients were relatively younger.

The patients with distal radius fractures should be identified as “high risk” of falls and secondary fractures. Intensive training could be effective for fall prevention.
Introduction:
Ulnar impaction syndrome is a degenerative wrist condition caused by increased loads of the ulnar head onto the carpal bones, resulting in painful degeneration of the triangular fibrocartilage complex and bony structures. Radiographic evaluation of these patients often reveals relative loss of radial height resulting in an ulnar positive wrist. We hypothesize that elongation of the central band of the forearm interosseous ligaments may change longitudinal radial-ulnar relationships resulting in an ulnar positive wrist and therefore carpal abutment.

Materials & Methods:
Six cadaveric, human forearms were used to measure the displacement experienced by the radius relative to the ulna during axial loading of the radius. Skin, muscles, tendons, vasculature, and nerves were discarded. The interosseous ligament complex, triangular fibrocartilage complex, distal and proximal radio-ulnar joints and the elbow collateral ligaments were preserved. The humerus was cut mid-shaft and the metacarpals were removed. The ulnar shaft was oriented vertically and rigidly fixed to an adjacent vertical beam. We applied axial loads onto the lunate fossa of the distal radius. Radial heights were measured in supination and pronation under a 5lbF preload. Gradual axial loads were applied up to 50lbF and the resultant axial displacement was measured in supination and pronation. All measurements were evaluated with the interosseous ligament intact and repeated with the central band of the interosseous ligament cut while preserving all other components.

Results:
Data showed that when the central band of the interosseous ligament was cut the resulting ulnar variance increased by 3.02±0.80mm in supination and 2.15±0.79mm in pronation, under a 5lbF preload. In supination, when the loads were increased from the 5 lbF preload to 50 lbF, ulnar variance further increased from 1.40mm (intact central band) to 3.00mm (p≤0.001) when the central band of the interosseous ligament was cut. In pronation, when the loads were further increased from the 5 lbF preload to 50 lbF, ulnar variance increased from 1.57mm (intact central band) to 2.84mm (p≤0.001) when the central band of the interosseous ligament was cut.

Conclusion:
Excising the central band was used to simulate its clinical failure. Due to a parallelogram effect, the radius shifted proximally under a 5lbF preload, creating an ulnar positive wrist relationship. Dynamic loading of the forearm after ligament excision resulted in significant additional radial displacement relative to the intact forearm (increased ulnar variance), suggesting dynamic impaction often observed clinically.
56 Lymphedema Following Elective Hand and Wrist Surgery in Women who are Post Axillary Lymph Node Dissection: A Prospective, Cohort Study
Mark Tait, MD1; Glenn Gaston, MD1; Lois Kathleen Osier, MD1; Susan M. Odum, PhD2; Bryan Loeffler, MD1; Robert Chadderdon, MD1; William Alan Ward, MD1
1OrthoCarolina Hand Center, Charlotte, NC; 2OrthoCarolina Research Institute, Charlotte, NC

Introduction:
We sought to evaluate the rate of lymphedema and perioperative complications in patients with a history of breast cancer and ipsilateral lymph node dissection undergoing elective upper extremity surgery with and without a brachial tourniquet.

Methods:
A prospective, multi-center study was undertaken and included procedures ranging from trigger finger release to metastatic cancer excision from the brachial plexus. Validated volumetric measurements of the limb were obtained pre- and post-operatively and all complications were recorded. 44 patients (mean age 61 years) completed follow up, included 24 operatively treated with a tourniquet and 20 without. Median time from mastectomy for patients without tourniquet was 10.8 years [IQR 2.2-18.5], compared to 8.0 years [IQR 3.7-15.7 years] (p=0.94). Standard descriptive statistics were calculated. Groups were compared using Fishers Exact and Wilcoxon tests.

Results:
There were no cases of lymphedema at 3 month and 6 month follow up. One patient, in the no tourniquet group, had lymphedema at the 2 week follow up visit only. No complications were noted in any patient. Procedures using a tourniquet were on average twice as long as those that were not, yet no difference in the incidence of lymphedema or complications was noted.

Discussion:
Elective upper extremity surgery appears safe in patients having undergone previous ipsilateral surgery for breast cancer with lymph node dissection including those with previous radiation and history of lymphedema. The use of a tourniquet does not appear to increase the risks of lymphedema or complications in this patient population.
57 Touch Surgery™: Analysis of Surgical Simulation Validity and Training Potential
Andrew Miller, MD; Joseph T Labrum, BA; Tulipan Jacob, MD; Andrew G. Park, MD; Asif I Ilyas, MD

Thomas Jefferson University Hospital, Philadelphia, PA; Sidney Kimmel Medical College, Philadelphia, PA

With recent limitations in post-graduate training hours and heightened focus on operating room efficiency and patient safety, there exists a need to supplement surgical education with surgical simulation. Touch Surgery™ is a smart device application that aims to provide a cognitive motor skill simulation and surgical step rehearsal based on technique and sequential steps that are hallmarks of a given surgical intervention. The aim of this study was to assess program validity, content authenticity, training potential, and user satisfaction of the Carpal Tunnel Surgery Phase 2: Carpal Tunnel Release Touch Surgery™ (CTR) module and the Tension Band Wire for Olecranon Fracture Touch Surgery™ (TBW) module.

Eighteen novices, twelve intermediates and five experts were recruited to complete the CTR and TBW simulation modules. All participants with prior exposure to Touch Surgery™ were excluded. All participants carried out Touch Surgery module learn and test simulations in a standardized fashion (Figure 1). Participants completed the CTR and TBW modules 3 consecutive times. A performance score was generated after completing each module attempt. The novice cohort was given a 12-item likert questionnaire assessing both face validity and user satisfaction. The intermediate and expert cohorts completed a 15-item likert questionnaire, with additional items assessing content validity of the surgical simulations. Analysis of Variance (ANOVA) was used to evaluate for significant differences in the simulation module performance.

All participants demonstrated improvement in all attempts for both modules (p< 0.05). Experts outperformed both intermediates and novices in both modules (Table 1). These results were significant for all modules (p< 0.05) except in the final two attempts of the TBW module. When combining novice and intermediate, expert results were significant for all attempts at the TBW module (p <0.05). All participants agreed on the utility for surgical training and learning new operations (Table 2). Both intermediates and experts agreed that the procedural steps were realistic. All participants agreed that the simulation module should be made available to all surgical trainees.

All participants demonstrated improvement with their simulation module scores over all attempts. Comparatively, all experts demonstrated higher scores in all attempted modules for carpal tunnel release and tension band wiring. These results were significant (p < 0.05) for all module performances except for the second and third tension band wiring modules attempts. The results of this study demonstrate that Touch Surgery™ is a valid simulation for surgical procedures that may prove to be beneficial in orthopedic surgical training.
58. Incidence of Serious Complications in Hand Surgery: A 10-Year Review
Avi D Goodman, MD; Joseph A Gil, MD; Edward Akelman, MD; Arnold Peter C Weiss, MD
Alpert Medical School of Brown University / Rhode Island Hospital, Providence, RI

Purpose
While the rate of serious complications following hand surgery has been assumed to be low, the unplanned readmission and/or reoperation rate for the most common procedures has not been well described. The goal of this study was to calculate the incidence and identify the risk factors associated with these complications in a high-volume academic practice.

Methods
Our institution's Quality Assurance (QA) database was retrospectively examined for all serious complications (unplanned readmission and/or reoperation within 30 days) for two senior attending hand surgeons from February 2006 – January 2016. Our cohort included only adults undergoing elective procedures. Each event was categorized by causative factor, and charts were reviewed to establish infection risk factors and cultured organisms. Our billing database was examined for the number of procedures performed over the same time period.

Results
Our cohort consisted of 18,081 surgeries, in which 27 serious complications occurred (0.15% total incidence; examples include: carpal tunnel release 0.10%, trigger digit release 0.09%, major wrist surgery 0.74%). There were 17 total infections (0.09% incidence). The complications were unevenly distributed with respect to time with eight (29.6%) occurring within seven days, 16 (59.2%) in 8-14 days, three (11.1%) in 15-21 days, and none in 22-30 days.

Conclusion
Complications after hand surgery requiring unplanned readmission and/or reoperation are infrequent, occurring at a rate of 15 per 10,000 cases, and varies based on the type of procedure performed. Infections were responsible for 40.7% of unplanned readmissions and/or reoperations, and 56.3% occurred in patients with an underlying risk factor. Although elective hand surgery is safely performed at high volumes, serious complications do rarely occur. More invasive and longer surgeries are associated with a higher incidence than other procedures, and these serious complications are most likely to occur within three weeks after surgery.
59 Patient Knowledge in Hand Surgery Pre- and Post- Consultation in the United States and Honduras: A Prospective Comparative Study
Marc E. Walker, MD, MBA; Carolyn Chuang, BS; Craig Moores, MD; Matthew L Webb, AB; Samuel Buonocore, MD; J. Grant Thomson, MD
Yale University, New Haven, CT

Purpose:
Patient-physician communication and education is a critical aspect of the patient-doctor relationship and leads to increased patient compliance, satisfaction, and improved outcomes. In hand surgery, patient education is particularly important due to functional impact of surgery, heightened by the potential effect of the benefits and risks of hand surgery on quality of life. Given the frequent lack of long-term follow-up, clear upfront communication is even more essential in the setting of international medical missions where multiple factors may limit understanding. The purpose of this study was to assess the impact of the surgeon consultation and informed consent process on patient education in a US academic hand surgery practice compared with an international hand surgery mission.

Methods:
A multi-part survey was administered to new patients presenting to a university hand center over a 3-month period during 2011 and patients presenting to a hand surgery mission during Spring 2012. Demographic data was collected and a quiz was used to assess knowledge of basic hand anatomy, physiology, disease, diagnoses, and surgical risks.

Results:
71 patients participated (university n=36, mission n=35). Pre-consultation quiz score averaged 56% in the university group versus 27% in the mission group (p=0.0001). Post-consultation quiz scores averaged 59% in the university group versus 40% in the mission group (p=0.0001). Only the mission group's quiz score improvement was statistically significant (p<0.05). 93% of the university group reported learning about their condition and diagnosis, but only 40% demonstrated correct insight into their diagnosis and etiology. In the mission group, 73% reported learning about their condition and diagnosis while 53% demonstrated correct insight into their diagnosis and etiology. Although all consultations involved discussion of surgical risks, only 62% of the university group and 52% of the mission group recalled discussing risks of surgery.

Conclusions:
This study highlights the impact of the surgeon consultation and informed consent process on patient knowledge in hand surgery at a university practice and international hand surgery mission. Both patient groups presented with little background in hand knowledge, but the mission group displayed greater improvement after surgeon consultation. Both groups over-reported knowledge gains and displayed relatively low retention of surgical risk discussions, strongly questioning the current effectiveness and relative value of the informed consent process. Future research is needed to explore novel methods of healthcare information delivery and retention in hand surgery, as improved patient education has been associated with enhanced clinical outcomes.
Background:
Medicare reimbursement payments for inpatient orthopedic surgeries, such as total joint arthroplasty and spinal fusion, have been shown to exhibit geographic variation. We seek to evaluate whether similar geographic variations exist in Medicare reimbursement payments for outpatient hand surgeries.

Methods:
We analyzed 2012 and 2013 Medicare Provider Utilization and Payment Data provided by Centers for Medicare & Medicaid Services (CMS) to evaluate average allowed charges and reimbursement payments for the four most common hand surgeries performed across the country.

Results:
Open carpal tunnel surgery was the most commonly performed outpatient Medicare hand procedure (n=21,944), followed by trigger finger release (n=15,345), endoscopic carpal tunnel surgery (n=7,106), and basal joint arthroplasty/LRTI (n=2,408). In terms of dollars per procedure, institutions received the highest Medicare reimbursement payments for basal joint arthroplasty ($613), followed by endoscopic carpal tunnel surgery ($363), open carpal tunnel ($295), and trigger finger release ($195). Open Carpal tunnel, trigger finger release, and endoscopic carpal tunnel surgery showed statistically significant variation across geographic regions for both allowed charges and reimbursement. Institutions in the West and Northeast on average had the highest charges and received the highest payments for the surgeries, while hospitals in the South and Midwest generally charged the least and received the lowest payments (Table 1). The percent reimbursement throughout the regions and surgeries remained similar with rates between 77%-79% (Table 2).

Conclusion:
Similar to Medicare payment trends in total joint arthroplasty and spinal fusion, hand surgery payments exhibit statistically significant variation across geographic regions. Further research must be done to determine why these regional variations exist and whether cost of living is the primary explanation for these disparities. Tables/Figures: Table 1: Average Charges and Medicare Payments for Outpatient Hand Surgeries

<table>
<thead>
<tr>
<th>Region</th>
<th>Open Carpal Tunnel Surgery</th>
<th>Trigger Finger Release</th>
<th>Endoscopic Carpal Tunnel Surgery</th>
<th>Basal Joint Arthroplasty / LRTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>New England</td>
<td>472 (64)</td>
<td>565 (65)</td>
<td>204 (77)</td>
<td>906 (42)</td>
</tr>
<tr>
<td>Middle Atlantic</td>
<td>402 (75)</td>
<td>377 (55)</td>
<td>254 (75)</td>
<td>906 (42)</td>
</tr>
<tr>
<td>East Northeast</td>
<td>372 (61)</td>
<td>285 (64)</td>
<td>217 (54)</td>
<td>849 (52)</td>
</tr>
<tr>
<td>West Central</td>
<td>305 (62)</td>
<td>280 (64)</td>
<td>242 (72)</td>
<td>758 (39)</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>302 (42)</td>
<td>272 (34)</td>
<td>255 (62)</td>
<td>703 (79)</td>
</tr>
<tr>
<td>East South Central</td>
<td>335 (40)</td>
<td>281 (38)</td>
<td>216 (64)</td>
<td>741 (53)</td>
</tr>
<tr>
<td>West South Central</td>
<td>315 (65)</td>
<td>288 (66)</td>
<td>230 (71)</td>
<td>703 (60)</td>
</tr>
<tr>
<td>Pacific</td>
<td>434 (49)</td>
<td>321 (49)</td>
<td>284 (62)</td>
<td>1086 (86)</td>
</tr>
<tr>
<td>Mountain</td>
<td>364 (51)</td>
<td>264 (49)</td>
<td>284 (62)</td>
<td>851 (58)</td>
</tr>
</tbody>
</table>

Note: Green highlight indicates largest value and red highlight indicates lowest value for each category.

Table 2: Percent Reimbursement for Outpatient Hand Surgeries

\[
\text{Percent Reimbursement} = \left( \frac{\text{Medicare Payment}}{\text{Allowed Charge}} \right) \times 100
\]
Green highlight indicates largest value and red highlight indicates lowest value for each category.

<table>
<thead>
<tr>
<th>Division</th>
<th>Open Carpal Tunnel Surgery (%)</th>
<th>Trigger Finger Release (%)</th>
<th>Endoscopic Carpal Tunnel Surgery (%)</th>
<th>Wrist Joint Arthroplasty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New England</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
</tr>
<tr>
<td>Maine Atlantic</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
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<tr>
<td>East North Central</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
</tr>
<tr>
<td>West North Central</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
<td>70.3%</td>
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<tr>
<td>South Atlantic</td>
<td>70.3%</td>
<td>70.3%</td>
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<tr>
<td>East South Central</td>
<td>70.3%</td>
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<td>West South Central</td>
<td>70.3%</td>
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<td>Pacific</td>
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<td>Mountain</td>
<td>70.3%</td>
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<td>70.3%</td>
<td>70.3%</td>
</tr>
</tbody>
</table>
The Majority of Patients Prefer Optional Follow-up for Simple Upper Extremity Fractures

David Ring, MD, PhD; Teun Teunis, MD; Abigail Finger, BSc; Michiel Hageman, MD, AMC; Valentin Neuhaus, MD

1Dell Medical School, Austin, TX; 2Massachusetts General Hospital, Boston, MA; 3Amsterdam, Netherlands

Purpose
Many common arm fractures have an excellent prognosis with little more than symptomatic treatment and an additional follow-up visit after diagnosis might not always be necessary. This study tested the primary null hypothesis that there is no difference in disability (Quick DASH) 2 to 6 months after injury between patients with and without an additional follow-up visit. Secondarily we assessed (1) differences in pain, satisfaction and return to work at 2 to 6 months after injury and (2) differences between patients choosing an optional or scheduled follow-up.

