Meeting Abstracts
Financial Disclosure and FDA Status

Symbol Key

● Something of Value — The authors of those presentations preceded by a ● have indicated that they have received something of value in the form of: research or institutional support, stock or stock options, equipment or services, paid travel, royalties or as a consultant or employee of a commercial company or institution related directly or indirectly to the subject of the presentation.

◆ Nothing of Value — The authors of those presentations preceded by a ◆ have indicated that they have not received anything of value in the form of: research or institutional support, stock or stock options, equipment or services, paid travel, royalties or as a consultant or employee of a commercial company or institution related directly or indirectly to the subject of the presentation.

▲ Documentation of FDA Status — The authors of those presentations preceded by a ▲ have indicated that the FDA has not cleared the listed pharmaceuticals and/or medical devices for the use described in this presentation or that the listed pharmaceuticals and/or medical devices are being discussed for an off-label use.

* AFSH Grant Research Acknowledgement — The authors of those presentations preceded by a * have indicated that research related to their presentation was supported by an AFSH Research Grant.

The ASSH does not view the existence of these interests or commitments as necessarily implying bias or decreasing the value of the presentations.

Disclaimer

The material presented in this continuing medical education program is being made available by the American Society for Surgery of the Hand for educational purposes only. This material is not intended to represent the only, or necessarily the best methods or procedures appropriate for the medical situation discussed, but rather is intended to present an approach, view, statement, or opinion of the authors or presenters, which may be helpful or of interest to other practitioners. The attendees agree to participate in this medical education program sponsored by ASSH with full knowledge and awareness that they waive any claim they may have against ASSH for reliance on any information presented in this educational program. In addition, the attendees also waive any claim they have against ASSH for any injury or other damage, which may result in any way from their participation in the program. All of the proceedings of this ASSH meeting, including the presentation of scientific papers, are intended for limited publication only, and all property rights in the material presented, including common law copyright, are expressly reserved to the speaker and ASSH. No statement of presentation made is to be regarded as dedicated to the public domain. Any sound reproduction, transcript or other use of the material presented at this course without the permission of the speaker or ASSH is prohibited to the full extent of common law copyright in such material. The approval of U.S. Food and Drug Administration is required for procedures and drugs that are considered experimental. Instrumentation systems discussed and/or demonstrated in ASSH educational programs may not yet have received FDA approval.

The ASSH assumes no responsibility or liability for the use or misuse of any information, materials or techniques described in the following abstracts and it makes no warranty, guarantee or representation as to the absolute validity or sufficiency of any information provided.
**Effect of Delayed Finger Extension on the Efficacy and Safety of Collagenase Clostridium Histolyticum Treatment for Dupuytren Contracture**

**Level 2 Evidence**

- **Hypothesis:** Treatment of Dupuytren’s contracture with collagenase clostridium histolyticum (CCH) involves a single injection of CCH into the cord of the affected joint, followed by a finger extension procedure. The current labeling for CCH indicates that the finger extension procedure should be performed 24 hours after injection. In practice the timing of the procedure may vary since physicians may not have clinic hours on sequential days. The effect of varying time to finger extension was evaluated as part of a study of patients who received two concurrent injections of CCH to concurrently treat two affected joints of the same hand.

- **Methods:** Patients with ≥2 contractures in the same hand caused by palpable cords participated in a 60-day, multicenter, open-label phase 3b study. Patients received two CCH doses (each 0.58 mg) injected into one or two cords in the same hand during the same visit. Finger extension was performed 24, 48, or 72 hours later. Changes in fixed flexion contracture (FFC) and range of motion (ROM), rates of clinical success (FFC = 72 hours).

- **Results:** The study enrolled 715 patients and 725 joint pairs were treated; 477 (64%) had ≥2 contractures in the same hand. Among these pairs, 268 (37%) had finger extension at 24 hours, 299 (41%) at 48 hours, and 158 (22%) at ≥72 hours. A total of 714 patients and 724 joint pairs were analyzed for efficacy. Improvement in FFC and ROM at 30 days post-CCH injection and clinical success rates were similar regardless of time to finger extension (Table 1). A similar percentage of subjects experienced ≥1 treatment-related AE regardless of time to finger extension (Table 2); the majority of AEs began on the day of injection or finger extension. Most AEs were mild to moderate and resolved without intervention.

- **Summary Points:**
  - Concurrent injections of CCH to treat two Dupuytren’s contractures on the same hand were effective in reducing contracture and increasing ROM; the safety profile was consistent with what has been reported in previous studies.
  - The timing of the finger extension procedure did not affect clinical response in terms of efficacy or safety, although numerically, the rate of lacerations appeared lower when finger extension was performed at 72 hours rather than at 24 or 48 hours.

  - The ability to vary the time between CCH injection and the finger extension procedure may allow for greater flexibility for both physicians and patients.

- **Results Table:**

```
<table>
<thead>
<tr>
<th>AE, %</th>
<th>Finger Extension at 24 hours</th>
<th>Finger Extension at 48 hours</th>
<th>Finger Extension at 72 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE, %</td>
<td>Finger Extension at 24 hours</td>
<td>Finger Extension at 48 hours</td>
<td>Finger Extension at 72 hours</td>
</tr>
<tr>
<td>Baseline</td>
<td>96.9 (n=117)</td>
<td>97.9 (n=112)</td>
<td>98.4 (n=107)</td>
</tr>
<tr>
<td>Day 3</td>
<td>70.3 (n=110)</td>
<td>70.6 (n=106)</td>
<td>69.6 (n=101)</td>
</tr>
<tr>
<td>Change, %</td>
<td>69.9 (n=117)</td>
<td>71.2 (n=112)</td>
<td>70.8 (n=107)</td>
</tr>
<tr>
<td>% change, %</td>
<td>75.6 (n=112)</td>
<td>74.8 (n=109)</td>
<td>73.6 (n=104)</td>
</tr>
<tr>
<td>ROM, °</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>96.6 (n=117)</td>
<td>97.7 (n=112)</td>
<td>98.2 (n=107)</td>
</tr>
<tr>
<td>Day 3</td>
<td>70.3 (n=110)</td>
<td>70.6 (n=106)</td>
<td>69.6 (n=101)</td>
</tr>
<tr>
<td>Change, %</td>
<td>69.9 (n=117)</td>
<td>71.2 (n=112)</td>
<td>70.8 (n=107)</td>
</tr>
<tr>
<td>% change, %</td>
<td>75.6 (n=112)</td>
<td>74.8 (n=109)</td>
<td>73.6 (n=104)</td>
</tr>
</tbody>
</table>
```

- **This presentation will discuss Concurrent injections of CCH**
  - Royalties/Honoraria received from: Biomet (Pess)
  - Speakers Bureau with: Auxilium (Pess, Tien)
  - Contracted Research: Auxilium (Pess, Gelb, Tien)
  - Fees for Non-CME Services Received Directly from a Commercial Interest or its Agent: Auxilium (Tien)
  - Salary: Auxilium (Tursi, Kaufman, Smith)
Results:

Biochemical assays for RhoA GTPase activity are as described (3). Acti-
collagen I; and 
vested for RT-PCR analysis of tenocyte markers tenomodulin, scleraxis,
staining of collagen I, collagen II and aggrecan. Tenocytes were also har-
collagen I. Tenocytes harvested from tendon that has adhered to sur-
ence, the tenocyte dedifferentiation state.

Summary Points:

- Vascular bypass in conjunction with sympathectomy may be superior to
 sympathectomy alone in digital ischemia caused by collateral vascular
disease
- Suitability for vascular bypass should be determined intraoperatively by
 clinical assessment rather than by preoperative angiographic findings.
- If either the radial or ulnar artery is atretic or thrombosed, bypass should
 be attempted.

- Royalties/Honoraria received from: Orthohelix Surgical Designs (Leversedge)
- Consulting Fee: Stryker Orthopaedics, Axogen (Leversedge)
- Contracted Research: Axogen, Bioventus (Leversedge)

PAPER 03

Best Papers
Thursday, September 18, 2014 • 2:29–2:34 PM
Category: Treatment, Prognosis/Outcomes, Basic Science
Keyword: Hand and Wrist, Diseases and Disorders, General Principles

Human Tenocyte Differentiation Drives Adhesion Formation
N/A - Not a clinical study

♦ Rowena McBeech, MD, PhD
♦ A. Lee Osterman, MD

Hypothesis: The molecular and cellular signalling events responsible for human tendon adhesion formation are unclear. Prior in vitro studies of human tenocytes have demonstrated tenocyte ‘dedifferentiation’ (1), as seen by change in shape (from elongated to round) and extracellular matrix production with growth in low-density culture. Correspondingly, we hypothesized that adhesion formation post-tendon injury and repair represents, in actuality, the tenocyte dedifferentiated state.

Methods: Human tendon tissue was isolated from patients undergoing revision amputation from traumatic hand injury as well as those undergoing delayed tendon reconstruction using standard protocols (2). Tendon tissue and tenocytes underwent immunohistochemical and immunofluorescent staining of collagen I, collagen II and aggrecan. Tenocytes were also harvested for RT-PCR analysis of tenocyte markers tenomodulin, scleraxis, collagen I; and fibrochondrocyte markers collagen II and aggrecan. Biochemical assays for RhoA GT-Pase activity are as described (3). Activation of RhoA GT-Pase using adenosine transduction is as described (4).

Results: Normal human tenocytes are elongated and produce predominantly collagen I. Tenocytes harvested from tendon that has adhered to surrounding tissue (‘adherent tenocytes’) display increased stress fiber formation, and produce more aggrecan than normal tenocytes. When analyzed for biochemical activity, adherent tenocytes express higher active RhoA GT-Pase levels than their normal counterparts. Furthermore, activation of RhoA GT-Pase in normal human tenocytes reproduces the adherent tenocyte cellular and molecular phenotype, in the form of rounded cell shape and increased aggrecan production.

Summary Points:

- While ordinarily thought to be due to a balance of intrinsic and extrinsic forces, we hypothesize that tendon adhesion formation post-injury actually represents a novel tenocyte differentiation state.
- Adherent tenocytes have increased stress fiber formation, express higher levels of aggrecan, and display a rounded cell morphology in tissue.
- Biochemical analysis reveals high RhoA activity levels in the adherent tenocyte differentiated state.
- Activation of RhoA GT-Pase in normal human tenocytes reproduces the adherent tenocyte phenotype.

- These results suggest that tendon adhesion formation is due to changes in tenocyte differentiation, and suggest a molecular mechanism by which this occurs.
- Clinical implications of these results affect tendon repair, tendon healing, adhesion formation and tendon regeneration.

REFERENCES

4. Pattabiraman PP, Rao PV. Mechanistic basis of Rho GT-Pase-induced extracel-

PAPER 04

Best Papers
Thursday, September 18, 2014 • 2:34–2:39 PM
Category: Treatment, Prognosis/Outcomes, Anatomy
Keyword: Elbow and Forearm, Congenital and Pediatric Problems, Nerve

Recovery of Motor Nerve Injuries Associated With Displaced, Extension-Type Pediatric Supracondylar Humerus Fractures
Level 4 Evidence

♦ Bryce T. Gillespie, MD
♦ Benjamin J. Shore, MD, MPH
♦ Patricia E. Miller, MS
♦ Donald S. Bae, MD
♦ Peter M. Waters, MD

Hypothesis: Nerve injuries occur in approximately 13% of pediatric exten-
type supracondylar humerus fractures, but no large-scale studies have analyzed recovery of these nerve injuries (Ref 1). We hypothesized that the time to recovery for a motor nerve palsy associated with a supracondylar humerus fracture would vary by which nerve is injured, if more than one nerve is injured, and if immediate decompression of the affected nerve(s) occurred at the time of fracture fixation.

Methods: Two hundred and seventeen children with traumatic nerve injuries associated with displaced, extension-type pediatric supracondylar humerus fractures treated at a single institution between 1996 and 2012 were reviewed. Fractures were treated with closed or open reduction and percu-
taneous pinning. We distinctly identified those patients who had decom-
pression of the affected nerve(s) at the time of fracture fixation. Nerve injuries were excluded if: iatrogenic, paresis only without motor de-
associated with flexion-type or intra-articular distal humerus fractures. Multi-
variable general linear modeling using a lognormal transformation of time to recovery was used to compare recovery times across nerve injury types and to determine the effect of injury and treatment characteristics on recovery time.

Results: Subjects had a mean age of 6.4 years and 139 (65%) sustained an isolated median nerve injury (inclusive of anterior interosseous nerve-only injuries) (Tables 1 and 2). Sixty-three (24%) patients had concurrent vascular injuries ranging from weak pulse to brachial artery transaction.