Methods
We prospectively enrolled 120 patients with well-aligned single metacarpal fractures (n=63), non- or minimally displaced distal radius fractures (n=39) and isolated non- or minimally displaced radial head fractures (n=18). The subjects then chose whether or not to schedule an additional appointment for evaluation of their fracture. At enrollment we recorded patient demographics, depression (Patient Health Questionnaire-2), Pain Self-Efficacy Questionnaire, disability (QuickDASH), a 0-10 ordinal rating of pain intensity, and satisfaction rated on an 11-point ordinal scale. Eighty-two (68%) subjects were available when contacted by phone or email 2-6 months after injury at which time we measured disability, numerical rating scale for pain and satisfaction, and employment. Eleven subjects (17%) of subjects who chose an optional follow-up returned for a follow-up visit. Nine subjects (16%) of subjects who scheduled a follow-up visit did not return. There were no adverse events in either group.

Results
Multivariable analysis accounting for difference in baseline characteristics showed no difference in QuickDASH between 2 and 6 months after fracture between patients with and without an additional visit (optional follow-up: \( \beta = -1.5, 95\% CI = -8.6 \) to 5.5, SE=3.5, \( P=0.67 \)). There were no differences in pain, satisfaction, or return to work. On multivariable logistic regression analysis, no variables were independently associated with choosing optional or scheduled follow-up.

Conclusions
In an urban academic hand surgery office, most patients prefer optional follow-up for simple upper extremity fractures with a good prognosis. There were no adverse events and there were equal outcomes and satisfaction among patients that did and did not return. Hand surgeons can safely consider offering patients with low-risk hand fractures an optional instead of a scheduled second visit, avoiding unnecessary waiting, travel, inconvenience, time, tests, and costs.
**The Role of External Fixation When Treating Terrible Triad Injuries**
Karan Dua, MD; Andrew Fischer, BS; Raymond A. Pensy, MD; W. Andrew Eglseder, MD; Joshua M. Abzeg, MD
University of Maryland School of Medicine, Baltimore, MD

**Introduction**
‘Terrible triad’ injuries of the elbow consist of a posterior elbow dislocation with concomitant fractures of the coronoid process of the ulna and radial head. The purpose of this study was to evaluate the usefulness or lack thereof of placing a static external fixator to be used as a removable brace when treating patients with terrible triad injuries.

**Materials and Methods**
A retrospective review was performed of patients treated for a terrible triad injury at a level-1 trauma center over a 15-year period. Patient demographics were examined and outcome data was recorded regarding complication rates and post-operative range of motion (ROM). Statistical analysis was performed using two-tailed fisher’s exact and t-tests assuming unequal variances. Additionally, data was analyzed when matching for age, body mass index (BMI), and presence of concurrent injury.

**Results**
93 terrible triad injuries were reviewed including 13 that were treated with open reduction and internal fixation (ORIF) with the addition of a static external fixator and 80 treated with ORIF alone. Patients treated with ORIF and an external fixator were older than those treated with ORIF alone (average 51 vs. 45.7 years). In the ORIF with external fixator treatment group, 61.5% (8/13) had concurrent injuries compared to 33.8% (27/80) of patients who underwent ORIF alone. 20% of patients (16/80) treated with ORIF alone needed a reoperation compared to only 1 of 13 patients (7.69%) initially treated with ORIF and the addition of an external fixator. The rationale for reoperation included capsulectomy, heterotopic ossification removal, hardware removal, and recurrent elbow subluxation. Patients initially treated with ORIF and an external fixator had greater forearm pronation/supination and elbow flexion earlier in the rehabilitation period, but less elbow extension. The average arc of motion was greater in patients treated with ORIF and an external fixator later in the rehabilitation period. In obese patients (BMI ≥ 30), ORIF with an external fixator allowed for significantly better forearm supination at the first and second follow-up evaluations.

**Conclusion**
The addition of a static external fixator when performing ORIF of terrible triad injuries serves to function as a rigid brace, which can be unlocked for supervised physical therapy leading to better postoperative ROM and lower reoperation rates, especially in obese patients.
INTRODUCTION
Current options for treating persistent elbow instability associated with complex elbow fracture-dislocations include splint or cast immobilization, transarticular cross-pinning, temporary bridge plating, and hinged or rigid external fixation. The recent development of an "internal joint stabilizer", acting as an internal "external fixator" allows for early ulnohumeral range of motion while maintaining a stable and congruent reduction of the ulnohumeral and radiocapitellar joints.

MATERIALS and METHODS
This retrospective study reviewed ten patients who underwent placement of a modified internal joint stabilizer for persistent elbow instability after severe elbow fracture-dislocations. Final post-operative range of motion and complication rates were monitored for all patients and five patients completed outcome-scoring questionnaires.

RESULTS
Ten patients who underwent placement of an internal joint stabilizer for persistent elbow instability after fracture-dislocation were reviewed. The final post-operative flexion-extension arc was 113° ±24.2°. When controlling for two uniquely complex patients, the final post-operative arc of motion improved to 124.3° ±11.0°. The average Mayo Elbow Performance Score improved from 10 ±11.2 to 64 ± 21.4 while the average Disabilities of Arm, Shoulder, and Hand score improved from 97.8 ± 2.5 to 40.5 ± 34.7.

CONCLUSIONS
Use of an internal joint stabilizer allows for early, congruent, and stable ulnohumeral and radiocapitellar range of motion in instances of persistent elbow instability after elbow fracture-dislocation.
64 Outcomes After MCP Arthroplasty Dislocation; An Analysis of 33 Consecutive Cases
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Mayo Clinic, Rochester, MN

Purpose:
There remains a paucity of information regarding the treatment outcomes of dislocation after metacarpophalangeal (MCP) arthroplasty. The purpose of this study was to assess the outcomes of surgical and nonoperative treatment modalities for MCP arthroplasty dislocations.

Methods:
Out of 816 primary MCP arthroplasties collected in a single institution's total joints registry, there were 33 (4%) dislocations that required intervention by a healthcare professional. Seventeen dislocations involved border digits, while diagnoses including osteoarthritis (n=1), inflammatory arthritis (n=30), and post-traumatic arthritis (n=2). Implants involved included pyrocarbon (n=13), silicone (n=9), and surface replacing arthroplasty (n=9). The analysis included treatment of dislocations after primary (n=25) and revision (n=8) MCP arthroplasty. Dislocation was defined as radiographic evidence of MCP prosthetic dislocation diagnosed and treated by a fellowship trained hand surgeon.

Results:
Out of the 33 dislocations, the initial treatments included 3 closed reduction and splinting, 19 revision arthroplasties, 2 MCP arthrodesis, and 9 soft tissue procedures. Etiologies underlying the dislocations included implant fracture (n=5), component loosening (n=2), and soft tissue deficiency (n=26) with soft tissue laxity. Of the 3 that underwent closed reduction and splinting, 2 failed nonoperative management secondary to recurrent instability and requiring revision arthroplasty combined with stabilization procedures. Ultimately, 21 MCP joints underwent revision arthroplasty and 9 underwent soft tissue stabilization procedures. Four (44%) of those who underwent ST procedures had recurrent instability. Of the 21 revision arthroplasties, 8 (38%) had repeat instability, with 6 (29%) requiring revision surgery. There was no difference in risk of repeat instability comparing ST procedures to revision arthroplasties (p=0.21). After revision arthroplasty for dislocation, survival-free of repeat instability at 2 and 5 years was 81% and 54%, respectively, while survival free of re-revision surgery at 2 and 5-years was 78% and 69%, respectively (Figure 1 and 2). Components used in revision MCP arthroplasty included pyrocarbon (n=5), SRA (n=3) and silicone (n=13). Pyrocarbon implants (4 out of 5, p=0.02) had an increased risk of repeat instability compared to SRA (1 out of 3) or silicone implants (3 out of 13).

Conclusion:
Treatment of MCP arthroplasty dislocation, while a rare event, is technically challenging, with high rates of repeat instability requiring repeat intervention.
65 Ulnar Nerve Complications Following Ulnar Collateral Ligament Reconstruction: A Systematic Review
Jason B Clain, BS1; Mark Vitale, MD, MPH, ONS, PC, ONS2; David Ruchelsman, MD3
1Tufts University School of Medicine, Boston, MA; 2Foundation for Clinical Research and Education, Greenwich, CT; 3Hand Surgery PC, Newton Wellesley Hospital, Newton, MA

Introduction:
While ulnar collateral ligament reconstruction (UCLR) has been shown to be an effective procedure to restore elbow stability in overhead athletes, the rates of ulnar neuropathy following surgery has been poorly characterized. Furthermore, the influence of type of surgical exposure, graft fixation technique and concurrent ulnar nerve transposition on ulnar nerve complications is unclear. This study sought to determine the overall postoperative rate of ulnar neuropathy following UCLR and to determine how surgical exposure, graft fixation and intraoperative ulnar nerve management influenced the rate of ulnar nerve complications following UCLR.

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 following surgery.

Results:
Sixteen articles met inclusion criteria (n=1675 cases). The overall rate of post-operative ulnar neuropathy following UCLR was 10.7%, and 1.0% of cases required reoperation to address ulnar neuropathy. The surgical approach associated with the lowest rate of neuropathy was muscle splitting (4.7%) [versus muscle retraction (13.1%) and detachment of flexor pronator mass (18.2%)]. The fixation approach associated with the the lowest rate of neuropathy was the docking technique (2.4%) [versus hybrid suture anchor-bone tunnel (2.9%), interference screw (5.0%), DANE TJ (9.1%), figure of 8 (9.3%)]. Concurrent ulnar nerve transposition was associated with a higher neuropathy rate (13.0%) compared to no handling of the ulnar nerve (4.0%).

Discussion/Conclusion:
Review of all published literature revealed that 1 in 10 UCLR results in postoperative ulnar nerve complications. UCLR techniques associated with the lowest rates of neuropathy were the muscle splitting approach, docking fixation, and lack of ulnar nerve transposition. This data may help guide surgeons on ways to minimize ulnar nerve complications following this procedure.
Correlating median nerve cross sectional area with distal sensory and distal motor nerve latencies
Benson Pulikkottil, MD; Micah Schub, BS; Tiffany Kadow, MD; William Wang, BS; John R. Fowler, MD
University of Pittsburgh Medical Center, Pittsburgh, PA

CTS is the most common nerve compression syndrome. Currently, aside from clinical exam, the main diagnostic aid is EMG/NCS. However, they are costly, uncomfortable, and time-consuming. Ultrasound measurement of median nerve cross sectional area has been shown to confirm the diagnosis of carpal tunnel syndrome with better specificity and equal sensitivity as compared with electrodiagnostic testing.

Hypothesis:
There is a direct measurable correlation between ultrasononographic median nerve cross sectional area (CSA) and both distal motor latency and distal sensory latency in patients referred for nerve conduction studies (NCS) due to carpal tunnel syndrome (CTS) symptoms.

Methods:
A prospective study was carried out on 91 wrists/52 patients referred by an orthopedic surgeon for nerve conduction studies due to clinical manifestations of CTS. Demographic information including age, gender, race, height and weight was recorded. Ultrasound examinations were performed using a 15-6 MhZ linear array transducer. Median nerve CSA was measured at the carpal tunnel inlet 3 times and the results averaged with greater than 10mm as the cutoff for CTS. Accuracy of CSA measurements is to 0.1mm. All NCS were performed according to the guidelines of the American Association of Electrodagnostic Medicine and no treatment was administered between the ultrasound test and the NCS. Median nerve CSA was compared to both distal sensory and distal motor latency using Pearson correlations. Pearson correlations were run again controlling for BMI. Sensitivity and specificity were calculated for CSA compared to both latencies.

Results:
Of the 91 wrists included in the study, all were used in the analysis of distal motor latency, while 4 were excluded in the analysis of distal sensory latency due to missing data. Correlation was significant between CSA and distal motor latency (R=0.493, p<0.005), as well as between CSA and distal sensory latency (R=0.352, p=0.001). When controlling for BMI, the correlations were also significant for CSA and distal and sensory motor latencies. CSA compared to distal motor latency had a sensitivity of 87% and a specificity of 50%. CSA compared to distal sensory latency had a sensitivity 92% and a specificity of 49%.

Conclusions:
The significant correlation and high sensitivity between CSA and nerve conduction studies indicate that diagnosis of carpal tunnel syndrome using ultrasononographic median nerve cross sectional area is a promising complementary and alternative diagnostic tool to the costly and uncomfortable nerve conduction studies; however the low specificity may preclude it from being a confirmatory test.
INTRODUCTION:
To evaluate open carpal tunnel release (CTR) using wide-awake, local anesthesia, no tourniquet (WALANT) anesthesia versus local anesthesia with sedation and a tourniquet (MAC). We hypothesize that patient outcomes and patient satisfaction will be equivalent in both groups.

METHODS:
Consecutive cases of EMG-confirmed open CTR were prospectively enrolled. Data collected included demographic data, EMG severity, surgical characteristics, Visual Analog Scale, Levine-Katz carpal tunnel syndrome scale, QuickDASH questionnaire, and a customized Likert scale. Descriptive statistics were performed.

RESULTS:
A total of 230 consecutive patients were enrolled. There were 81 patients in the WALANT group and 149 patients in the MAC group. There were no re-operations in either group nor any epinephrine-related complications in the WALANT group. Disability and symptom scores did not differ significantly between WALANT and sedation groups at either postoperative time point. Average postoperative QuickDASH scores were 34.4 versus 36.7 for WALANT versus MAC groups, respectively (p>0.05). Average postoperative Levine-Katz scores were 1.27 versus 1.29 for WALANT versus MAC groups, respectively (p>0.05). Average VAS pain score were 4.7 versus 4.2 was 4.7 for WALANT versus MAC groups, respectively (p>0.05). Both groups of patients reported high levels of satisfaction at 91% versus 96% for the WALANT versus MAC groups, respectively (p>0.05). Patients in each group were likely to have the similar anesthesia if they were to undergo surgery again.

CONCLUSION:
Patients undergoing Open CTR experience similar levels of satisfaction and outcomes with either WALANT or MAC techniques. There was no statistically significant difference between either group relative to complications, VAS pain scores, Levine-Katz and QuickDASH questionnaires, and Likert responses. There were no epinephrine related complications in the WALANT group. This data should facilitate surgeons and patients to choose freely between WALANT and MAC techniques relative to complications and outcomes.
INTRODUCTION:
The onset of trigger digits after carpal tunnel release (CTR) have been reported inconsistently across the literature. The aim of this study is to assess the incidence of trigger digits after CTR using a nationwide population cohort data.

MATERIALS AND METHODS:
We conducted a retrospective cohort study using the Longitudinal Health Insurance Database 2000 (LHID2000) from the National Health Insurance Database (NHIRD) in Taiwan. The LHID2000 contained one million beneficiaries randomly selected from the year 2000 Registry for Beneficiaries in NHIRD. From 2000 to 2010, 2,605 carpal tunnel syndrome (CTS) patients received CTR (CTR cohort, n = 2,605). For each CTR patient, 4 CTS patients without CTR were randomly selected in the control cohort from the general population frequency matched by age, sex, and diagnosed year (non-CTR cohort, n = 10,420). Both cohorts were followed up until the end of 2011 to investigate the occurrence of trigger digits. Adjusted hazard ratios (aHRs) with 95% confidence interval (CI) of trigger digits were estimated using the Cox proportional hazards model after controlling for age, sex and comorbidities.

RESULTS:
The CTR cohort had a mean follow-up period of 5.58 ± 3.18 years and the non-CTR cohort had a mean follow-up period of 5.90 ± 3.10 years. The overall risk of trigger digits was 3.63-fold greater in the CTR cohort than in the non-CTR cohort (incidence rate: 12.6 vs 3.38/1,000 person-years, aHR: 3.63, 95% CI, 2.97 - 4.44). The incidence of postoperative trigger digits was highest in the first six months (incidence rate: 27.9/1,000 person-years, aHR: 9.65, 95% CI: 5.27 - 17.7) and then significantly decreased over time.

CONCLUSION:
CTR was significantly associated with the subsequent development of trigger digits, especially in the first postoperative six months.
69 Increasing the Accuracy of NIR Fluorescence Angiography in Assessing Flap Viability Using an Intraoperative Thermal Challenge
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Introduction:
Indocyanine green (ICG) angiography is a reliable method of predicting flap survival. It provides the surgeon real time information regarding flap vascularization and it can be used intra-operatively to guide resection of nonviable tissue prior to flap inset. However, the blood flow pattern in a flap immediately after harvest is reduced. Skin perfusion recovers gradually reaching a maximum point after 24h, thus intraoperative use of ICG angiography underestimates flap viability. We used a local skin warming procedure to induce vasodilatation and increase intra-operative flap perfusion comparing the results to those observed clinically at 72h.