Forty patients had immediate nerve decompression at the time of fracture fixation. Three patients required later surgical intervention for poor nerve recovery (two had median nerve neurolysis and one had tendon transfers for radial nerve palsy); none of these three had undergone nerve decompression at the time of fracture fixation.

172 patients had recovery of the nerve injury by final follow-up. Most (53%) recovered within 3 months from injury and the overall mean time to recovery was 2.8 months (SD 2.2).

Summary Points:

- If either the radial or ulnar artery is atretic or thrombosed, bypass should be attempted.

♦ Speaker has nothing of financial value to disclose
• A majority (73%) of nerve injuries associated with displaced, extension-type pediatric supracondylar humerus fractures heal within 6 months, with most (53%) recovering within 3 months. Awareness of differences in rate and timing of nerve recovery may facilitate patient counseling and surgical decision making.
• Isolated radial nerve injuries take 32% longer to heal than isolated median nerve injuries \((P=0.03)\).
• Patients with more than one nerve injured simultaneously (23 patients) take 49% longer to reach recovery than patients with single nerve injuries \((P=0.02)\).
• Nerve decompression at the time of fracture fixation had no effect on recovery time.

### Table 1: Patient and Injury Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N</th>
<th>Median (IQR)</th>
<th>CRPP</th>
<th>ORPP</th>
<th>CRPP</th>
<th>ORPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years; mean (± SD))</td>
<td>6.4 (2.2)</td>
<td>6.3 (2.3)</td>
<td>6.6 (2.1)</td>
<td>6.7 (2.1)</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Nerve Injury</td>
<td>139 (65%)</td>
<td>61 (12%)</td>
<td>78 (14%)</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (including 64 AIN-only)</td>
<td>139 (65%)</td>
<td>52 (24%)</td>
<td>87 (40%)</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulnar</td>
<td>3 (1%)</td>
<td>3 (1%)</td>
<td>3 (1%)</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than one nerve</td>
<td>23 (11%)</td>
<td>23 (11%)</td>
<td>23 (11%)</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concurrent Vascular Injury</td>
<td>63 (29%)</td>
<td>0 (0%)</td>
<td>63 (29%)</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Fracture Treatment</td>
<td>172 (79%)</td>
<td>172 (79%)</td>
<td>172 (79%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRPP</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORPP</td>
<td>40 (18%)</td>
<td>40 (18%)</td>
<td>40 (18%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate Surgical Nerve Decompression</td>
<td>3 (1%)</td>
<td>3 (1%)</td>
<td>3 (1%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Nerve-Related Surgery</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Nerve Recovery</td>
<td>172 (79%)</td>
<td>172 (79%)</td>
<td>172 (79%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 months</td>
<td>115 (53%)</td>
<td>61 (12%)</td>
<td>54 (24%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-6 months</td>
<td>43 (20%)</td>
<td>13 (6%)</td>
<td>30 (14%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 6 months</td>
<td>14 (7%)</td>
<td>8 (7%)</td>
<td>6 (6%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to recovery (months; median (IQR))</td>
<td>2.1 (1.2-3.5)</td>
<td>2.1 (1.2-3.5)</td>
<td>2.1 (1.2-3.5)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete Nerve Recovery at Final Follow-up</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>45 (21%)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nerve Injury</th>
<th>Median (IQR)</th>
<th>CRPP</th>
<th>ORPP</th>
<th>CRPP</th>
<th>ORPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years; mean (± SD))</td>
<td>6.3 (2.3)</td>
<td>6.6 (2.1)</td>
<td>6.7 (2.1)</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Concurrent Vascular Injury</td>
<td>59 (42%)</td>
<td>2 (2%)</td>
<td>1 (33%)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Initial Fracture Treatment</td>
<td>103 (74%)</td>
<td>48 (92%)</td>
<td>2 (67%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>CRPP</td>
<td>36 (26%)</td>
<td>4 (8%)</td>
<td>1 (33%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>ORPP</td>
<td>33 (24%)</td>
<td>3 (6%)</td>
<td>2 (67%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Immediate Surgical Nerve Decompression</td>
<td>2 (1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>Secondary Nerve-Related Surgery</td>
<td>114 (82%)</td>
<td>41 (79%)</td>
<td>2 (67%)</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Full Nerve Recovery</td>
<td>86 (75%)</td>
<td>21 (51%)</td>
<td>1 (50%)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Recovery time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 months</td>
<td>20 (18%)</td>
<td>18 (44%)</td>
<td>1 (50%)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>3-6 months</td>
<td>8 (7%)</td>
<td>2 (5%)</td>
<td>0 (0%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>≥ 6 months</td>
<td>1.8 (0.9-3.8)</td>
<td>2.5 (1.3-3.7)</td>
<td>3.9 (2.2-3.7)</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Time to recovery (months; median (IQR))</td>
<td>25 (18%)</td>
<td>11 (21%)</td>
<td>1 (33%)</td>
<td>0.77</td>
<td></td>
</tr>
</tbody>
</table>

\* \(P\) values represent comparisons between median and radial nerve injury groups

CRPP: closed reduction and percutaneous pinning

ORPP: open reduction and percutaneous pinning

IQR: interquartile range (25\% percentile to 75\% percentile)

### Table 2: Patient and Injury Characteristics for Patients with Single Nerve Injuries (n=194)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median (IQR)</th>
<th>CRPP</th>
<th>ORPP</th>
<th>CRPP</th>
<th>ORPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years; mean (± SD))</td>
<td>6.3 (2.3)</td>
<td>6.6 (2.1)</td>
<td>6.7 (2.1)</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Concurrent Vascular Injury</td>
<td>59 (42%)</td>
<td>2 (2%)</td>
<td>1 (33%)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Initial Fracture Treatment</td>
<td>103 (74%)</td>
<td>48 (92%)</td>
<td>2 (67%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>CRPP</td>
<td>36 (26%)</td>
<td>4 (8%)</td>
<td>1 (33%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>ORPP</td>
<td>33 (24%)</td>
<td>3 (6%)</td>
<td>2 (67%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Immediate Surgical Nerve Decompression</td>
<td>2 (1%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>Secondary Nerve-Related Surgery</td>
<td>114 (82%)</td>
<td>41 (79%)</td>
<td>2 (67%)</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Full Nerve Recovery</td>
<td>86 (75%)</td>
<td>21 (51%)</td>
<td>1 (50%)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Recovery time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 months</td>
<td>20 (18%)</td>
<td>18 (44%)</td>
<td>1 (50%)</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>3-6 months</td>
<td>8 (7%)</td>
<td>2 (5%)</td>
<td>0 (0%)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>≥ 6 months</td>
<td>1.8 (0.9-3.8)</td>
<td>2.5 (1.3-3.7)</td>
<td>3.9 (2.2-3.7)</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Time to recovery (months; median (IQR))</td>
<td>25 (18%)</td>
<td>11 (21%)</td>
<td>1 (33%)</td>
<td>0.77</td>
<td></td>
</tr>
</tbody>
</table>

### Reference

Hypothesis: Long gap nerve repair injuries provide a significant challenge, especially when available autograft donor nerve is inadequate. We studied the functional recovery outcomes of processed nerve allografts for the repair of long gap nerve injuries between 30 mm and 65 mm to determine their efficacy in this application.

Methods: The RANGER Study is a multicenter registry designed to collect data on the use of processed nerve allografts (Avance Nerve Graft, AxoGen, Inc). IRB approval was obtained and standardized data reports were used to collect utilization, safety and functional outcomes. The registry database was queried for nerve repairs measuring 30 mm to 65 mm with a mean follow up time of 308 ± 165 days. Meaningful recovery was observed in 87% of repairs with 59% reaching higher thresholds of function. Analysis by nerve type observed meaningful recovery in 95% of sensory, 82% of mixed, and 67% of motor nerve repairs. Meaningful recovery for subgroups: injury location, mechanism of injury, and time to repair are detailed in Table 1.0. No adverse events were reported.

Summary Points:
- Processed nerve allograft demonstrated meaningful recovery in sensory, mixed, and motor nerve injuries between 30 and 65 mm.
- Overall meaningful recovery was reported at 87% with outcomes consistent across subgroups
- No adverse events or revisions were reported.
- These outcomes compare favorably to historical data in the literature for nerve autograft.
- The registry remains ongoing and continues to collect outcomes data on the use of processed nerve allografts for long gap nerve reconstructions.

RESULTS

The current RANGER registry has sufficient quantitative outcomes data on 135 nerve repairs. From this population, the long gap cohort consisted of 39 injuries (19 sensory, 17 mixed, and 3 motor nerves) occurring in 32 study subjects. Mean age of the cohort was 39 ± 16.4 (19–70) years and was predominantly male at 71.9%. Mean gap length was 36 ± 8.9 (30–65) mm with a mean follow up time of 308 ± 165 days. Meaningful recovery was observed in 87% of repairs with 59% reaching higher thresholds of function. Analysis by nerve type observed meaningful recovery in 95% of sensory, 82% of mixed, and 67% of motor nerve repairs. Meaningful recovery for subgroups: injury location, mechanism of injury, and time to repair are detailed in Table 1.0. No adverse events were reported.

REFERENCES


PAPER 06

Best Papers

Thursday, September 18, 2014 2:44 PM

Category: Treatment, Surgical Technique, Prognosis/Outcomes

Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Nerve

Functional Recovery From the Utilization of Processed Nerve Allografts for Large Gap Nerve Discontinuities: Outcomes From a National Registry Study

N/A - Not a clinical study

• Bauback Safa, MD
  • Jeffrey A. Greenberg, MD
  • Wesley P. Thayer, MD, PhD
  • Jason H. Ko, MD
  • Mickey Cho, MD
  • Gregory M. Buncke, MD

Hypothesis: Long gap nerve repair injuries provide a significant challenge, especially when available autograft donor nerve is inadequate. We studied the functional recovery outcomes of processed nerve allografts for the repair of long gap nerve injuries between 30 mm and 65 mm to determine their efficacy in this application.

Methods: The RANGER Study is a multicenter registry designed to collect data on the use of processed nerve allografts (Avance Nerve Graft, AxoGen, Inc). IRB approval was obtained and standardized data reports were used to collect utilization, safety and functional outcomes. The registry database was queried for nerve repairs measuring 30mm reporting sufficient quantitative data to determine the outcome of the repair. The long gap cohort was further stratified into nerve type, injury location, mechanism of injury and time to repair subgroups. Reported sensory and/or motor assessments included 2-point discrimination, Semmes-Weinstein Monofilament (SMW) testing, range of motion, electromyography (EMG) studies, qualitative questionnaires and safety assessments. Reported outcomes data were incorporated into the MRCC scale for sensory and motor function. Meaningful recovery was defined as ≥ S3/M3 on the MRCC scale with higher thresholds of recovery defined at S3+/M4 or greater.

Results: The current RANGER registry has sufficient quantitative outcomes data on 135 nerve repairs. From this population, the long gap cohort consisted of 39 injuries (19 sensory, 17 mixed, and 3 motor nerves) occurring in 32 study subjects. Mean age of the cohort was 39 ± 16.4 (19–70) years and was predominantly male at 71.9%. Mean gap length was 36 ± 8.9 (30–65) mm with a mean follow up time of 308 ± 165 days. Meaningful recovery was observed in 87% of repairs with 59% reaching higher thresholds of function. Analysis by nerve type observed meaningful recovery in 95% of sensory, 82% of mixed, and 67% of motor nerve repairs. Meaningful recovery for subgroups: injury location, mechanism of injury, and time to repair are detailed in Table 1.0. No adverse events were reported.

Summary Points:
- Processed nerve allograft demonstrated meaningful recovery in sensory, mixed, and motor nerve injuries between 30 and 65 mm.
- Overall meaningful recovery was reported at 87% with outcomes consistent across subgroups
- No adverse events or revisions were reported.
- These outcomes compare favorably to historical data in the literature for nerve autograft.
- The registry remains ongoing and continues to collect outcomes data on the use of processed nerve allografts for long gap nerve reconstructions.

REFERENCES


• Consulting Fee: AxoGen Inc (Safa)
• Consulting Fee: AxoGen Inc (Buncke)
**Microfracture for Ulnar Impaction Syndrome: Outcomes With Minimum Two-Year Follow-Up**

**Hypothesis:** Arthroscopic microfracture has a long history of successful use of treating osteochondral defects within the knee. This procedure has not been previously described for use in wrist arthroscopy. The purpose of this study is to identify if the microfracture procedure is a viable treatment modality for osteochondral lesions within the lunate due to ulnar impaction syndrome.