Materials and Methods:
Submental flaps were created in 8 pigs. The flaps were harvested on a single submandibular perforator. ICG angiography using the Artemis System (Quest Medical Imaging) was performed three times: After raising the flap (ICG-Cold), after flap warming at 42°C (ICG-Warm), and at 24h (ICG-24h). All perfusion values were analyzed using the ImageJ processing software with a fluorescence threshold of 33%. A perfusion map was created for each flap, and the ICG perfusion values were used to calculate the viable flap area and the predicted necrosis for each flap. The values obtained were then compared to the actual necrosis observed clinically at 72h. Image Analysis: The values recorded during the ICGA were analyzed separately. Three angiography’s were performed for each flap. ICG-Cold, ICG-Warm and ICG-24h. We calculated the surface area of the predicted necrosis in each case. We then compared the actual necrotic surface area observed clinically at 72h with the results obtained during the angiography.

Results:
Flap perfusion increased significantly in the first 24H, with an average of 10.82%. ICGA-Cold underestimated flap perfusion in all cases by an average of 14,17%. After flap warming and induced vasodilatation ICGA-Warm underestimated perfusion with an average of 4,33%. The difference in perfusion between ICGA-Warm and ICGA-24h is just under 1% (0,98%). The theoretical tissue loss after flap warming was reduced from 14,17% to just 4,33% (9,84%)

Conclusion:
ICGA performed performed after flap harvesting underestimates perfusion in all cases. Intra-operative ICG angiography performed after inducing vasodilatation by local skin warming at 42OC provides perfusion values similar to those obtained at 24h and correlates with flap survival at 72h. Local warming increases the accuracy of ICG angiography in predicting flap survival while reducing the amount of viable tissue sacrificed.
Introduction:
The coverage of soft tissue defects in fingers are a constant provocation in the field of hand and plastic surgery. The aim of the treatment, in such cases, is to achieve a result both functional and cosmetically accepted. The answer to these demands might be the the digital artery perforator flaps. In this study we investigated the results obtained after the use of this method.

Materials and methods:
A total of 43 patients with soft tissue defects in fingers, were operated using this technique (study period: 2006 – 2016). The sex ratio was 34 males to 9 women. The etiology of the defects was posttraumatic in 32 cases, post combustional scars in 8 cases, and postsurgical (tumor removal) in 3 cases.

Results:
In our hands, the survival rate was 100%. Minor marginal necrosis of the tip of the flap occurred in 4 cases. Patient satisfaction was high with good cosmetic and functional outcome. No sensitivity loss was described, while a fast recovery was possible due to early hand therapy.

Conclusions:
The bilobed digital artery perforator flaps is a reliable flap that requires a not complicated dissection technique. The end results offer a good functional and aesthetical result for the treatment of finger soft tissue defects.
71 Our Results in “Spaghetti Wrist” Injuries Associated with Soft Tissue Defects
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Introduction
“Spaghetti wrist” defines complex volar wounds involving more than three major structures; it is a very severe lesion and with a significant morbidity. The lesion becomes more severe in association with skin defects. This paper will present the results in 49 patients operated in a 10 years period, in terms of functional recovery and socio-professional reintegration.

Materials and Methods
We analyze the patients operated in a ten years period for pure “spaghetti wrist” lesion, or associating a skin alone or a complex soft tissue defect. The patients were analyzed with regard to the mechanism of injury, type of surgery, functional recovery and socio-professional reinsertion.

Results
In a ten years period, 49 patients (35 men and 14 women), with an average age of 34 were operated for a “spaghetti wrist” lesion. From those, 37 presented a pure “spaghetti wrist” lesion and 12 associated also a soft tissue defect, of more anatomical elements in 7 cases and of skin alone in 5 cases. The mechanism of injury was work related in 35 cases, traffic accidents in 2 cases, home accidents in 10 cases, and suicidal attempt in 2 cases. At least 3 tendons were injured in all the cases. The median nerve was injured in 19 cases, the ulnar nerve in 13 cases, and both of them in 17 cases. The radial artery was lacerated in 11 cases, the ulnar artery in 19 cases, and both of them in 7 cases. A complex soft tissue defect, including skin and tendons/arteries/nerves was registered in 7 cases, and a skin defect alone in 5 cases. All the cases were solved in emergency as an all-in-one procedure. A free flow through simple or composite flap was used in 7 cases, and a propeller perforator flap in 5 cases. The range of motion was very good in 31 patients (8 from those associating defects), good in 12 patients (4 from those associating defects), and fair in 6 patients. The sensory recovery was very good in only 21 patients, good in 19 patients, and only protective in 9 patients (two-point discrimination of 2-5mm in 21 patients, and of more than 6mm for the others).

Conclusions
The outcomes after repair of both simple spaghetti wrist or associated with soft tissue defects are similar if a careful emergency all-in-one procedure is done. The overall functional outcomes after repair are generally good, allowing the socio-professional reintegration of the patients.
Introduction:
The elbow region is a very challenging area to reconstruct. The difficulty is due to two reasons: elbow’s joint high tendency to stiffness and the abundance of neuro-vascular structures in the area. The paper presents a series of cases where elbow defects were reconstructed with propeller perforator flaps. In our hands, this method is very efficient by reducing both the intraoperative time as well as the postoperative rehabilitation period.

Materials and methods:
21 patients from our service in 2016 were included in the study. The defects were either posttraumatic or post surgical. The coverage was done with propeller perforator flaps based on pedicles originating in from the anastomotic elbow vascular circle. In 12 cases the closure of the donor area was done by direct suture, in the other cases skin grafting was necessary. The physical therapy was initiated starting from the first postoperative day.

Results: We experienced a 100% flap survival. In 6 patients, a marginal necrosis of the flap occurred. Secondary skin grafting due to complications was done in 2 cases. Both patients and surgeons were satisfied bye the cosmetic and functional results.

Conclusions:
Soft tissue defects coverage in the elbow, using propeller perforator flaps is a safe procedure. The intraoperative times are shorter if compared with free flaps surgery times. Physical therapy is started from the first postoperative day. The patients appreciate the aesthetic end result.
Introduction
Fixation of diaphyseal metacarpal fractures with cortical screws is a technique employed by many surgeons due to the implants low profile, biomechanical stability, and no need for removal. With each fracture a unique problem to solve, surgeons must decide the optimal construct to allow for stability and early range of motion. Frequently surgeons are confronted with a long oblique fracture that may either accommodate several small screws or fewer larger screws. We propose a biomechanical analysis of a metacarpal fracture model to determine whether three 1.5 mm cortical screws or two 2.0 mm cortical screws prove a more stable construct.

Materials and Methods
9 matched pairs of fresh frozen cadaveric upper limbs were used for this study. The second and third metacarpal was harvested from each of the pairs and a spiral fracture in each of the metacarpals. Specimens were then be divided into two groups. One group consisted of 18 specimens that underwent reduction and fixation with two 2.0 mm cortical lagged screws; the second group consisted of 18 specimens that underwent reduction and fixation with three 1.5 mm cortical lagged screws. Both groups were further divided into subgroups A and B with subgroup A undergoing torsional testing and subgroup B bending testing. Finally, all specimens were subject to torsional and bending load to failure, respectively. Statistical analysis with the paired Student's t-test were used to compare the results of each subgroups tests with a level of significance set a p <0.05.

Results
In cyclic torsional testing, the '2 screws' group exhibited significantly less rotational creep that the '3 screws' group. No other significant differences were found between the test groups. In the bending tests, there were no significant differences in any outcome parameters between the two groups, although the '2 screws' group exhibited slightly higher stiffness and less cyclic creep.

Conclusions
Based on this study, both constructs are biomechanically similar. In a clinical setting, it may be preferable to use two 2.0 mm cortical lagged screws when fixing spiral metacarpal fractures as there was significantly less loosening during torsional loading as well as a trend towards less loosening during bending loading. In addition, using two screws may be advantages due to the cost of an additional screw in the '3 screws' construct without an obvious biomechanical advantage.
A Biomechanical Evaluation of a Two Suture Anchor Repair Technique for Thumb Metacarpophalangeal Joint Ulnar Collateral Ligament Injuries

Joseph A Gil, MD; Alison Biercevicz, PhD; Christopher Got, MD; Edward Akelman, MD; Brown University, Providence, RI

Introduction:
A thumb metacarpalphalangeal (MCP) ulnar collateral ligament (UCL) repaired with one suture anchor has been demonstrated to be significantly weaker compared to the intact UCL. Therefore, UCL repairs have been protected and return to full activity has been limited until there is adequate ligament healing which occurs at approximately 10 weeks. More recently, there has been a report of successful, early return to football for patients with a two-anchor UCL repair at 4 weeks after surgery. We hypothesize that this two anchor repair is significantly weaker than the intact UCL ligament.

Methods:
Nine paired fresh frozen hands were used for this biomechanical analysis. From each pair, one thumb was randomized to the control group and the contralateral side was assigned to the repair group. Care was taken to dissect all the soft tissues off of the thumb, leaving only the ulnar collateral ligament attached to the first phalanx and the metacarpal. In the control group, the specimen was mounted to the base of a servohydraulic materials test frame (MTS 810, Eden Prairie, MN) using a X-Y translational platform and the UCL was loaded to failure. In the repair group, the UCL was dissected off of the proximal phalanx and subsequently repaired with a two anchor technique. Each repaired specimen was mounted to the servohydraulic materials test frame and the UCL was loaded to failure.

Results:
The mean age of the cadavers was 52.6 ± 14.9. The mean yield load (N) was 342 N (95% Confidence Interval (CI), 215-470 N) in the control group and 68 N (95% CI, 45-91 N) in the repair group (P=0.0003). The mean maximum load at failure (N) was 379 N (95% CI, 246-513 N) in the control group and 84 N (95% CI, 62-105 N) in the repair group (P=0.0003). The mean stiffness was 72 N/m (95% CI, 48-96 N) in the control group and 17 N/m (95% CI, 13-21 N) in the repair group (P=0.0002). The mean displacement at failure was 7.8 mm (95% CI, 7-9 N) in the control group and 7.8 mm (95% CI, 7-9 N) in the repair group (P=0.4928).

Conclusions:
Our results suggest that while the tested two anchor repair technique does not compromise the structural properties of the thumb UCL tissue, it is not initially possible to reestablish the strength of the insertion of the native insertion of the UCL with this surgical technique.
75 Acute Deep Infections of the Upper Extremity: The Utility Of Obtaining Atypical Cultures and Risk Factors for Culture Positivity

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University of Pennsylvania, Philadelphia, PA

Introduction:
Evidence is lacking to guide the decision whether to send atypical cultures (fungal, AFB - acid-fast-bacillus) during surgical debridement of acute deep infections of the upper extremity. The purpose of this study is to elucidate the frequency of positive atypical cultures in this patient population and to determine how these cultures influence the ultimate treatment. Further, we aim to identify factors influencing the yield of atypical cultures.

Materials & Methods:
Consecutive adult patients undergoing surgical debridement of acute deep infections of the upper extremity between 2013-2015 were identified retrospectively. Necrotizing infections and superficial infections were excluded. Descriptive statistics were calculated to describe patient baseline characteristics, infection diagnoses, cultures sent during the index surgical procedure with corresponding rates of positivity, and treatments. Clinical records were studied to determine whether management was influenced by positive atypical culture results. Cohorts with positive and negative atypical cultures were compared with univariate analysis for all collected variables (continuous variables - Student t-test or Mann-Whitney, categorical variables - chi-squared or Fisher exact tests). Multivariable logistic regression analysis with a backward stepwise method and the Hosmer-Lemeshow test were performed.

Results:
One hundred patients were included (mean age 47.8 years and 7.8 days of preoperative symptoms). Preoperative antibiotics were given to 87%, and 46% of all patients had one or more immunocompromising comorbidities. Diagnoses included soft tissue abscess (46%), suppurative flexor tenosynovitis (22%), septic arthritis (21%), osteomyelitis (9%), and septic bursitis (2%). Aerobic bacterial, anaerobic bacterial, fungal, and AFB cultures were sent in 100%, 99%, 94%, and 82% of patients, respectively. Corresponding rates of positivity were 74%, 34%, 5%, and 2%, respectively (Table 1). Atypical cultures were positive for 7% of patients and 2.9% of all cultures (5/129 fungal, 2/113 AFB). For those with positive atypical cultures, management was influenced for the 3 patients (3% of the cohort) referred for infectious disease consultation and 1 patient (1%) with broadened antimicrobial coverage to include atypical organisms. Univariate analysis demonstrated symptom duration >7 days as potentially associated with atypical culture positivity (OR 6.0 – Table 2), which remained as the sole independent predictor in the multivariate model (OR 2.0). Goodness-of-fit testing suggests the multiple regression model satisfactorily fit the data (p=0.06).

Conclusions:
In the setting of acute deep infections of the upper extremity, atypical cultures are expensive but infrequently positive (7%) and rarely alter antimicrobial treatment (1%). Symptoms >7 days predict a higher rate of atypical culture positivity.
Table 2 - Univariate Analysis for Positive Atypical Culture Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Difference (Atypical+ minus Atypical-)</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>-8.8</td>
<td>-21.84 - 2.2</td>
<td>0.11</td>
</tr>
<tr>
<td>Mean BMI (kg/m²)</td>
<td>-2.6</td>
<td>-8.72 - 2.5</td>
<td>0.20</td>
</tr>
<tr>
<td>Immunosuppressed</td>
<td>0.5</td>
<td>0.04 - 2.9</td>
<td>0.45</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.6</td>
<td>0.01 - 5.1</td>
<td>1.00</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>0.0</td>
<td>0.00 - 4.4</td>
<td>0.59</td>
</tr>
<tr>
<td>Smoker</td>
<td>0.8</td>
<td>0.08 - 5.1</td>
<td>1.00</td>
</tr>
<tr>
<td>Organ transplant</td>
<td>0.0</td>
<td>0.00 - 51.4</td>
<td>1.00</td>
</tr>
<tr>
<td>HIV positive</td>
<td>0.0</td>
<td>0.00 - 74.9</td>
<td>1.00</td>
</tr>
<tr>
<td>ERAD</td>
<td>0.0</td>
<td>0.00 - 35.4</td>
<td>1.00</td>
</tr>
<tr>
<td>Intravenous drug use</td>
<td>0.0</td>
<td>0.00 - 7.7</td>
<td>1.00</td>
</tr>
<tr>
<td>Rheumatologic disease or on DMARD</td>
<td>3.6</td>
<td>0.06 - 45.7</td>
<td>0.31</td>
</tr>
<tr>
<td>Immunosuppressing medication</td>
<td>2.9</td>
<td>0.05 - 33.1</td>
<td>0.36</td>
</tr>
<tr>
<td>Active malignancy</td>
<td>0.0</td>
<td>0.00 - 35.4</td>
<td>1.00</td>
</tr>
<tr>
<td>Obese (BMI ≥ 30 kg/m²)</td>
<td>0.8</td>
<td>0.07 - 5.0</td>
<td>1.00</td>
</tr>
<tr>
<td>Morbidly obese (BMI ≥ 40 kg/m²)</td>
<td>0.0</td>
<td>0.00 - 10.6</td>
<td>1.00</td>
</tr>
<tr>
<td>Intraoperative gross purulence</td>
<td>2.8</td>
<td>0.32 - 135.7</td>
<td>0.43</td>
</tr>
<tr>
<td>Pre-operative symptoms &gt; 3 days</td>
<td>1.1</td>
<td>0.17 - 12.5</td>
<td>1.00</td>
</tr>
<tr>
<td>Pre-operative symptoms &gt; 7 days</td>
<td>6.0</td>
<td>0.91 - 66.6</td>
<td>0.03*</td>
</tr>
</tbody>
</table>

* Mann-Whitney performed due to non-normally distributed data
* Statistically significant with confidence level of α = 0.05.

Table 1 - Summary of Cultures

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of Patients (%) of Total</th>
<th>Aerobic / Anaerobic</th>
<th>Number sent (% by Diagnosis)</th>
<th>Mean Number sent per Patient</th>
<th>Number Positive (%)</th>
<th>Number sent (% by Diagnosis)</th>
<th>Mean Number sent per Patient</th>
<th>Number Positive (%)</th>
<th>Number sent (% by Diagnosis)</th>
<th>Mean Number sent per Patient</th>
<th>Number Positive (%)</th>
<th>Number sent (% by Diagnosis)</th>
<th>Mean Number sent per Patient</th>
<th>Number Positive (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Tissue Abscess</td>
<td>26 (46%)</td>
<td>24 (46%)</td>
<td>2.00</td>
<td>0.79</td>
<td>8 (35%)</td>
<td>0.34</td>
<td>1.17</td>
<td>0.34</td>
<td>2 (20%)</td>
<td>0.34</td>
<td>1.17</td>
<td>0.34</td>
<td>1.17</td>
<td>0.34</td>
</tr>
<tr>
<td>Flexor Tendinitis</td>
<td>22 (25%)</td>
<td>19 (41%)</td>
<td>2.71</td>
<td>1.41</td>
<td>14 (18.2%)</td>
<td>2.00</td>
<td>1.45</td>
<td>0.00</td>
<td>5 (62.5%)</td>
<td>1.61</td>
<td>5.00</td>
<td>1 (100%)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Septic Arthritis</td>
<td>21 (41%)</td>
<td>19 (41%)</td>
<td>1.89</td>
<td>0.00</td>
<td>9 (11.7%)</td>
<td>2.44</td>
<td>1.11</td>
<td>0.00</td>
<td>8 (88.9%)</td>
<td>1.17</td>
<td>8.00</td>
<td>1 (100%)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Septic Osteomyelitis</td>
<td>9 (19%)</td>
<td>7 (19%)</td>
<td>1.00</td>
<td>0 (0%)</td>
<td>3 (33.3%)</td>
<td>0.84</td>
<td>1.00</td>
<td>0 (0%)</td>
<td>2 (66.7%)</td>
<td>1.00</td>
<td>2.00</td>
<td>0 (0%)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Septic Periostitis (Elephant)</td>
<td>2 (1%)</td>
<td>1 (50%)</td>
<td>2.00</td>
<td>0 (0%)</td>
<td>1 (100%)</td>
<td>1.00</td>
<td>1.00</td>
<td>0 (0%)</td>
<td>1 (100%)</td>
<td>1.00</td>
<td>1.00</td>
<td>1 (100%)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100 (100%)</td>
<td>94 (94%)</td>
<td>2.73</td>
<td>0.77</td>
<td>77 (77%)</td>
<td>2.73</td>
<td>1.30</td>
<td>0 (0%)</td>
<td>42 (42%)</td>
<td>1.30</td>
<td>42.00</td>
<td>2 (2%)</td>
<td>1.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>
76 Efficacy of a Low-Profile Functional Splint for Protecting the Thumb Metacarpophalangeal Joint Ulnar Collateral Ligament
Joseph A Gil, MD; Kerry Ebert, MEd, OTR/L, CHT2; Keri Blanchard, OTR/L, CHT; Avi D Goodman, MD; Joseph Crisco, PhD; Julia A. Katarincic, MD
Brown University, Providence, RI

Introduction
Thumb metacarpophalangeal (MCP) joint ulnar collateral ligament (UCL) injury results from a sudden thumb hyperextension or hyperabduction force. A repaired UCL has been demonstrated to be significantly weaker compared to the intact UCL, and further, the repaired UCL must be protected for approximately 10 weeks, until adequate ligament healing has occurred. However, Division I collegiate football players have been allowed to return to sport as early as 4 weeks. The purpose of our study was to determine the efficacy of a low-profile functional splint in resisting abduction across the UCL of the thumb and protecting it from reinjury.

Methods
Ten fresh frozen cadaver thumbs were tested by implanting a threaded Kirschner wire (K-wire) into the proximal phalanx of the thumb, leaving the distal aspect protruding from the first phalanx. A second K-wire was implanted into the thumb metacarpal for a reference. The distal radius and ulna were mounted to a board in a standardized fashion. An anteroposterior (AP) radiograph of the thumb was obtained with a 2 N preload valgus force applied to the thumb, and the angle between the K-wires was measured as a baseline. Subsequently, 20 N, 40 N, 60 N, 80N and 100N valgus forces were applied to the distal K-wire through an adjustable pulley that provided a stable MCP joint position. AP radiographs of the thumb were then obtained after each force was applied. The angle of displacement between the wires was measured and compared to baseline. A custom low-profile functional splint, immobilizing the thumb MCP but leaving the carpometacarpal and interphalangeal joints free, was fashioned for each cadaveric thumb, and the above protocol repeated. A repeated measures 2-way ANOVA with a post-hoc Sidak's multiple comparisons test was performed to assess mean differences in the abduction angle between the control and splinted specimens at each applied load.

Results
The tested low-profile functional splint significantly reduced mean abduction angles at each applied load (P< 0.05). There was 41% reduction in abduction angle at 20 N, 35% reduction at 40 N, 31% reduction at 60N, 30% reduction at 80 N, and 25% reduction at 100N.

Conclusion
The low-profile functional splint significantly reduces abduction of the thumb MCP UCL up to 100N. We have previously demonstrated that the maximum load to failure of a repaired UCL is 84N; therefore, this splint effectively protects the UCL up to at least 100N after UCL repair.
Introduction:
Pyogenic flexor tenosynovitis (PFT) of the hand remains a challenging problem that often requires surgical irrigation and parenteral or oral antibiotics. We hypothesize that the pathophysiology and microenvironment of PFT can be likened to that of periprosthetic joint infections (PJI), where bacteria thrive in a closed synovial space with limited blood supply. As such, we postulate that PFT is also facilitated by bacterial attachment and biofilm formation rendering standard treatments less effective. In this study, we evaluate infected tendons for the presence of biofilm and explore new treatment strategies, comparing corticosteroids in conjunction with antibiotics together or separately, as well as ultrasonication in their efficacy in eliminating bacterial colonization.

Methods:
Fresh human cadaveric hand tendons were harvested and divided into 0.5cm segments. Samples were sterilized and inoculated with 1x10^4 cfu/ml Green Fluorescent Staphylococcus Aureus (GFP-SA) for 48hrs, 37˚C. After saline washing to rid planktonic bacteria, samples were treated for 24 hours with: 1) Saline irrigation 2) antibiotics (Vancomycin), 3) corticosteroids, 4) Antibiotics/corticosteroid combined or 5) Ultrasonication in the presence of antibiotics. Samples were visualized using Confocal Laser Scanning Microscopy (CLSM) and Scanning Electron Microscopy (SEM), or sonicated, plated and counted. Three samples were plated from each condition and counts were expressed as means ± SE.

Results:
Following bacterial challenge, CLSM revealed heterogeneous green fluorescence representing bacterial attachment with dense areas of signal, typical of biofilm formation. SEM at >3000X, demonstrated bacterial colonization in grape-like clusters that at higher magnifications, appear as colonies covered by a thick matrix characteristic of biofilm. Next we examined the efficacy of various treatments in decreasing bacterial load by direct colony counting. Irrigation with saline alone yielded a 18.5% decrease in bacteria burden as compared to 42.6% with steroids, 54.4% with antibiotics, and 77.3% with antibiotics/steroids combined. Adding ultrasonication eliminated any remaining bacteria. These findings were further demonstrated with confocal and electron microscopy.

Conclusions:
To the best of our knowledge, this is the first study that demonstrates that Staphylococcus aureus can readily form biofilm on human tendons. This may render current PTF treatments less effective contributing to its typical sequale. The addition of both local antibiotics and corticosteroids results in considerable decrease in biofilm formation on flexor tendons while treatment with ultrasonication almost eliminates bacterial burden. We suggest re-thinking the current treatment of PFT and recommend considering a strategy more analogous to PJI management with the adjunctive use of local antibiotics, corticosteroids and mechanical agitation.
78 The Effects of hPTPβ Inhibitor on Microcirculatory Hemodynamics of Muscle Flaps Following Ischemia Reperfusion Injury
Andy F Zhu, MD; Kagan Ozer, MD; Geoffrey Burns, MS; Breana Siljander, BS; Jennifer F. Waljee, MD, MPH
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Tissue ischemia may negatively influence the outcome of reconstructive procedures performed by microsurgical transfer of skin and muscle flaps and transplantation of organs, which are cut off from blood circulation and remain under ischemic conditions during transplantation.

Evidence suggests that activation of receptor tyrosine kinases is negatively regulated by protein tyrosine phosphatases (PTP). Inhibition of PTPs enhances endothelial receptor tyrosine kinases activation and may have beneficial effects on blood vessel growth and improve blood flow to ischemic tissue. Human PTP beta (hPTPβ) is specifically expressed by endothelial cells and may play an important role in dynamic response to injury. The purpose of this study is to determine the influence of hPTPβ inhibitors on ischemia and ischemia-reperfusion injury in the rat cremaster muscle flap model.

Material and Methods

Following the cremaster muscle flap dissection, sixty male Lewis rats divided into 10 experimental groups (control, placebo and treatment groups at different time points). In all groups, following the group-specific treatment, microcirculatory hemodynamics (vessel diameters, functional capillary index, vascular permeability index) and leukocyte-endothelial activation (number of rolling, sticking and transmigrating leukocytes in postcapillary venules) were recorded for 4 hours in 1 hour intervals after a 2h period of reperfusion. The effects of drug and placebo were analyzed with Mann Whitney U and Wilcoxon test.

Results
The results of subcutaneous administration of the hPTPβ inhibitor following different periods of muscle ischemia showed preservation of capillary perfusion in group subjected to 2 hours of ischemia when compared with placebo. hPTPβ treated ischemic groups (1h, 2h and 3h) showed decreased activation of rolling, sticking and transmigrating leukocytes compared to the respective placebo groups at all time points. The differences were significant for transmigrating leukocytes after 2h and 3h of ischemia. There was also a significant reduction in the endothelial edema index in the 2h ischemia group.

Conclusions
This study confirmed that administration of hPTP inhibitors after submission of tissue to sub-critical ischemic conditions (1-2 hours) improved functional capillary perfusion and decreased leukocytes-endothelial activation during 4 hours observation time after muscle reperfusion. These results indicate that hPTPβ has potential as a post-conditioning therapy applied after tissue ischemia, before the reperfusion injury insult will take effect.
79 Carpalmetacarpal Fractures: A New Classification to Direct Outcomes
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¹TriHealth Hand Surgery Specialists, Cincinnati, OH; ²Naval Medical Center Portsmouth, Portsmouth, VA

Hypothesis
Our aims were to evaluate treatment of carpometacarpal (CMC) fracture-dislocations in our military population and create a clinically relevant classification system based upon injury radiographs to assist in guiding treatment. We hypothesized that the incidence of these injuries is higher than previously reported and that operative fixation would provide excellent results.

Methods
A retrospective chart review identified 205 patients with CMC base fracture-dislocations. Data collected included demographics, nicotine use, mechanism of injury, injury patterns, method of fixation, time to union, and postoperative complications. Statistical analysis was performed to compare healing times with the different treatment methodologies and patient factors that could affect healing.

Results
A total of 205 CMC fracture/dislocations were identified that met inclusion criteria. Radiographic review revealed that three patterns of injury could be delineated. Type 1 injuries were unstable CMC dislocations without an intra-articular fracture that often occurred with an extra-articular 4th metacarpal base fracture. Type 2 injuries demonstrated a partial intra-articular fracture of the CMC joint - either of the metacarpal or hamate - with or without dislocation. Type 3 injuries involved fracture of one or both sides of the entire CMC joint surface (pilon equivalent) with or without dislocation. 23/25 the Type 1 injuries and 90/104 of the Type 2 fracture/dislocations were successfully treated with closed reduction and percutaneous pin fixation. 31/76 Type 3 fractures were able to be treated in the same fashion, with the remainder requiring open reduction to restore articular congruity. Radiographic union was achieved on average in 6.9 weeks in 91 percent of fractures. All patients with the exception of one were retained for active military duty or returned to their prior activity level. There were no statistical differences as far as fracture union based upon age, gender, nicotine use, mechanism of injury, or injury pattern.

Summary Points
• Carpometacarpal base fracture dislocations are common injuries in the active duty military population
• These injuries are frequently unstable and require internal fixation to maintain a congruent reduction of the CMC joint
• Using the proposed classification system, it is possible to use the injury radiographs to assist in determining operative approach and direct treatments, obtain excellent radiographic healing rates, and return nearly all patients to previous activity levels.
**The Vascular Anatomy of the Capitate: New Discoveries Using Micro-CT Imaging**

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1Mayo Clinic, Rochester, MN; 2Orthopedic Division, Tel Aviv Sourasky Medical Center Orthopaedic Division, Tel Aviv, Israel

**Purpose**

To study the interosseous 3D micro-vasculature of the capitate bone using a novel high resolution micro-CT (µCT) imaging technology, and to examine the blood supply as it relates to the most common fracture types.

**Methods**

Ten wrists were injected with a lead-based contrast agent. The capitates were harvested and imaged using a µCT scanner. The intraosseous vascularity was incorporated into a 3D image. Vascular pattern, as well as vessels' cross sectional area, number and distribution were measured. An average capitate fracture line was calculated using clinical data from 22 patients with capitate fractures. The fracture line was projected on the representative capitate in order to assess its relation with the nutrient vessels entry points.

**Results**

The capitate is a hyper-vascular carpal bone supplied by dorsal and volar vascular systems which anastomose in 30% of cases. There was no predominance of one vascular system over the other. The majority of vessels enters the capitate at the distal half and supplies the proximal pole in a retrograde fashion. In addition, 70% of the specimens also had at least one vessel entering the proximal pole through the volar capitate ligaments and supplying the proximal pole directly. The average fracture line had an oblique orientation, and 90% of the specimens had a blood vessel enter proximal to that line.

**Conclusions**

This µCT vascular study further verifies that the capitate receives most of its vasculature in a retrograde fashion, but this study also shows that most capitates have vessels supplying the proximal pole directly. These findings might explain why most capitate waist fractures don't progress to proximal pole avascular necrosis.

**Figure 1.** Three-dimensional rendering of a left capitate specimen showing the microvascular architecture within the bony structure. View of the A, Radial surface; B, Volar surface; C, Ulnar surface and; D, Dorsal surface (red vessels, intraosseous vessels; green vessels, extraosseous vessels entering the bone).
Figure 2. Entry points of nutrient vessels of all capitates projected onto the structure of one right capitate showing the density of nutrient vessels and the relation to the average fracture line. View of the A, Radial surface; B, Volar surface; C, Ulnar surface and; D, Dorsal surface. A predominance of the vessels entering below the fracture is volar (Blue line, average fracture; light blue area, 95% fracture line confidence interval).
INTRODUCTION:
Postoperative pain management and opioid consumption following orthopaedic surgery and hand surgery can be influenced by a multitude of variables. To better understand the effect that the type of anesthesia has on post-operative pain management, we prospectively evaluated opioid consumption post-operatively following Trigger Finger Release (TFR) and open Carpal Tunnel Release (CTR), and hypothesized that cases performed wide awake with local anesthesia and no tourniquet (WALANT) would result in increased opioid consumption compared to cases performed under sedation (MAC).

METHODS:
Patient post-operative opioid consumption following all consecutive cases of CTR and TFR was prospectively collected over a 6 month period. Additional data collected included patient demographics, and procedure type. The three primary endpoints of the study were the (1) evaluation of total opioid consumption, (2) the overall utilization rate of opioids, and (3) the total number of days an opioid was used for both the WALANT and MAC groups. Student t-tests were performed to evaluate statistically significant differences.

RESULTS:
Mean opioid use for MAC cases for all procedures evaluated was approximately 3.95 opioid pills compared to 3.85 opioids pills for the WALANT cases (p=0.86). The average opioid utilization rate with MAC compared to WALANT for all procedures was 62% to 49%, respectively (p=0.009). The average number of days requiring opioid use was 1.83 days for MAC cases, compared to and 1.61 days for WALANT (p=0.03).