**Methods:** This was a retrospective review of all patients undergoing wrist arthroscopy for ulnar impaction syndrome by one surgeon from 2007 until 2010. Patients who demonstrated osteochondral lesions within the lunate on preoperative MRI that were confirmed during arthroscopy were treated with microfracture of the lesion. DASH scores were assessed pre-operatively and at minimum 2-year follow-up. PWRE and bilateral wrist range of motion, grip strength, and key pinch strength were assessed at final follow up.

**Results:** 7 patients underwent isolated microfracture of the lunate without a concomitant ulnar leveling procedure during the study period. Mean DASH scores improved from 55.7 prior the procedure to 21.3 at minimum 2-year follow up. There was no significant difference in wrist range of motion or grip strength between the operative and non-operative side at final follow-up. There were no complications and no recurrences of pain. All 7 patients were pleased with their outcome and reported willingness to have the procedure again if necessary. One patient who underwent a secondary wrist arthroscopy surgery for an unrelated problem demonstrated a dense layer of fibrocartilage that had formed (Figure 1) over the previously microfractured osteochondral defect (Figure 2).

**Summary Points:**
- Microfracture has a long history of use in knee arthroscopy for treatment of osteochondral defects.
- Not previously described in wrist arthroscopy, microfracture may be a promising form of minimally invasive treatment of osteochondral lesions in the wrist.
- Based on this study, microfracture has been shown to be a useful technique for treating articular defects of the lunate secondary to ulnar impaction syndrome in lieu of an ulnar leveling procedure.
- Second look arthroscopy reveals microfracture will lead to confluent coverage of the osteochondral defect with fibrocartilage.
- Microfracture of the lunate has been shown to provide durable relief of ulnar-sided wrist pain secondary to ulnar impaction syndrome for a minimum of 2 years.

**Elevated Hemoglobin A1C Levels Correlate With Blood Glucose Elevation in Diabetic Patients Following Local Corticosteroid Injection in the Hand: A Prospective Study**

**Hypothesis:** Diabetic patients are prone to develop hand conditions that are frequently managed with local corticosteroid injections. It is well known that these injections can result in a transient elevation in serum glucose levels in diabetic patients. Hemoglobin A1c (HbA1c) is the accepted measure of long-term plasma glucose control in diabetic patients. The purpose of this study is to assess the relationship between HbA1c levels and the intensity of the increased blood glucose levels after corticosteroid injections.
Methods: Twenty-five diabetic patients were prospectively evaluated for this study. An injection of 1 mL containing 10 mg triamcinolone acetonide was used. On the day of the injection, the most recent HbA1c level and the normal average baseline blood glucose levels were obtained for each patient. Daily follow-up telephone interviews to record post-injection glucose levels were performed until levels returned to their pre-injection baseline.

Results: Twenty patients (80%) experienced elevation of their blood glucose relative to baseline. No patient had elevated blood glucose levels after five days. Patients with HbA1c levels of 7% or greater had a higher blood glucose elevation than those who had a lower HbA1c level (P=0.003) and maintained the elevated blood glucose levels for a longer period of time (P=0.0004). Patients in the higher HbA1c group also had a higher number of hyperglycemic events (P<0.0001). There was a strong or moderate correlation between HbA1c level and elevation in blood glucose levels in days 1 to 4.

Summary Points: In the clinical setting, HbA1c levels of 7% or greater are considered a marker of poor blood glucose control in diabetic patients. Based on our results, patients above this threshold have elevations in blood glucose that are higher and last longer than patients with lower levels. As such, it is possible that HbA1c levels can be used to roughly predict the degree of blood glucose elevation after corticosteroid injections into the hands of diabetic patients.

Ownership Interest: Tornier, Inc (Beredjiklian)
Consulting Fee: Synthes (Lutsky)
Royalties/Honoraria received from: Arthrex (Kakar)
Contracted Research: Arthrex, Skeletal Dynamics (Kakar)

PAPER 09
Clinical Paper Session 01: Distal Radius
Friday, September 19, 2014 • 8:45–8:52 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist
Outcomes Following Use of Volar Hook Plate in Fragment Specific Distal Radius Fixation
Level 4 Evidence

Maureen A. O’Shaughnessy, MD
Sanjeev Kakar, MD, MCRS
Alexander Y. Shin, MD

Hypothesis: Distal radius fractures with involvement of the volar lunate facet are a unique subset of fractures that are not amenable to standard volar plate fixation. This study reviews the outcomes of patients treated with a novel volar hook plate, specifically designed to capture the volar ulnar corner marginal rim type fractures.

Methods: An IRB approved retrospective study was performed over an 18 month period of all cases using the volar hook plate in the management of AO type C distal radius fractures. At latest follow up, data including range of motion, grip strength, complications and quality of reduction on radiographs were recorded.

Results: The series includes 27 patients (8 male, 19 female) with an average age at injury of 55 (range 21 to 89). Average follow up was 6 months (range 1 – 15). Average flexion to extension arc was 92 degrees on the affected extremity and average grip strength was 70% of unaffected extremity. Postoperative radiographs demonstrated average radial inclination of 24 degrees, radial height of 10mm, volar tilt of 3 degrees and tear drop angle of 58 degrees. None of the patients had a loss of fixation of the critical volar ulnar corner and there was no evidence of carpal subluxation. Three patients experienced signs and symptoms of hardware irritation related to the volar hook plate which necessitated removal of the hardware. Two of the removed plates were first generation and the other was a second generation hook plate. There were no cases of tendon rupture.

Summary Points: The volar marginal rim fragment of intraarticular distal radius fractures is often not amenable to standard volar plate fixation. Fragment specific fixation using a novel volar hook plate designed specifically for this fragment allowed for stable fixation when combined with other fragment specific fixation techniques. There was no loss of fixation of this critical corner in this series; however, hardware irritation to flexor tendons may necessitate removal.