CONCLUSION:
The observed prevalence of post-operative opioid consumption and the number of days that opioids were used after undergoing soft tissue hand surgeries under WALANT were found to be less compared to surgeries performed under MAC. The overall amount of consumption was comparable between the two groups, and averaged less than 4 pills. These results suggest that effective pain control postoperatively may be independent of anesthesia type and we recommend that postoperative pain regimens should not be varied to reflect the modality of anesthesia. We also suggest that for common hand surgery procedures such as CTR and TFR that only a limited number of opioid pills be prescribed for post-operative pain.
82 Physician Rating Scales Do Not Accurately Rate Physicians: A Systematic Review
Matthew B Burn, MD; David M Lintner, MD; Pedro E Cosculluela, MD; Kevin E Varner, MD; Shari R Liberman, MD; Patrick C McCulloch, MD; Joshua D Harris, MD
*Houston Methodist Hospital, Houston, TX*

**Introduction:**
Physician rating systems are becoming widely utilized. Many surgeons argue that the multifaceted nature of these questionnaires includes factors outside of the physician's control. The purpose of this investigation was to perform a systematic review to determine (i) the components of care evaluated by currently available online physician rating scales, and (ii) which of these factors are under the direct control of or directly rate the physician. The study hypothesis was that less than 50% of the factors used to rate physicians are under their direct control and/or directly rate them.

**Materials & Methods:**
A systematic review was performed to identify online, patient-reported, physician rating scales. Data extracted from these scales included: (1) website demographics/characteristics, (2) components of the physician rating scale relevant to the physician, and (3) components of the physician rating scale not relevant to the physician. Descriptive statistics were calculated.

**Results:**
Fourteen websites were identified containing patient-reported physician rating scales. There was a mean of 11 (SD 16, Range 1-62) checkbox questions and 1 (SD 1, Range 0-2) comment box. Overall, 31% of questions directly rated the physician, 47% rated both the physician and office, and 21% rated the office alone. The most common questions used were versions of: (1) "courtesy/helpfulness of office staff" (79%), (2) "overall rating" (57%), (3) wait times/promptness/punctuality (57%), (4) "trust/confidence in physicians' knowledge & decisions" (50%), (5) "time spent with patient" (43%), (6) "listens to and answers questions" (43%), and (7) "recommend to family/friend" (43%). While 2 questionnaires (14%) included a patient-reported "treatment success" question, none (0%) included patient-reported "surgeon skill" questions or reported any outcome scores to measure success.

**Conclusions:**
Only 4 of the 14 rating scales reviewed had the highest proportion of questions rating the physician directly. The other 10 systems focused their questions on either: the physician and the office together or the office alone. Overall, the proportion of questions directly rating the physician was well below our hypothesis at 31%. This tendency for ratings to be determined by "the office staff and decor, rather than the quality of care received" has been mentioned in prior studies. It is vital that physicians understand these systems and help to shape them into something more pertinent by incorporating questions focused on the interactions with the physician themselves and incorporating objective outcome scores. This will allow patients to make more educated choices about their care.
83 Ultrasonographic Evaluation of the Prevalence of Intracompartamental septum in de Quervain's Disease Patients
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Ishii Orthopaedic & Rehabilitation Clinic, Gyoda, Saitama, Japan

Introduction:
It has been reported more patients with de Quervain's disease who had undergone surgical treatment had a septated dorsal compartment than did normal cadavers. The purpose of this study was to evaluate sonographically the prevalence of an intracompartamental septum in patients with de Quervain's disease, and to compare the prevalence between groups categorized by sex, age, or peripartum status.

Materials & Methods:
We performed ultrasonographic examination of 112 wrists from 103 consecutive patients admitted to our clinic with de Quervain's disease over the 4-year period. The sonographic appearance of the first dorsal compartment was evaluated on transverse images. If a hypoechoic structure was visible between the APL and EPB tendons, then we classified it as an "intracompartamental septum-like structure" (Figure 1-3). The prevalence of a septum-like structure in the first compartment was compared between men and women, between older (≥40 years old) and younger (≤39 years old) patients, and between pregnant or lactating women and other patients.

Results:
Table 1 reports patient demographic data. There were 19 men and 44 women in the older age group, and 12 men and 28 women in the younger group. In total, The prevalence of intracompartamental septum in the patients with de Quervain's disease was 61.6% (69/112). Of the 69 wrists with intracompartamental septum-like structure, 53 (76.8%) showed this structure completely through the level of radial styloid, and 16 (23.2%) showed it partially on the level of distal radial styloid, respectively. There were no significant differences in the prevalence of dorsal compartment septation between any two groups categorized by patients' demographics (Table 2).

Conclusions:
The prevalence of intracompartamental septation in the patients with de Quervain's disease was higher than previously reported prevalence of the cadavers and lower than that of the patients who underwent surgery. This result was consistent with the previous report that the patients with a septated dorsal compartment might be more liable to de Quervain's disease and more prone to failure of nonsurgical treatment.
Table 1 Patient demographics

<table>
<thead>
<tr>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>[years old]</td>
<td>[m]</td>
<td>[kg]</td>
<td></td>
</tr>
<tr>
<td>Men (N=31)</td>
<td>49.0 ± 17.6</td>
<td>196.0 ± 5.8</td>
<td>77.0 ± 1.0</td>
</tr>
<tr>
<td>(19–81)</td>
<td>(152–190)</td>
<td>(50–115)</td>
<td>(16.8–34.0)</td>
</tr>
<tr>
<td>Women (N=72)</td>
<td>47.6 ± 15.1</td>
<td>166.1 ± 5.6</td>
<td>64.9 ± 9.8</td>
</tr>
<tr>
<td>(19–79)</td>
<td>(140–167)</td>
<td>(38–87)</td>
<td>(16.8–22.2)</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>34.2 ± 4.9</td>
<td>158.3 ± 4.7</td>
<td>62.9 ± 9.0</td>
</tr>
<tr>
<td>The other women</td>
<td>51.9 ± 14.8</td>
<td>155.6 ± 5.7</td>
<td>65.8 ± 10.2</td>
</tr>
<tr>
<td>(N=55)</td>
<td>(19–79)</td>
<td>(140–196)</td>
<td>(38–97)</td>
</tr>
<tr>
<td>Older (&gt;40 years old)</td>
<td>58.7 ± 9.8</td>
<td>158.8 ± 8.1</td>
<td>59.1 ± 11.3</td>
</tr>
<tr>
<td>(N=63)</td>
<td>(40–81)</td>
<td>(140–177)</td>
<td>(38–95)</td>
</tr>
<tr>
<td>Younger (&lt;39 years old)</td>
<td>31.4 ± 5.7</td>
<td>161.2 ± 7.2</td>
<td>57.7 ± 12.9</td>
</tr>
<tr>
<td>(N=40)</td>
<td>(18–50)</td>
<td>(147–190)</td>
<td>(44–110)</td>
</tr>
<tr>
<td>Total</td>
<td>48.1 ± 16.8</td>
<td>158.7 ± 7.8</td>
<td>58.6 ± 11.8</td>
</tr>
<tr>
<td>(N=103)</td>
<td>(19–81)</td>
<td>(140–190)</td>
<td>(38–110)</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation (range). BMI: body mass index

Table 2 Prevalence of intracompartamental septum-like structures on ultrasonographic examination of affected wrists

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of wrists with septum-like structures</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>44 (52%)</td>
<td>0.144</td>
</tr>
<tr>
<td>Pregnant or lactating women</td>
<td>44 (52%)</td>
<td>0.15</td>
</tr>
<tr>
<td>The other patients</td>
<td>84 (100%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Older (&gt;40 years old)</td>
<td>13 (55%)</td>
<td>-</td>
</tr>
<tr>
<td>Pregnant or lactating women</td>
<td>13 (55%)</td>
<td>-</td>
</tr>
<tr>
<td>The other patients</td>
<td>84 (100%)</td>
<td>-</td>
</tr>
<tr>
<td>Younger (&lt;39 years old)</td>
<td>30 (30%)</td>
<td>0.89</td>
</tr>
<tr>
<td>Pregnant or lactating women</td>
<td>30 (30%)</td>
<td>-</td>
</tr>
<tr>
<td>The other patients</td>
<td>84 (100%)</td>
<td>-</td>
</tr>
</tbody>
</table>

A number of corresponding affected wrists is described in the box.

The number of the wrist with intracompartamental septum-like structure completed through the lateral side of the wrist in the patients who showed this structure partially on the laterial side without a complete structure was 30.

Statistical significance was determined by the Chi-square independence test in all comparisons between two groups.
Opposition is the most important motion of the hand and it requires a congruent saddle-shaped carpometacarpal joint (CMCJ), thenar muscles, and the median nerve to innervate these thenar muscles. In chronic, severe carpal tunnel syndrome (CTS), two of these components may be lost as the result of the median nerve injury. The modified Camitz opponensplasty which employs a pulley at the level of the carpal tunnel to direct the pull of the PL in line with the APB restores thumb palmar abduction and has the advantage being able to perform an open carpal tunnel release at the same time of the opponensplasty. This study was to assess the recovery and level of activity of the APB, as well as the activity of the PL muscle during thumb opposition and abduction after performing the modified Camitz opponensplasty. A total of 21 patients were identified and included in the study.

RESULTS
Pre-operatively, all patients complained of hand weakness or clumsiness in handling objects, or both. Improvement of numbness and paresthesia were noted in 19 (90%) of patients, with 2 (9.5%) having full resolution of symptoms. Twenty (95.2%) patients were able to reach 80% of the abduction height of the contralateral hand. Good outcomes were attained in 13 (61.9%) patients. There was significant improvement in the mean grip strength (P=0.000) and tripod pinch grip strength (p=0.000). Seven (33.3%) patients did not have any signs of APB recovery after the procedure, while 6 (28.6%) had full recovery. For palmaris longus activities, on thumb opposition, 12 (57.1%) patients had an abundant muscle contraction, 7 (33.3%) had moderate while 2 (9.5%) had sparse activity. During thumb abduction, it was noted that 11 (52.4%) had abundant activity, 6 (28.6%) had moderate activity, 3 (14.3%) had sparse and 1 (4.8%) had no activity.

CONCLUSION
We conclude that the Camitz opponensplasty is a viable option for patients with severe carpal tunnel syndrome and severe thenar muscle atrophy. While results of open release alone is promising, there is difficulty in pinpointing which patient is likely to recover, and which one will not. Also, it is beneficial to the patient during the early post-operative rehabilitation period when the APB and opponens muscles have not recuperated yet. It is a good adjunct to improving hand function during this time.
85 Bidirectional Barbed Suture Repair in Flexor Tendons: A Novel Technique
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Cleveland Clinic-Akron General Medical Center, Akron, OH

Introduction:
Repair of flexor tendon ruptures in Zone II remains a challenging problem. Both the flexor digitorum profundus and flexor digitorum superficialis pass within the same fibro-osseous sheath. A suture construct must be employed that maximizes strength while minimizing increases in bulk and friction. Various configurations of barbed suture have been studied and found to be promising solutions to the issues created by these injuries; such techniques have not taken full advantage of the bidirectional orientation of the barbs in the suture in order to prevent distraction at the tendon repair site. This study proposes a repair technique in which all barbs, throughout the length of the repair, are acting to prevent distraction at the repair site.

Methods:
Twenty-four flexor tendons from cadaver specimens were transected to mimic Zone II tendon injuries. Four repair techniques were studied: Amadeo (barbed suture repair), McClellan (barbed suture repair), Kessler (standard, knotted technique), and the experimental configuration (barbed suture repair). The repairs underwent biomechanical testing to examine ultimate load and 2-mm gap force, normalized to cross-sectional area of the tendon.

Results:
Prior to normalization to tendon cross-sectional area, the Amadeo technique had a significantly larger force at 2-mm gap than the Kessler (p < 0.01) and McClellan (p < 0.05) techniques. The ultimate load for the Amadeo technique was significantly larger than that of the Kessler (p < 0.05) and McClellan (p < 0.01) techniques. Differences were found among techniques when parameters were normalized to the cross-sectional area of the tendon both before transection and after repair. Specifically, the Amadeo technique had a significantly larger force at 2-mm gap than Kessler (p < 0.05), and a significantly higher ultimate load than McClellan (p < 0.05). There was no statistically significant difference between the novel knotless suture technique and any other repair type.

Conclusion:
The suture technique developed in this study was found to have equivalent biomechanical strength to the Amadeo, McClellan, and Kessler techniques. Amadeo did have superior 2mm gap force strength when compared to Kessler and a greater ultimate load than McClellan. The experimental suture technique has sufficient strength of repair in biomechanical testing to be used for flexor tendon injuries, and it eliminates the need for a knot.
86 The Effect of Orthopaedic Surgeon's Attire on Patient Confidence and Trust in a Suburban Setting
Vince W. Lands, MD
St Luke's University Health Network, Bethlehem, PA

Background:
Previous studies have recognized that patients are more likely to have confidence and trust in physicians who dress in more formal attire, with the white coat acting as a major source of patient perceived trust and confidence.

Purpose:
This study aims to explore any connection that may exist between an orthopedic surgeon's attire and its influence on patient perception of surgeon competence and trustworthiness in a suburban setting.

Patients/Methods:
Patients older than the age of 18 who presented for outpatient evaluation in a suburban setting were asked to participate in this survey-based study. Patients were first asked about various demographic factors. They were then shown images of male and female surgeons wearing different outfits (formal, business, casual, and scrubs) and asked to rate seven perceived characteristics of each surgeon using a Likert Scale: confidence, perceived intelligence, technical prowess, willingness to discuss confidential information, trust, perceived safety, and empathy. Finally, patients were asked about absolute preferences regarding physician attire and physical attributes.

Results:
85 surveys were fully completed. Participants were mostly female (65%), Caucasian (79%), and completed higher education (52%). The age groups of 45-54 (25%) and 55-64 (26%) equally constituted the biggest groups of participants. Patient confidence, perceived intelligence and trust was comparably higher in physicians pictured in a white coat or scrubs, compared to a low approval of physicians wearing gender specific professional or casual attire. When asked to directly compare physician attire, patient responders were most confident in male surgeons wearing a white coat and female surgeons wearing either white coats or scrubs.

Conclusions:
Combining strong clinical skills with appropriate clinical attire, particularly the traditional physician white coat, appears to be an effective way to enhance patient trust and confidence in their orthopaedic surgeon.
87. Fixation of Unstable Metacarpal Neck Fractures: Comparison of Crossed K-Wires and Intramedullary Headless Screw Fixation
Eitan Melamed, MD; Omri Ayalon, MD; Matin Lendhey, Msc; Oran Kennedy, PhD; John T. Capo, MD
NYU Hospital for Joint Diseases, New York, NY

Background: Numerous constructs are used in the fixation of metacarpal neck fractures. Currently one of the most common methods is K wire fixation. Recently, intramedullary headless screw (IMHS) has shown promise as an alternative to K wire fixation of metacarpal fractures. The purpose of this study was to compare the biomechanical performance of IMHS versus standard retrograde crossed K-wire fixation in a simulated metacarpal neck fracture model.

Methods: Transverse metacarpal neck fractures were created in 29 human cadaveric metacarpals. The specimens were randomly fixed with 3.0mm IMHS or retrograde crossed 0.045 inch K-wires. Constructs were then loaded to failure in cantilever bending. Stiffness, peak load to failure, maximal displacement and energy absorption were measured from the force-displacement curve. Data were analyzed via T test.

Results: The K wire group and the IMHS group had similar stiffness (15.18±8.07 N/mm, and 15.77±9.46 N/mm, respectively). Statistical difference was only found in maximal displacement which was higher in the K wire group (23.56± 3.72mm versus 20.60± 4.18mm). A statistically significant difference was not detected between the peak loads, and energy absorption of the K wires and IMHS.

Conclusion: For transverse metacarpal neck fractures, IMHS provides similar fixation to K-wires with limited dissection and without exposed hardware or the potential for pin track infection and collateral ligament tethering. The implant is inserted using a minimally invasive technique and would be suitable for unstable metacarpal neck fractures.
Clinical Application of Mathematical Long Bone Ratios to Calculate Appropriate Donor Limb Lengths in Bilateral Upper Limb Transplantations
Justyn Lutfy, MD, CM\(^1\); Alexis Pietak, BSc Eng, BSc, PhD\(^2\); Shaun D. Mendenhall, MD\(^1\); Michael W. Neumeister, MD\(^1\)
\(^1\)Southern Illinois University School of Medicine, Springfield, IL; \(^2\)Tufts University, Medford, MA

Introduction:
Limited methods exist to aid in deciding the appropriate donor limb lengths in bilateral upper limb amputees qualifying for vascularized composite allotransplantation. To aid in this decision, our hypothesis was that mathematical equations could be created using long bone length ratios to approximate the patient's limb length prior to amputation.

Methods:
A collection of thirty skeletons' unilateral upper limb long bones were measured using osteometric board and calipers to create a base data set. Anatomic segment ratios were calculated based on humerus length for males and females after multivariate linear regression analysis indicated a statistical difference. For clinical application testing, five minimally preserved cadavers underwent standardized upper limb x-rays. Radiographic bone lengths were measured along the long axis of the humerus, forearm, and third ray. These measured radiographic anatomic lengths were then compared to the predicted bone lengths, generated from the skeleton data set ratios, for each cadaver.

Results:
The Chi Square Goodness of Fit test showed excellent fit (p<0.025 to p<0.001) between the predicted and radiographically measured lengths for the five cadavers. Depending on the cadaver, percent error in total limb length predicted to measured ranged from 0.1% to 5%. Table 1 shows the variables to multiply an individual humerus length to calculate a given anatomic segment. Inter-observer measurements showed no statistically significant difference using the Bland-Altman method.

Conclusion:
If a bilateral upper limb amputee has one intact humerus, ratios to the humerus length can be reliably applied to calculate the pre-amputation limb length based on the patient's radiographic humerus length. These formulas are indicated for finding the appropriate limb lengths, and smaller anatomic segments, for donor-recipient matching in upper limb transplantation.

<table>
<thead>
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<tr>
<td>MC+C 0.31</td>
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<td>MP 0.084</td>
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<td>DP 0.056</td>
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Table 1 Value to multiply the radiographically measured humerus to acquire the missing anatomic segment length based on sex. R/U: forearm, MC+C: 3\(^{rd}\) metacarpal and carpus (i.e. palm height), MC: 3\(^{rd}\) metacarpal, PP: proximal phalanx long finger, MP: middle phalanx long finger, DP: distal phalanx long finger
Intratendinous Injection of Hydrogel for Reseeding Decellularized Human Flexor Tendons
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PURPOSE
Tendon tissue engineering addresses the challenge of limited donor tendons for tendon reconstruction. Decellularized tendons are a possible source for reconstruction, however reseeding of only the tendon surface is undesirable. We utilize a novel needle injection technique to evaluate intratendinous delivery of cells.

METHODS
Decellularized human tendons (n=3/group) were reseeded with rat adipose-derived stem cells (ASCs) in culture, injected with fetal bovine serum (FBS), or with hydrogel. ASCs were stained with PKH26 dye and seeded at 0.5 million cells/mL. On Day 7, tendons were embedded and cryosectioned, cross-sections (n=30/group) were imaged under fluorescence microscopy and PKH26+ cells in cross-section were counted. Scanning electron microscopy (SEM) was used to confirm the location of cells. To evaluate cell viability, we delivered luciferase-labeled ASCs and performed bioluminescent imaging. To evaluate synthetic ability, immunohistochemistry (IHC) of procollagen was performed. ASCs’ ability to attract tenocytes was assessed by seeding tenocytes in the upper chamber and either tenocytes (negative control) or ASCs in the lower chamber of a transwell plate. Cell-to-cell interaction was assessed by directly co-culturing ASCs and tenocytes at various ratios, measuring proliferation and Collagen I production, and quantifying synergy using the interaction index. Finally, tensile strength was tested.

RESULTS
Both FBS (p<0.001) and hydrogel (p<0.001) injection led to more ASCs inside the tendon compared to culturing. On SEM, the cultured group demonstrated cells on the surface but not inside, while both FBS and hydrogel injection groups demonstrated cells inside but not on the surface (Figure 1). Hydrogel injection initially demonstrated greater bioluminescence than culturing (p<0.005) and FBS injection (p<0.05). IHC of procollagen for injection groups demonstrated positive intratendinous staining correlating with the location of PKH26+ cells seen under fluorescence microscopy (Figure 2). ASC co-culture led to greater tenocyte migration (p<0.05). Interaction index (II) of hemocytometer counts, CyQuant assay, and Collagen I were >1 for all co-culture ratios, demonstrating synergistic proliferation and collagen production as compared to 100% ASC and 100% tenocyte controls (II=1) (p<0.05). There were no differences in tensile strength (p>0.05).

CONCLUSIONS
Intratendinous ASCs demonstrated synthetic capabilities. Tenocyte migration suggests that injected ASCs have the potential to attract tenocytes inside the tendon, where synergistic proliferation and Collagen I production can then promote intrinsic tendon healing. Figure 1
Efficacy of PROMIS Pain Scores and Likert Pain Scores to Assess Function
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Introduction:
Patient Reported Outcome Measurement Information System (PROMIS), developed by the NIH, utilizes a health domain related to pain. We evaluated this domain and its association with self-reported function (as determined by PROMIS physical function CAT), and secondarily its association to a Likert 0-10 pain score.

Methods:
Adult patients presenting to upper extremity clinic from February to December 2015 completed PROMIS physical function, pain interference, and Likert 0-10 pain scale questionnaires. PROMIS models were completed electronically in their computer adaptive form. Mean population scoring on each module is defined at 50 (SD 10, range 0-100) with larger scores indicating greater amounts of each health element (100=maximal function and most pain). Patients were also asked to rate their pain on a 0-10 scale with 0 being no pain and 10 being worst pain possible. They repeated this same procedure at each subsequent appointment. These data were collected prospectively as routine clinical care and were extracted from the electronic health record for cross-sectional evaluation. Univariate descriptive analyses explored each module's scores in the cohort. Bivariate Pearson correlation analysis defined the directional relationship between modules and Likert pain scores. Fisher transformation was used to correlate significance between correlations.

Results:
10,174 first visit, 4,847 second visit, 2,445 third visit, 1,289 fourth visit, and 684 fifth visit patient's data were recorded. Likert pain scores were slightly-modestly negatively correlated to PROMIS function at each visit ($r_p$1=-0.32; $r_p$2=-0.38; $r_p$3=-0.40; $r_p$4=-0.41; $r_p$5=-0.42, $p<0.01$). PROMIS pain scores were moderately-highly negatively correlated to PROMIS function at each visit ($r_p$1=-0.64; $r_p$2=-0.67; $r_p$3=-0.70; $r_p$4=-0.73; $r_p$5=-0.69, $p<0.01$). Likert pain scores were also moderately correlated to PROMIS pain scores ($r_p$1=0.52; $r_p$2=0.57; $r_p$3=0.59; $r_p$4=0.60; $r_p$5=0.59, $p<0.01$). Likert pain scores were significantly less correlated than PROMIS pain scores through time ($p<0.01$) relative to self-reported function (Figure 1).

Conclusions:
Both PROMIS pain and Likert pain scores had statistically significant correlations to self-reported physical function for each office visit.
PROMIS pain had a significantly stronger correlation to physical function than Likert pain scores. Likert pain scores consistently had only a slight-moderate correlation, while PROMIS pain consistently had moderate-high correlation to self-reported function.
PROMIS pain and Likert pain scale scores are only moderately correlated, and are less correlated than PROMIS pain and self-reported function.
91 Partial Radial Nerve Transfers for Patients with Isolated Traumatic Axillary Nerve Injuries
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University of California, Irvine, Orange, CA

Hypothesis:
Isolated axillary nerve injuries can occur subsequent to trauma or as a direct complication from shoulder procedures. While partial radial to axillary nerve transfers have previously been described, there has been a lack of information related to patient selection, surgical methodology, and outcomes. We hypothesize that partial radial to axillary nerve transfers is an under-utilized, promising treatment option for patients with this devastating injury.

Methods:
We performed a retrospective analysis of all partial radial nerve transfers for isolated axillary nerve injuries (n=7) performed by a single surgeon over the past four years. All patients had nerve conduction studies verifying a complete axillary nerve lesion with no reinnervation as detailed by fibrillation potentials without evidence of nascent potentials. The surgery consisted of (1) using a direct posterior approach to the arm, (2) isolating one fascicle of the radial nerve responsible for only elbow flexion as confirmed by intra-operative monitoring, and (3) coapting this branch to the proximal portion of the axillary nerve in the quadrilateral space. All patients were protected in a shoulder sling for three weeks until the nerve repair healed.

Results:
There was no donor nerve deficit for any patient. Four of the seven patients had undergone previous shoulder surgery and had received a preoperative nerve block. One patient had the nerve transfer performed within four months of injury and regained functional motion with forward elevation to 160 degrees and M4 strength. The other patients had surgery after the initial 7 months after the injury and did not have any meaningful improvement in function after the nerve transfer. The other three patients had an axillary nerve injury related to a traumatic injury and had nerve transfer performed within the initial 6 month time period. One patient has subsequent restoration of his deltoid muscle; however, his range of motion was limited due to an underlying proximal humerus nonunion. The other two patients have forward elevation to 160 degrees with M4 strength.

Conclusion:
For patients with axillary nerve injuries, a partial radial to axillary nerve transfer is a safe procedure without donor deficit that can provide functional recovery with early intervention. While the expanded use of regional anesthesia may cloud the initial post operative exam for patients undergoing shoulder surgery, the surgeon should be suspicious of patients who do not demonstrate recovery and refer patients early for intervention rather than prolonged observation in order to maximize the chances of recovery.

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Purpose:
In delayed presentation of brachial plexus trauma, the question arises as to whether donor nerves should be devoted to nerve reconstruction or reserved for free functional muscle transfer (FFMT). The purpose of this study was to systematically review recovery of elbow flexion after delayed nerve reconstruction versus FFMT for traumatic brachial plexus palsy.

Methods:
A systematic review was performed using the PUBMED, SCOPUS, and Cochrane databases in order to identify all cases of traumatic brachial plexus palsy in patients 18 years or older. Patients who underwent delayed (>=12 months) nerve reconstruction or FFMT for elbow flexion were included. Demographics were recorded, including age, time to operation, and level of brachial plexus injury. Functional outcomes were evaluated, including British MRC strength and range of motion for elbow flexion.

Results:
Thirty-three studies met criteria (Figure 1) for a total of 103 patients (53 delayed nerve reconstruction, 50 FFMT). The methodological quality of included studies (MINORS) ranged from 50-92%, with a median MINORS criteria score of 54% (IQR 54-71%) for nerve reconstruction and 54% (IQR 54-56%) for FFMT articles (p=0.72). Surgical age and preoperative elbow flexion were no different across the groups, whereas time to surgery and follow-up time were significantly longer in the FFMT group (Table 1). For upper trunk injuries, 53% of nerve reconstruction patients versus 100% of FFMT patients achieved M3 or greater strength (p<0.01) and 43% of nerve reconstruction patients versus 70% of FFMT patients achieved M4 or greater strength (p=0.17). In total brachial plexus injuries, 37% of nerve reconstruction patients versus 78% of FFMT patients achieved M3 or greater strength (p<0.01) and 16% of nerve reconstruction patients versus 46% of FFMT patients achieved M4 or greater strength (p<0.04).

Conclusion:
In delayed presentation of traumatic brachial plexus injuries, donor nerves should be reserved for free functional muscle transfer rather than for nerve reconstruction to restore elbow flexion.

Figure 1. Attrition diagram for systematic review
Introduction:
Neural scar formation constitutes a major barrier to peripheral nerve regeneration following repair or injury. Extra-neural scarring occurs through myofibroblastic collagen deposition that leads to fibrosis. These adhesions compromise nerve gliding and result in poor function. In contrast, intra-neural scarring results in diversion or blockade of regenerating axons. The goals of this study were to evaluate the pathophysiology of neural fibrosis.

Methodology:
We utilized 4 White New Zealand rabbits to create a peripheral nerve injury model. Crush and 50% partial transection injuries were performed to replicate Seddon Grade 2 and 3 nerve injuries.

In Phase 1 of the study, we histologically compared the partially transected and crushed nerves two week time intervals and evaluated changes in the healing nerve. We measured the extent of fibrosis by analyzing the expression of Heat Shock Protein (HSP) 47, a collagen-specific chaperone and alpha smooth muscle actin. The percent positivity of HSP47 was calculated in regions of interest.

Results:
Fibrotic tissue was heterogeneously concentrated in the epineurium and at the site of injury in the partial transection injury (Figure 1 B). Fibrotic tissue was concentrated homogeneously in the epineurium and endoneurium in the crush injury model (Figure 1 C). The epineurium of both the transection and crush nerve injury models yielded comparable positivity for HSP47 (Graph 1). There was a significant increase in HSP47-positive cells in the crushed nerve injury endoneurium compared to the transection nerve injury endoneurium distant to the site of injury (p< 0.001) (Graph 1). Finally, while aSMA-positive cells were clearly apparent in epineurium of cut and crushed nerves, this marker, except in pericytes, was absent in the endoneurium (Figure 2).

Conclusions:
Increased number of HSP47-positive cells suggests that a pro-fibrotic response in peripheral nerves includes activation of a mechanism that controls increased collagen production. The absence of aSMA-positive cells in endoneurium of injured nerves suggests an independent intra-neural fibrotic pathway that may exist outside the myofibroblastic cascade.
**FIGURE 1:**

A.) Uninjured nerve on Hematoxylin and Eosin Stain (H&E)  
B.) 50% Partial Transection Injury at 2 weeks on H&E  
C.) Crush injury at 2 weeks on H&E

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**Figure 2:**

A.) Transection injury at 2 weeks staining for HSP47  
B.) Crush injury at 2 weeks staining for HSP47  
C.) Transection Injury at 2 weeks staining for alpha SMA  
D.) Crush Injury at 2 weeks staining alpha SMA

**LEGEND:** ENDO (Endoneurium), EPI (Epineurium), P (Perineurium), FTX (Fibrotic Tissue)
Introduction:
Nerve autografts are considered the “gold standard” for reconstructing digital nerve injuries with segmental loss, but are associated with donor site morbidity. The terminal branch of the posterior interosseous nerve (PIN) is easy to harvest, is usually of sufficient caliber for digital nerve reconstruction, and its harvest yields no known donor deficit. Despite this, the PIN is not routinely used as a source of autograft, and there is minimal outcome data in the literature.

Materials & Methods:
A retrospective review was conducted of all patients who underwent reconstruction of a digital nerve gap with a PIN autograft by a single surgeon between 2004 and 2014. Demographics, medical history, location and mechanism of injury, interval between injury and repair, concomitant injuries, gap length were recorded. Clinic and therapy charts were accessed to obtain sensory recovery data and identify complications. Recovery was graded according to the Medical Research Council Classification for sensory function, with meaningful recovery defined as ≥ S3. Outcomes were compared to historical data for autograft reconstructions using other donor nerves.

Results:
37 digital nerve repairs in 34 subjects were included. In 5 additional patients the PIN was deemed of insufficient caliber. There were 28 males and 6 females (mean 35). Two patients gave a prior history of diabetes, and there were 13 smokers. The most commonly reported mechanisms of injury were saw injuries (n=10), glass lacerations (n=7), and knife injuries (n=5). The average gap length was 10.7 ± 3.1 mm (range 5-18 mm). Objective outcomes data were recorded for 22 patients at three months postop, and for 17 patients at 6 months. Recovery to the ≥ S3 level was reported in 88% of repairs at 6 months. Mean s2PD was 10.1 ± 3.3 mm at 3 months, and 8.1 ± 2.7 mm at 6 months. Mean m2PD was 9.1 ± 3.9 mm at 3 months, and 7.8 ± 3.1 mm at 6 months. These data compared favorably to historical data for nerve autograft repairs, with reported levels of meaningful recovery of 60-88%. Two patients had delayed healing, and three patients had mild local cellulitis. No patient required reoperation or readmission.

Conclusions:
The caliber of the PIN varies, but it was sufficient for use in 87% of patients. The PIN is a suitable donor for digital nerve reconstruction in gaps up to 18 mm, and high rates of meaningful recovery can be achieved, without significant donor sensory loss.
INTRODUCTION:
The need and utilization for surgical simulation training in medical school and residency programs continue to grow. The "TouchSurgery" application is a new interactive virtual reality smartphone or tablet-based application that offers a step-by-step tutorial and simulation for the execution of various operations. The purpose of this study was to compare the efficacy and validity of the application versus traditional teaching modalities utilizing the "Carpal Tunnel Surgery" module.

METHODS:
A total 100 medical students were recruited to participate. The control group (n=50) consisted of medical students learning about carpal tunnel release surgery using the "traditional" medium consisting of a video lecture on powerpoint. The study group (n=50) consisted of students learning the procedure through the application. Each group was blinded to the other. The content covered was identical in both groups but delivered through the different mediums. Outcome measures included comparison of standardized test scores and overall application satisfaction.