PAPER 10
Clinical Paper Session 01: Distal Radius
Friday, September 19, 2014 • 8:52–8:59 AM
Category: Evaluation/Diagnosis, Treatment, Therapy/Rehabilitation, Prognosis/Outcomes
Keyword: Hand and Wrist, Nerve, Practice Management
Factors Associated With Complex Regional Pain Syndrome Type I in Patients With Surgically Treated Distal Radius Fracture
Level 2 Evidence

Young Hak Roh, MD
Jong Ryoon Baek, MD
Beom Koo Lee, MD
Hyun Sik Gong, MD
Goo Hyun Baek, MD

Hypothesis: Wrist fracture is considered a typical initiating trauma for complex regional pain syndrome type I (CRPS I). However, few studies have comprehensively evaluated factors associated with the occurrence of CRPS I after the surgical treatment of a distal radius fracture. This study was performed to evaluate factors associated with the occurrence of CRPS I after the surgical treatment of a distal radius fracture.

Table: Multivariate logistic regression analyses for the prediction of CRPS I after distal radius surgery

<table>
<thead>
<tr>
<th>Variables</th>
<th>aOR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>2.172</td>
<td>1.492 – 3.434</td>
<td>0.02</td>
</tr>
<tr>
<td>Fracture type</td>
<td>3.123</td>
<td>1.522 – 6.034</td>
<td>0.01</td>
</tr>
<tr>
<td>Combined soft tissue injury</td>
<td>3.332</td>
<td>1.632 – 6.812</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Speaker has nothing of financial value to disclose
Methods: Four hundred and seventy seven patients with a distal radius fracture who had been treated surgically were enrolled, and CRPS I was diagnosed using the modified criteria of the International Association for the Study of Pain (IASP). The factors assessed for an association with the development of CRPS I were: age, gender, body mass index, fracture type, combined soft tissue injury, number of trial reductions, type of surgery, and duration of immobilization. Multivariate logistic regression analysis was used to identify independent predictors of the occurrence of CRPS I.

Results: Of the 477 patients, 42 (8.8%) patients satisfied the Budapest criteria within 6 months of surgery. Female patients developed CRPS I more frequently, and patients that developed CRPS I were older, and more frequently had a comminuted fracture or soft tissue injury. Multivariate analysis revealed that a female gender, severe fracture type, and combined soft tissue injury contributed to CRPS I development (P = 0.02, 0.01, and 0.01, respectively).

Summary Points: We conclude the severity of distal radius fracture is associated with the occurrence of CRPS I after surgical treatment, and that female gender and combined soft tissue injury are important risk factors for the development of CRPS I. Identifying patients on high risk for developing CRPS I after distal radius surgery may help physicians initiate early and adequate treatment for CRPS I, and facilitate patient recovery.

REFERENCES

PAPER 11
Clinical Paper Session 01: Distal Radius
Friday, September 19, 2014 • 8:59–9:06 AM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist
Intraarticular Fractures of the Sigmoid Notch of the Distal Radius: Analysis of Progression to Distal Radial Ulnar Joint Arthritis and Impact on Upper Extremity Function in Surgically Treated Fractures
Level 3 Evidence
❖ Mark A. Vitale, MD, MPH
❖ David M. Brogan, MD
❖ Alexander Y. Shin, MD
❖ Richard Berger, MD

Hypothesis: Studies have established increased risk of radiocarpal joint post-traumatic arthritis (PTA) in patients with displaced intra-articular fractures of the distal radius, although this has yet to be evaluated in the distal radioulnar joint (DRUJ). We hypothesize that patients with displaced intra-articular fractures of the sigmoid notch would have a higher prevalence of DRUJ PTA and greater upper extremity dysfunction compared to fractures without sigmoid notch involvement.

Methods: A retrospective review was conducted on surgically treated patients with distal radius fractures with preoperative computed tomography (CT) scans. Patients were divided into those with and without involvement of the articular margin of the sigmoid notch. Within the sigmoid notch group, postoperative CT scans were used to measure sigmoid notch stepoff and diastasis in axial and coronal planes (mm), as well as volar or dorsal DRUJ subluxation (%). At final follow-up patients were administered Disabilities of the Arm, Shoulder, and Hand (DASH) scores and AP and lateral XRIs were obtained to grade DRUJ PTA based on the Kellgren Lawrence (KL) scale.

Results: Thirty-three patients were included (19 with sigmoid notch involvement and 14 without) with an average radiographic follow-up of 6.4 years. DASH scores were available for all patients, and long-term radiographic follow-up was available in 24 patients. There was a trend towards poorer average DASH in those with sigmoid notch involvement (mean=53.4, SD=26.5) versus those without (mean=42.43, SD=22.9), but this was not statistically different (P=0.05). Similarly, there was a trend towards higher grade of DRUJ arthritis in those with sigmoid notch involvement (mean KL score=1.6, SD=1.1) versus those without (mean KL score=1.1, SD=0.8), but this was not significantly different (P=0.05). There were no significant correlations between sigmoid notch stepoff, diastasis or DRUJ subluxation with DASH scores or KL grade. Within the subset of patients with sigmoid notch involvement there were poorer DASH scores in patients with coronal stepoff > 1.0-mm (mean=94.0, SD=15.6) versus those with stepoff <= 1.0-mm (mean=49.4, SD=23.9, P=0.022).

Summary Points:
- Fractures involving the sigmoid notch did not appear to have a greater prevalence of DRUJ PTA in operatively treated patients at greater than 6 years of follow-up.
- Postoperative stepoff, diastasis and subluxation did not appear to correlate with subsequent risk of DRUJ PTA.
- While overall there appeared to be a minimal effect of postoperative sigmoid notch stepoff, diastasis or DRUJ subluxation on postoperative upper extremity function, fractures with a coronal stepoff > 1.0-mm had poorer upper extremity function.

REFERENCES

PAPER 12
Clinical Paper Session 01: Distal Radius
Friday, September 19, 2014 • 9:06–9:13 AM
Category: Evaluation/Diagnosis, Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist

❖ Speaker has nothing of financial value to disclose e9
Incidence and Reasons for Hardware Removal Following Operative Fixation of Distal Radius Fractures

Level 4 Evidence

- Mark C. Snoddy, MD
- Nicholas Pappas, MD
- Benjamin S. Hoee, BS
- Harrison F. Kay, BS
- Thomas J. An, BS
- Donald H. Lee, MD

Hypothesis: Despite advancements in both plate design and surgical technique, some patients may still require implant removal following operative fixation of their distal radius fractures. Our hypothesis is that the primary reason for plate removal is pain secondary to tendon dysfunction.