RESULTS:
The study group using the "TouchSurgery" application significantly outperformed the control group with the given assessment by 14.2%. The average grade on the assessment for the application study group was 89.3 % with a Stdev of 6.05%. The average grade for the control group was 75.6% with a Stdev of 8.71%. A Two-tailed T-test was conducted and demonstrated that the difference was statistically significant (p <0.001). The students rated the overall quality of the application including content validity, quality of graphics, and ease of use as (Median: 5, Mean 4.81 ± 0.38), Usefulness for surgical training (Median: 5, Mean: 4.74 ± 0.41), Willingness to use the app to learn more procedures (Median: 5, Mean: 4.83 ± 0.33), and willingness to add this application as a part of their training curriculum (Median: 5, Mean: 4.85 ± 0.35).

CONCLUSION:
The results of the study demonstrated that the use of the "TouchSurgery" application was superior than the traditional teaching methods for preparing medical students about the steps of a carpal tunnel release surgery. With regards to secondary objective regarding content validity, usefulness, and willingness to include this simulation as a part of the surgical education curriculum, students strongly agreed in the study group that this should be implemented within the curriculum and preferred to use it to learn other surgical procedures. The study findings lend support for the use of the application for medical students to prepare for and learn the steps for various surgical procedures.
**Background:**
Recent data of modern war conflicts, natural disasters and traffic accidents show an increase in the number of patients suffering from severe peripheral nerve injuries. Persistent stump pain is reported in 74% limb amputees. Furthermore, it is estimated that up to 25% of patients after limb amputation develop painful end-bulb neuromas. This study investigates the efficacy of epineural sheath jacket (ESJ) as a novel technique to prevent neuroma formation in the rat sciatic nerve model.

**Methods:**
Eighteen Lewis rats were divided into three experimental groups (n=6): Group I– 20mm sciatic nerve segment was resected and proximal nerve stump was left without protection (positive control), Group II- nerve stump was buried into the adjacent muscle (standard for neuroma management), Group III- nerve stump protected by ESJ. The ESJ was created from the resected 20mm segment of sciatic nerve by removal of the fascicles and ligation of its distal end. Next, the ESJ was applied over the proximal sciatic nerve stump as a cap. The presence of neuropathic pain was assessed weekly up to 24 weeks post-surgery by autotomy, pinprick test and Tinel sign. At 24 weeks end-point, macroscopic evaluation, histomorphometry and neural/connective tissue ratio (N/C) were assessed. Retrograde labeling (RNL) of sensory neurons was used to evaluate Dorsal Root Ganglions (DRGs) viability.

**Results:**
ESJ application significantly reduced neuroma formation, which was associated with decreased autotomy (16.7%, p<0.05) and Tinel sign (16.7%, p<0.05) compared to the nerve stump control. Moreover, ESJ reduced axonal sprouting, bulb–shape nerve ending formation and perineural adhesions as confirmed by macroscopic evaluation. Histological staining showed that nerve stumps protected by ESJ were less fibrotic and presented well-organized axonal architecture and lower number of inflammatory cells. N/C ratio and RNL analysis revealed significantly better results in the ESJ group compared to the stump group (p=0.032 and p=0.042, respectively).

**Conclusion:**
The protective effect of ESJ against neuroma formation was confirmed by behavioral and histological analysis showing outcomes comparable to the muscle burying – the standard for neuroma management. ESJ inhibits neuroma development by creating a physical barrier for nerve fascicle outgrowth and limits inflammation, fibrosis and scar tissue formation around the nerve stump. The surgical technique for ESJ creation is straightforward and can be easily transferred to the clinic by applying the same principles of ESJ creation from human cadaver donor nerves. ESJ may become an off-the-shelf product, readily available for both the civilian and military patients.
Purpose
Evaluate the tensile strength of conduit-assisted primary digital nerve repairs with varying suture number and location with and without fibrin glue.

Methods
Ninety cadaveric digital nerves were harvested and divided equally into the following repair groups: A (4/4), B (2/2), C (0/2), D (0/1), E (0/0) with the first number referring to the number of sutures at the coaptation and the second number referring to the number at each proximal and distal end of the nerve-conduit junction. Fibrin glue (Tisseel, Baxter, Deerfield, IL) was added to half of each group. The nerve specimens were transected and then repaired with 8-0 nylon suture and conduit (AxoGuard Nerve Protector, Axogen, Alchua, FL). The tensile strength of the repairs was tested at a rate of 0.33 mm/s and maximum failure load was determined. The results were analyzed with a two-way and one-way ANOVA (Minitab 17, Minitab Inc., State College, PA). Tukey’s Post Hoc Test with a 95% confidence interval compared repair groups if the two-way ANOVA showed a significant difference between the groups.

Results
Both suture group and glue presence significantly affected the maximum failure load. Increasing the number of sutures increased the maximum failure load and the presence of fibrin glue also increased the failure load. Groups B’ and B were not statistically different from Group A, the second strongest repair, but contains half the suture (6 vs 12).

Conclusion
This is the first study to demonstrate that fibrin glue is of any benefit to increase the tensile strength of conduit-assisted primary digital nerve repair. Also, strength of the repairs can be maintained despite less suture, which may be most important at the primary coaptation to improve nerve regeneration.
Introduction:
Traumatic transections of peripheral nerves are associated with poor nerve regeneration. The use of nerve grafts with stem cells provides an alternative to autograft for nerve repair. The purpose of this study was to track the fate of amniotic fluid derived stem (AFS) cells that are seeded into nerve allografts and to elucidate the mechanism of their impact on the regenerating nerve.

Methods:
AFS cells were labeled using supraparamagnetic micron sized iron oxide (MPIO) coated with fluorescent dye. Labeled cells were plated and viability was assessed. Next, cells were cultured in neurogenic induction media; the conditioned media was collected to evaluate the neurogenic growth factors. Differentiated cells were confirmed with real-time PCR for neurogenic lineage markers. Viable MPIO labeled AFS cells were injected into an acellular nerve allograft (ANA) used to repair a 1.5 cm sciatic nerve defect in 10 rats. Labeled AFS cells were evaluated by MRI at 1, 2, and 4 weeks post-surgery. Intensity of the MPIO regions was quantified using ImageJ. Contiguous frozen sections were stained for iron to identify the labeled AFS cells incorporated into the nerve graft. Co-localization of transplanted cells was confirmed using human specific nuclear antibody (Anti-NuMA).

Results:
Labeled AFS cells were viable in vitro(Figure 1). Proliferation rate and morphology between the control and labeled cells demonstrated no significant differences (p=0.58). Cells differentiated towards Schwann-like cells after being cultured in neurogenic induction media. NGF and NEFL gene expression were elevated by fold change of 202.60±1.89 and 30.62±1.99, respectively (p<0.005) compared to control. Cytokine quantification analysis of AFS cells showed significantly increased BDNF, β-NGF, β-FGF, GDNF, NGF R, NT-4 and TGF-β production. (Fold change compared to undifferentiated control: 10.25±1.96, 383.06±12.93, 3.95±1.06, 5.78±1.33, 46.84±3.67, 2.69±0.77, 25.39±3.74, p<0.001 respectively). 7T MRI demonstrated MPIO labeling with a strong decrease in signal, appearing as fuzzy dark spots in T2-weighted images at 4 weeks post-surgery. There was no significant difference in average normalized hypointense region volume between 2 and 4 weeks post-injury (0.47±0.06 and 0.52 ± 0.12, respectively, Figure 2). Cell integration was confirmed by iron and Anti-NuMA staining.

Conclusions:
AFS cells remained viable after labeling and can be used to augment nerve repair by seeding onto ANAs. Cytokine analysis suggests a paracrine-mediated effect on nerve repair. MRI can effectively track the AFS cells longitudinally in the rat model, demonstrating the potential to monitor AFS cell delivery strategies for nerve regeneration.
Comparison Between Two Collagen Nerve Conduits and Nerve Autograft for Motor Nerve Regeneration in a Rat Model
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Introduction:
Current synthetic conduits fail to provide equivalent motor recovery compared to autologous nerve repairs of peripheral nerve injuries. Autograft repairs are additionally associated with donor site morbidity and are limited by tissue availability. A synthetic conduit that enables equivalent motor recovery would thus provide an ideal graft alternative. A novel polyglycolic acid conduit (Nerbridge, Toyobo Co., Ltd., Osaka, Japan), uniquely contains collagen fibers within the tube to provide support and guidance for regenerating peripheral nerves through the transected site. We hypothesized that this collagen-filled conduit would generate motor recovery equivalent to that of autograft, and superior to a hollow collagen conduit (NeuraGen nerve guide, Integra, Plainsboro, NJ) as a result of its internal scaffold.

Methods:
72 Lewis rats were randomized into 3 experimental groups, in which a unilateral 10-mm sciatic defect was repaired using nerve autograft, collagen-filled conduit, or hollow collagen conduit. Outcomes were measured at twelve and sixteen weeks postoperatively, and included bilateral tibialis anterior muscle weight, voltage and force maximal contractility, assessment of ankle contracture, and nerve histology. Results were expressed as a percentage of recovery from the contralateral side. Kruskal-Wallis analysis was utilized with an alpha level of p < 0.05 to determine significance, and post-hoc Bonferroni correction was used for multiple comparisons.

Results:
At twelve weeks, mean muscle force compared to that of the contralateral control side was 50% ±21 for autograft, 9% ±6 for the collagen filled conduit, and 32% ±21 for the hollow collagen conduit. After sixteen weeks, the mean muscle force was 72.4% ±22.5 for autograft, 58.0% ±19.3 for collagen-filled conduit, and 61.1% ±24.8 for collagen hollow conduit. Autograft was statistically superior to both conduits for all outcomes except histology (Fig 1). The conduits demonstrated equivalence to each other across outcomes. Although all three groups experienced improved outcomes from twelve to sixteen weeks, the collagen filled conduit demonstrated the greatest rate of recovery in axonal density over this period.

Conclusion:
Autograft repair provided superior motor recovery than the use of two distinct collagen conduits for a 10-mm nerve gap in a rat model. Nevertheless, the collagen filled conduit demonstrated encouraging improvement in muscle force and axon density between 3 and 4 months postoperatively, highlighting its utility in spanning nerve gaps, particularly when autograft is unavailable.

Fig 1. Transverse sections of rat tibial nerve (100 microns): autograft group (A), collagen-filled conduit group (B), and hollow collagen conduit group (C) at 12 weeks. Autograft group (D), collagen-filled conduit group (E), and hollow collagen conduit group (F) at 16 weeks.
100 Study of Nerve Regeneration in Peripheral Nerve of Spontaneously Hypertensive Rats (SHR) Using Nerve Graft Covered with Vein Tube and Enriched with Platelet Rich Fibrin (PRF)

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Universidade Federal de São Paulo, São Paulo, Brazil

Introduction:
The treatment of peripheral nerve injuries has quite varied results. The search for new treatment methods allowed the knowledge of Platelet Rich Fibrin (PRF) and vein tubes, which release growth factors with potential for tissue regeneration. This study aims to determine if the addition of an adjuvant (vein tube with or without PRF) improve nerve regeneration rate, measured by functional score and histomorphometric analysis.

Methods:
We used SHR rats divided into 4 groups: nerve graft covered with vein (NGCV) (n = 10); nerve graft covered with vein filled with PRF (NGCVP) (n = 10); nerve graft (NG) (n = 10) and the SHAM control group (n = 10). The repair results of sciatic nerve damage through nerve grafts, nerve grafts enriched vein tubes with or without PFR obtained from centrifugation of blood were evaluated by sciatic functional index (SFI) at 0, 30, 60 and 90 days, morphological and morphometric analysis of nerve distal to the lesion, and quantitative histological analysis of neurons labeled by the dye-Fluoro Gold® the anterior horn of the spinal cord.

Results:
The graft groups covered with vein (NGCV) and graft covered with vein filled with PRF (NGCVP) had lower SFI values than the control group (SHAM) throughout the study period. The NGCV group showed improvement in the sciatic functional index at day 90, a statistically significant when compared to the nerve graft group (NG). The diameter of the fiber and the axon of NGCV and NGCVP groups were similar to each other, and were lower statistically significant, the SHAM and NG groups.

Conclusion:
All experimental groups obtained parameters decreased in relation to statistically significant SHAM. Functional improvement of the sciatic functional index at day 90, in NGCV group compared to NG, can be explained due to factors released by vein or vein itself as a conduit to reorient axonal. Further studies are needed to evaluate the role of adjuncts to nerve graft in repair of peripheral nerve injuries.
101. Anatomic and Histologic Evaluation of Brachialis to Anterior Interosseous Nerve Transfer
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Hospital for Special Surgery, New York, NY

Introduction: Brachialis to anterior interosseous nerve (AIN) transfer offers patients improved hand function with the ability to pinch. The AIN fascicle has previously been described topographically within the postero-medial region of the median nerve. We present a new description of the AIN fascicle based on anatomic terms seen intra-operatively to improve fascicular identification. We hypothesize that this nerve transfer can be performed with reliable anatomy, tension free neurorrhaphy, and appropriate donor-to-recipient axon count ratio.

Methods: Six cadaveric specimens were dissected. The median and musculocutaneous nerves were identified in the mid upper arm. The epineurium overlying the median nerve was incised to expose three fascicles (Figure 1). The fascicle location was described in anatomic terms seen intra-operatively with the arm in the abducted position (ventral, dorsal, cranial, and caudal)(Figure 2). The dorso-caudal fascicle was marked. The AIN was then identified in the proximal forearm as it branched from the median nerve and dissected proximally to confirm that the initial prediction of the AIN fascicle was correct. The AIN branching pattern, length, and fascicle location were recorded. All distances were measured from the medial epicondyle (ME). Brachialis branching pattern and length were also measured from the ME. The brachialis nerve was transferred to the AIN and overlap was measured. Each nerve was then sectioned and sent to histology lab for axon counts.

Results: The AIN fascicle was correctly predicted in all six specimens and was identified in the dorso-caudal portion of the median nerve. The AIN exited the median nerve 6.9 cm (SD 1.04) distal to the ME. Total neurolysable distance of the AIN was 13.9 cm (SD 1.46) proximal to the ME. The brachialis nerve branched from the musculocutaneous nerve 14.7 cm (SD 1.15) proximal to the ME. Length of brachialis nerve prior to branching was 5.2 cm (SD 1.15). Total neurolysable distance of the brachialis was 5.1 cm (SD 1.31). All nerve anastomoses overlapped by average of 1.8 cm (SD 0.49). AIN axon counts averaged 2661.2 while brachialis axon counts averaged 1452.5 (donor-to-recipient ratio 1:1.8).

Conclusions: Identifying the AIN fascicle in the median nerve is predictable based on topographic mappings of the median nerve. Describing the AIN fascicle as dorso-caudal, instead of previously described postero-medial, helps identify AIN fascicle with arm in abducted surgical position. Brachialis to AIN transfer is a tension free transfer with appropriate axon count ratio.
102. Bionic Hand Reconstruction Successfully Reduces Deafferentation Pain in Patients with Brachial Plexus Avulsion Injuries
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Introduction: Root avulsions of the brachial plexus represent one of the most severe nerve injuries. Next to apparent sensorimotor deficits, the avulsion injury often leads to unbearable pain in the arm and hand, frequently referred to as deafferentation pain. In avulsion injuries of the inferior trunk the burden of pain is most intense and hand function that can be expected by reconstructive surgery (intra-/extraplexual nerve transfers) is less than poor. Here, we report of seven patients with global brachial plexopathies with multiple root avulsions, who have approached our specialist center of extremity reconstruction in the years of 2011 to 2016. The impact of bionic hand reconstruction on hand function, deafferentation pain and quality of life is presented.

Materials & Methods: In all seven patients selective nerve transfers (and muscle transfers in selected cases) were performed but in some did not avail sufficient hand function. However, thereby generated electromyographic signals could be used for the control of a prosthetic device. After intense rehabilitative training and consequent intuitive signal control, the functionless hand was electively amputated and replaced by a prosthetic hand, a procedure now defined as Ôbionic reconstructionÔ. Pain was assessed with the Visual Analogue Scale (VAS). Additionally pre-and post-interventional pain medication was documented and quality of life as well as general health were assessed on a regular basis (Health Survey SF-36). Patients were evaluated pre-interventionally, during the rehabilitative process and after amputation as well as after final prosthetic fitting.

Results: Bionic hand reconstruction led to significant pain reduction compared against pre-interventional pain conditions. Pain medication intake could be reduced in all patients after the prosthetic hand had been incorporated into the userÔs activities of daily living. Quality of life, subjectively perceived health state, and psychological role functioning also improved significantly.

Conclusion: The functional and cognitive re-integration of the extremity into the patientÔs body image led to major pain relief as well as markedly improved quality of life in all so far treated patients. In some patients even a re-entry into working life was permitted by the functional gain of the prosthetic hand, which also came along with social and economic benefits.
103. Use of Processed Nerve Allografts to Repair Nerve Gap Injuries Greater than 25mm in the Hand
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Introduction: Recent research has shown that processed nerve allografts (PNA) have improved clinical results compared to hollow conduits for reconstruction of digital nerve gaps less than 25 mm. However, the utility of PNAs as a nerve autograft alternative in injuries involving longer gaps warrants further clinical investigation. Long nerve gaps have been traditionally hard to study due to low incidence. We queried a large national registry to examine the efficacy of PNA in the reconstruction of long gaps.

Materials & Methods: The RANGER registry is an IRB approved, active database for PNA (Avance® Nerve Graft, AxoGen, Inc). The database was queried for digital nerve repairs ≥ 25 mm. Demographics, injury, treatment, and functional outcomes were recorded on standardized forms. Patients younger than 18, and those lacking quantitative follow-up data were excluded. Recovery was graded according to the Medical Research Council Classification (MRCC) for sensory function, with meaningful recovery defined as ≥ S3. Outcomes were compared to historical data for nerve autograft reconstructions.

Results: Fifty digital nerve injuries in 28 subjects were included. There were 22 males and 6 females, and the mean age was 45. Three patients gave a prior history of diabetes, and there were six active smokers. The most commonly reported mechanisms of injury were saw injuries (n=13), crushing injuries (n=9), resection of neuroma (n=9), amputation/avulsions (n=8), sharp lacerations (n=7), and blast/gunshots (n=4). The average gap length was 35 ± 8 mm (range 25-50 mm). Recovery to the S3 or greater level was reported in 86% of repairs. Static two point discrimination (s2PD) and Semmes-Weinstein monofilament (SMF) were the most common completed assessments. Mean s2PD in 24 repairs reporting 2PD data was 9 ± 4 mm. For the 38 repairs with SWF data, protective sensation was reported in 33 repairs, deep pressure in 2, and no recovery in 3. These data compared favorably to historical data for nerve autograft repairs, with reported levels of meaningful recovery of 60-88%. There were no reported adverse effects.

Conclusions: Processed nerve allograft can be used to reconstruct long gap nerve defects in the hand with consistently high rates of meaningful recovery. Results for PNA repairs of digital nerve injuries with gaps longer than 25 mm compare favorably to historical reports for nerve autograft repair, but without donor site morbidity.
104. Anterior Subcutaneous Transposition for persistent Ulnar Neuropathy after Neurolysis
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Introduction: The standard for surgical treatment of ulnar neuropathy at the elbow is neurolysis. Success rates of this procedure vary between 75 and 90%. Little is known about optimal treatment if neurolysis fails. Anterior subcutaneous transposition is than one of the treatment options.

Materials & Methods: A consecutive series of 26 patients treated by a single surgeon between 2009-2014 was retrospectively analysed. All patients had anterior subcutaneous transposition to treat persistent ulnaropathy after neurolysis. Pre- and postoperative differences in three clinical modalities were compared: pain and tingling, weakness and numbness. A 6-point satisfaction score was obtained using a telephonic systematic survey.

Results: At presentation, 88% of patients experienced pain and tingling, 46% had weakness and 50% had numbness of the forth and fifth finger. The mean age was 55 years (range 28-79). The mean duration of complaints until transposition was 32 months (range 4-49) with a mean interval of 12 months between the two surgeries. After transposition, pain and tingling improved in 35%, motor function in 23% and sensory disturbances in 19% of all patients. Improvement in at least one of the three clinical modalities was found in 58% of patients of which two symptoms improved in 15%. However, a deterioration in one of the three modalities was noted in 46% of patients. Improvement in at least one of the modalities was noted in 46% of patients. On the patient satisfaction scale, 61% reported good or excellent outcome. Patient satisfaction was correlated with pain (Pearson correlation coefficient 0.62), more than weakness (0.40) or numbness (0.22). Patients with good/excellent outcome were on average 10.3 years younger than patients with a poor outcome. No other factors were significantly related to satisfaction score.

Conclusions: Symptoms that persist after neurolysis employed to treat sulcus ulnaropathy are difficult to treat. Subcutaneous transposition is a viable surgical option. The majority of patient is satisfied after this second surgery, however, only part of the initial symptoms resolve. In some patients, symptoms even deteriorate. The reason why some patients do not fair well remains unknown. The total outcome of treatment of all patients that present with ulnar neuropathy can still be improved. Patient selection, timing of intervention and choice of surgical technique need to be considered.
Introduction: Hand sensibility is extremely important but most difficult to achieve in upper extremity reconstruction. Loss of median nerve (MN) distribution sensation disables hand function after upper brachial plexus injury and failed MN repair. Motor fascicular and/or tendon transfers are commonly used strategies for motor restoration. However, options for sensory reconstruction are limited. The common digital nerve (CDN) to ring and small of the ulnar nerve may be used for first web space sensory restoration, but it further sacrifices ring and small finger sensation. The current study describes anatomical considerations and feasibility of transferring the dorsal cutaneous branch of ulnar nerve (DCBUN) to the MN for sensory restoration. We hypothesize the DCBUN is a feasible donor nerve and provides more than one branch for transfer without sacrificing existing volar sensation.

Methods & Methods: Seven fresh cadaveric upper limb specimens were used for this study. The DCBUN was identified proximally and dissected distally identifying and preserving all branches. The MN was dissected within the carpal tunnel; CDNs were identified. The DCBUN was isolated from the ulnar nerve proximally. Nerve transfer was performed after transecting the branches of the DCBUN distally. The DCBUN was transferred volar for coaptation with the MN CDNs. The branching point, length, isolation point, and transfer length were measured utilizing the wrist crease as a reference point. Samples of each branch from the MN and DCBUN were analyzed histologically.

Results: The DCBUN had 2-4 branches. The longest branch consistently innervated the dorsal 4th web space (7.6 ± 0.82 cm). The 2nd, 3rd, and 4th longest had lengths of 4.7 ± 2.01, 3.8 ± 3.89, and 2.7 ± 1.19 cm, respectively. After transfer to the palm, the DCBUN branch lengths were 7.9 ± 0.90, 6.2 ± 1.33, 5.1 ± 3.71, and 2.4 ± 1.28 cm distal to the wrist crease, respectively. The DCBUN could be isolated from the ulnar nerve proper 10.5 ± 2.7 cm and 17.8 ± 5.45 cm proximal to the wrist crease before and after internal neurolysis, respectively. On histology, the MN CDNs and DCBUN branches had mean nerve surface areas of 1.44 ± 1.14 and 0.40 ± 0.34 mm², respectively, and mean axon counts of 10.4 ± 4.57 and 4.05 ± 2.48, respectively.

Conclusion: The DCBUN reliably provides 2 or more branches suitable for transfer to the MN CDNs. It has the potential to reconstruct all 3 CDNs of the MN without sacrificing function of the 4th CDN.
106. Does Partial Muscle Reinnervation Preserve Future Reinnervation Potential?
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**Introduction:** Inadequate recovery following nerve injury or repair offers a difficult treatment dilemma. Partial innervation may have a “baby sitting” or muscle preservation effect. Alternatively, partial reinnervation may only protect a limited percentage of muscle fibers and once a critical time period has passed, revision nerve repair may not improve final motor recovery. Therefore, our purpose was to evaluate final muscle recovery following partial denervation and with and without delayed repair.

**Materials & Methods:** Sixty (three months old) Sprague-Dawley rats underwent the following tibial nerve manipulations (n=15/group): Group A (partial denervation of tibial nerve - 2/3rds of nerve resected and remaining 1/3rd crushed; revision repair after 8 months with 1cm autograft, and testing at 11 months), Group B (partial denervation and testing at 11 months), Group C (full denervation and immediate reconstruction with 1cm autograft followed by testing at 11 months), Group D (full denervation, delayed reconstruction with 1cm autograft at 8 months, and testing at 11 months). Final testing included functional and morphological assessment.

**Results:** Muscle weight was significantly (p < 0.01) different between all groups (from highest to lowest: B> C> A> D), with the delayed reconstruction groups (A and D) having the lowest weights. Group A and Group D also had significantly smaller muscle areas than Groups B and C (p < 0.05). Group A and Group D were not significantly different in muscle area when compared to each other. Developed muscle force were not different between groups (p > 0.05).

**Conclusions:** Partial reinnervation with subsequent delayed reconstruction did not preserve muscle over a long period of denervation compared to partial denervation without repair or full denervation with immediate repair. However, partial reinnervation over a prolonged period in a rat model did result in increased muscle size when compared to delayed repair without partial reinnervation.
AAHS 1 Simple Assessment of Global Bone Density and Osteoporosis Screening Utilizing Standard Radiographs of the Hand
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Background:
Osteoporosis and resultant fragility fractures have vast consequences at both the individual level and to the overall health care system. Screening rates remain low, and our current system tends to be more reactive than preventative. While dual-energy x-ray absorptiometry (DXA) is the gold standard for assessing bone mineral density (BMD), other simpler tools may be able to provisionally screen bone quality and signal the need for intervention. We hypothesized that the second metacarpal cortical percentage (2MCP) that is calculated from standard radiographs of the hand or wrist would correlate with hip BMD derived from DXA, and could provide a novel simple screening tool for osteoporosis.

Methods:
200 consecutive patients who had hand or wrist radiographs and hip DXA scans within one year of another were included in this retrospective diagnostic series. Mid-diaphyseal 2MCP was calculated as a ratio of the cortical diameter to the total diameter (Figure 1). The correlation between 2MCP and total hip BMD was assessed. Subjects were stratified into normal, osteopenic, and osteoporotic cohorts based on hip t-scores, and thresholds were identified to optimize screening sensitivity and specificity.

Results:
Second metacarpal cortical percentage (2MCP) correlated significantly with BMD and t-scores from the hip (Figure 2, \( r^2 = 0.44, P<0.001 \)). A 2MCP threshold of < 60% optimized sensitivity (88%) and specificity (60%) for discerning osteopenic subjects from normal subjects, whereas a threshold of < 50% optimized sensitivity (100%) and specificity (91%) for differentiating osteoporotic from normal subjects.
Conclusions:
By demonstrating that global BMD may be assessed from 2MCP, our data suggests that radiographs of the hand and wrist can play a roll in accurately screening for osteopenia and osteoporosis. This simple screening tool that is already ubiquitously utilized for patients with hand or wrist problems may help identify patients at risk for fragility fractures. This would thereby prompt additional studies, appropriate referral, or initiation of treatment. Routine use could be valuable for decreasing morbidity on an individual level and improving financial efficiency on a systems level.
AAHS 2 Are Opioids Necessary to Manage Post-Operative Pain after Carpal Tunnel Release? A Prospective Cohort Evaluation
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INTRODUCTION:
Managing postoperative pain in hand surgery is important for both patients and surgeons. However, there is growing concern over prescription opioid abuse. We hypothesized (1) that pain medications after carpal tunnel release (CTR) surgery are over-prescribed and (2) that opioids are unnecessary in the majority of patients.

METHODS:
We prospectively studied two demographically similar patient cohorts receiving either opioid or tramadol for CTR performed by two hand surgery fellowship-trained orthopaedic surgeons over a 1 year period. The first cohort of patients undergoing CTR received opioids pills postoperatively. The second cohort of patients received a standard prescription of 10 tramadol pills postoperatively. Student t-tests were performed to evaluate statistically significant differences between the tramadol and opioid cohorts in total pill consumption and number of postoperative days the medication was used.

RESULTS:
The opioid cohort consisted of 159 patients with a mean opioid consumption of 4.9 pills for 2.3 days. Eleven of these patients declined the use of opioids postoperatively and instead substituted for NSAIDs and/or acetaminophen. The tramadol cohort consisted of 110 patients with a mean tramadol consumption of 3.3 pills for 1.8 days. Seven of these patients requested opioids postoperatively, and 14 substituted for NSAIDs and/or acetaminophen. When comparing the postoperative consumption of opioids and tramadol for CTR, there was a statistically significant difference in total pill consumption based on both intention to treat as well as the medication ultimately prescribed. There was no difference in the duration of postoperative utilization.

CONCLUSION:
Following CTR, pain medications are being over-prescribed, with patients receiving more than double the amount of pills than they consume. Tramadol appears to be equally effective in managing post-operative pain compared to opioids. Based on our findings, we recommend prescribing less than 10 pills of either tramadol or an opioid to manage post-operative pain after primary CTR.
ASPN 1 The DNND (Diabetic Neuropathy Nerve Decompression) Study: A Controlled Randomized Double Blinded Prospective Study on The Effect Lower Extremity Nerve Decompression on Pain and Quality of Life in Patients with Painful Diabetic Neuropathy

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Purpose:
An estimated fifty-percent of 74.8 million pre-and diabetic patients in the USA suffer from Painful Diabetic Neuropathy (PDN), of which approximately one-third are prone to nerve compression. Previous studies suggest surgical decompression alleviates pain, however the American Neurological Association considers available evidence level U (Unproven). We present a seven-year NIH and institutionally funded, prospective, controlled, randomized double-blinded study to determine the long-term effect of nerve decompression in patients with PDN on pain and quality of life.

Methods:
A multidisciplinary neurology, endocrinology, PM&R, pain, and surgery group performed baseline pain examinations (Likert 0-10, Neuropathy-scores) and SF-36 quality of life exams. Patients were randomized into surgical and non-surgical-control groups (2:1 ratio, respectively). Surgical patients underwent surgery bilaterally with each side randomized to nerve decompression or sham surgery. Patient and final evaluators were blinded to side. Quarterly, final one-year, and four-year evaluations were performed. A 2 way repeated measures ANOVA statistical analysis on pain was performed on all groups at one year and 54.5 month follow-up.

Results:
Of 2987-screened patients, 138 enrolled: 92 randomized to surgery and 46 as controls. 40 surgical and 27 controls completed the study. At one year the surgical group experienced a mean pain reduction of 5.70 in the surgical leg (SD=2.54;p<0.0001) and 5.25 (SD=2.79;p<0.0001) in the sham leg while the control group had no statistically significant reduction of pain. A 54.5-month follow-up of 36 surgical patients revealed a mean pain reduction of 7.47 in the surgical leg (SD=2.09;p<0.0001) and 5.97 (SD=2.43;p<0.0001) in the sham leg, while the control group revealed no reduction in pain. The SF-36 General Health component score revealed a significant interaction for group by time, p=.0010; while group means at baseline, 3mo, and 6months (p=0.53, 0.24, and 0.10, respectively) were not significantly different, means at 9 months and 1 year were significant (p=0.01 and 0.02, respectively).

Conclusion:
Surgical decompression in patients with PDN unequivocally reduces bilateral pain with statistical significance at one year and continued bilateral improvement at four years, yet demonstrates more statistically significant pain reduction in the decompressed side at four years. In addition, quality of life is significantly improved at 1-year follow up.
ASPN 2 Macaques Implanted with Regenerative Peripheral Nerve Interfaces (RPNIs) Control Prosthesis Finger Movements
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INTRODUCTION:
Regenerative Peripheral Nerve Interfaces (RPNIs) are promising for interfacing human intentions to myoelectric prostheses. Rat studies led to proof of RPNI long-term function and high signal to noise ratio with no adverse biological effects. However, true voluntary fine control of fingers and hand prostheses would be more convincing with macaque implanted RPNIs.

METHODS:
Two macaques had Regenerative Peripheral Nerve Interfaces (RPNIs) implanted (n=3/macaque) in the forearm. The RPNI consists of a free muscle graft implanted on the end of a transected nerve fascicle. Intramuscular EMG electrodes were implanted in each RPNI. Macaques were trained to perform index finger movements to acquire virtual targets on a computer screen. Finger position was recorded via a flex sensor on the index finger.

RESULTS:
At harvest RPNIs were well vascularized but smaller in size than when implanted (Fig 1). For the continuous EMG decode using 10-fold cross-validation, the resulting predicted finger position had a correlation coefficient $\rho=0.82$ between predicted and true finger positions. The EMG decode correctly classified 97.7% of movements (out of 261 total movements). RPNI muscle fibers were continuing to regenerate after implantation for 1 year (Fig 2).

CONCLUSIONS:
Macaques voluntarily controlled virtual finger movements with signals transferred through implanted RPNIs.