Methods: 44 patients who underwent removal of a distal radius plate from 2007 to 2013 were retrospectively reviewed. The primary reason for plate removal and the location of the plate (either dorsal or volar) were recorded, in addition to the following variables: patient gender, body mass index (BMI), AO fracture type, and plate manufacturer. The total number of both distal radius plating procedures and implant removals over that time frame was also analyzed. Both chi-squared and multivariate analysis were used to determine statistical differences.

Results: Of the 44 patients who underwent implant removal, the most common reasons for removal were tendon dysfunction (27%), painful hardware (25%), malunion (16%), infection (9%), nonunion (7%), and tendon rupture (5%). 33 (75%) of the plates removed were volar and the remaining 11 (25%), dorsal. Most patients were female (58%) with an average BMI of 25. The most common AO fracture type requiring plate removal was C3 (12 of 44). The most common AO fracture type requiring plate removal was C3 (12 of 44). 25 of the plates removed were manufactured by Synthes, 18 by Hand Innovations, and 1 by Acumed. A total of 599 distal radius fractures were plated at our institution from 2007 to 2009, a number which rose to 870 from 2010-2012. The number of distal radius plate removals over those same time frames was relatively constant at 23 and 21, respectively.

Summary Points:
- The most common reason for implant removal in our study was tendon dysfunction (27%), followed closely by painful hardware (25%) and malunion (16%).
- 75% of the plates removed had been placed volarly, while the remaining 25% were dorsal.
- Patients with the most severe fracture type (AO Type C3) comprised the largest percentage of the implant removal group.
- While the incidence of distal radius plating at our institution increased by approximately 45% over our time frame, the total number of plate removals remained nearly the same.
- As the use of distal radius plates continues to rise, we should continue to study the reasons for implant removal so as to limit future hardware complications.

REFERENCES


Consulting Fee: Biomet, Elsevier (Lee)

PAPER 13

Clinical Paper Session 01: Distal Radius
Friday, September 19, 2014 • 9:13–9:20 AM
Category: Treatment, Surgical Technique
Keyword: Hand and Wrist

A Prospective Randomized Trial Comparing Fragment-Specific Fixation and Volar Locking Plates in Displaced and Unstable Distal Radial Fractures

Level 2 Evidence

- Marcus Landgren, MD
- Antonio Abramo, MD, PhD
- Mats Geijer, MD, PhD
- Philippe Kopylov, MD, PhD
- Magnus Tägil, MD, PhD

Hypothesis: To compare the subjective, clinical, and radiographic outcomes of two methods of internal fixation for distal radial fractures.

Methods: A prospective randomized study of patients with AO A and C distal radial fractures, age 18-70 was performed. Fifty patients (mean age 56 years, 39 women) with primary unstable, non-reducible, as well as secondarily re-dislocated distal radial fractures were included between December 2010 and December 2012. The patients were randomized between open reduction and internal fixation with either a volar locking plate (n=25) or fragment-specific wrist fixation system (n=25). The primary outcome was grip strength at 52 weeks. Secondary outcomes were range of motion (ROM), QuickDASH, Visual Analog Scale (VAS) for pain at rest, pain at activity, subjective function, and cosmetic appearance and radiographic analysis. Continuous variables were analyzed using the Student t-test or Mann-Whitney test.

Results: At 52 weeks grip strength was 86% (SD 17) of the uninjured side in the volar locking plate group and 90% (SD 16) in the fragment-specific group (P=0.48). The ROM at 52 weeks for the volar locking plate and fragment-specific fixation group respectively, were 150° and 147° in pronation/supination (P=0.41), 131° and 128° in extension/flexion (P=0.57) and 62° and 57° in radial/ulnar deviation (P=0.15). The median QuickDASH score was 5 in both groups at 52 weeks. No differences were found regarding grip strength, range of motion, QuickDASH, and VAS in the three of the four measured parameters. A significant higher VAS score regarding cosmetic appearance was found at 12 and 52 weeks in the fragment-specific group vs. the volar locking plate group (P=0.04 and P=0.02, respectively). Minor complications were registered in both groups such as CTS, transient
Three groups of 30 Lewis rats each underwent a 10 mm sciatic nerve injury and were repaired with RA, UA from a Sprague-Dawley rat, or acellular (processed) human xenograft (AX). Half the rats were given saline injections while the other half were given FK (0.5 mg/kg/day). At 1 wk and 12 wks, 10 animals (5 saline, 5 FK) last 10 animals in each group were evaluated for histology (axon counts, CD14, IL16, IL17, NFAT2, NFAT3, TNFa) proximal, midgraft, and distal to the graft (P/M/D). At 12 wks the highest axon counts were in RA followed by UA followed by AX. The highest ITF was by RA followed by UA and by saline followed by AX.

Results:

- RA repair did not have substantially less inflammation than UA or AX.(p>0.05).
- FK tended to decrease inflammatory markers.
- CD14 (a marker of macrophages) level was found to strongly negatively correlate with ITF. (Fig. 1)
- The highest axon counts were in RA followed by UA followed by AX.(p<0.05)
- The highest ITF was by RA+saline followed by UA+saline followed by AX+saline. (Fig. 2) FK did not increase ITF for RA but it did increase it for UA to equal RA ITF recovery, as well as for AX to equal UA+saline recovery.

Summary Points:
- Inflammation is needed in nerve regeneration even in autograft repair.
- FK improves nerve recovery but decreases inflammation despite a sub-immunosuppressive dose.
- Macrophages at 12 wks negatively correlate with functional recovery.
- Autograft repair remains the best nerve repair method while acellular human xenograft in the rat has poor regeneration.
- Understanding the impact of inflammation on nerve regeneration can allow modulation to improve outcomes.

REFERENCES


PAPER 14

Clinical Paper Session 02: Nerve Repair/Regeneration
Friday, September 19, 2014 • 8:45–8:52 AM
Category: Basic Science
Keyword: Nerve

An Evaluation of Inflammation, Histology, and Function in Nerve Regeneration

Hypothesis:

1. Inflammation plays an important role in nerve regeneration.
2. Reversed autograft (RA) repair of a segmental rodent sciatic nerve defect will have less inflammation than untreated allograft (UA) or acellular (processed) human xenograft (AX). (*NB: acellular rat allograft was planned but not available)
3. A sub-immunosuppressive dose of FK506 (FK) (a known immunosuppressant that improves nerve healing) will improve nerve regeneration but will not decrease inflammatory markers.
4. Some inflammatory markers will correlate with functional outcome.
5. The best histologic and functional recovery will be by RA followed by UA followed by AX.

Methods: Three groups of 30 Lewis rats each underwent a 10 mm sciatic nerve injury and were repaired with RA, UA from a Sprague-Dawley rat, or AX. Half the rats were given saline injections while the other half were given FK (0.5 mg/kg/day). At 1 wk and 12 wks, 10 animals (5 saline, 5 FK) in each group underwent harvest of the nerve repair and the nerve was stained for in each group underwent harvest of the nerve repair and the nerve was stained for inflammation, Histology, and Function in Nerve Regeneration in primary and secondarily dislocated distal radius fractures.

REFERENCES


PAPER 15
Clinical Paper Session 02: Nerve Repair/Regeneration
Friday, September 19, 2014 • 8:52–8:59 AM
Category: Evaluation/Diagnosis, Prognosis/Outcomes, Patient Education, Anatomy, Basic Science
Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Nerve, Diseases and Disorders, General Principles

A Pharmacologic Test to Establish Continuity and Function in the Crush-Injured Nerve
N/A - Not a Clinical Study

Hypothesis: Severe nerve crush injury produces damage indistinguishable from that of a severely nerve with complete loss of function. And yet some crush injuries show amazing potential for recovery while others do not. We hypothesized that a crush injury differs in the extent of damage to myelin and neurons and must leave a subset of neurons preserved to support functional improvement. Perhaps it is these intact, partially injured neurons which could be targeted for pharmacologic diagnostic testing. In such a case, compounds used to stabilize partially injured neurons could be used diagnostically to prove the existence of intact fibers even in the severest of crush injuries.

Methods: Twelve mice received standard severe crush injuries using a needle driver closed to the first click around the sciatic nerve as previously published (5). All mice underwent walking task analysis daily, including immediately before and every hour after administration of 4-AP. Group A (6 mice): On post-injury day (PID) 3, mice received a single IP dose of 4-AP Group A (6 mice): On post-injury day (PID) 3, mice received a single IP dose of 4-AP Group B (6 mice) received the same dose of 4-AP on PID 5. Dosage of 4-AP was weight-based, based on human dosing for its current FDA approved indication of Multiple Sclerosis. No animals demonstrated adverse side effects (seizures). Sciatic Function Indices (SFI) were computed by blinded reviewers and data was analyzed using student’s t test.

Results: At PID3 mice receiving a single dose of 4-AP demonstrated 50% improvement in Sciatic Function Index (SFI) immediately following administration (figure 1). The duration of the improvement was 4 hours, the reported half-life of 4-AP in dogs.2 At PID5, functional improvement with the same dose of 4-AP was half as effective. Prior studies of identical animal models not treated with 4-AP did not reach 50% improvement until 3 weeks post-injury (data not shown).

Summary Points:
- The crush-injured nerve, though functionally indistinguishable from the completely severed nerve, can be demonstrated to have intact fibers capable of supporting function. To our knowledge, this is the first demonstration of a pharmacologic test which can predict intact fibers soon after a crush injury in nerves where function is completely absent.
- This may advance our understanding of the nature of different peripheral nerve injuries and could yield to clinically significant prognostic testing.

Note: The use of 4AP for peripheral nerve continuity testing is not approved by the FDA.

REFERENCES

PAPER 16
Clinical Paper Session 02: Nerve Repair/Regeneration
Friday, September 19, 2014 • 8:59–9:06 AM
Category: Treatment, Basic Science
Keyword: Nerve

Returning What is Lost: Schwann Cell Versus VEGF Addition to Acellular Nerve Allografts
N/A - Not a clinical study

Hypothesis: Acellular nerve allograft (ANA) processing removes Schwann cells (SCs) and vasculature which may contribute to reduced nerve regeneration in ANAs compared to autografts. Addition of SCs or vascular endothelial growth factor (VEGF) may improve the regenerative microenvironment and therefore, facilitate nerve regeneration.

Methods: Individual contributions of exogenous SCs and VEGF were evaluated in a short ANA model of axonal regeneration. A rat sciatic nerve transection model was used to study 20mm grafts. Four groups were studied: 1) isograft, 2) ANA, 3) ANA-SCs, and 4) ANA - VEGF. In the ANA-SC group, 1x106 SCs were injected along the length of the graft. In the ANA-VEGF group, VEGF suspended in fibrin was injected along the length of the nerve. After 10wks in vivo, the nerve distal to the graft was analyzed for axonal regeneration using histomorphometry to assess total nerve fiber counts, density, width, and percent neural tissue. Light microscopy was used to assess nerve architecture.

Results: All grafts showed myelinated fibers in the distal nerve, demonstrating successful axonal growth through the graft. The architecture of the nerve appears more organized with more uniform arrangement and size of fibers in the isograft, ANA-VEGF, and ANA-SC groups. The most nerve fibers were regenerated in the isograft followed by the ANA-SC group: 9171±1822 and 7103±1576, respectively. The ANA-VEGF group had 5709±2657 and the ANA produced 5225±2994. ANA and ANA-VEGF groups were significantly less compared to the isograft (P<0.05). For fiber density and percent nerve, the ANA and ANA-VEGF groups were significantly reduced compared to the isograft, and the isograft and ANA-SC

Another significant reduction was observed in the ANA-SC group compared to the isograft.

Speaker has nothing of financial value to disclose.
groups were not significantly different ($P<0.05$). Fiber widths for all groups were similar. **Summary Points:**

- These results show that SCs improve axonal regeneration in a 20mm ANA to a greater extent compared to VEGF addition.
- Given that VEGF treatment showed a trend toward increased axonal regeneration but was not significantly different compared to the untreated ANA, the role of VEGF may be more significant in longer grafts. With increasing ANA length, ischemia maybe a more important contributor to poor axonal regeneration.
- Exogenous SCs and VEGF addition may have a greater effect in long ANAS, beyond promoting axonal regeneration, where it also may reduce the accumulation of cellular senescence.

**REFERENCES**

● Wnt/beta-catenin pathway may be a useful therapeutic target to prevent the motor endplate degeneration that occurs following traumatic nerve injury with Wnt inhibitors serving as a pharmacologic adjunct to surgical repair.

REFERENCES


PAPER 18

Clinical Paper Session 02: Nerve Repair/Regeneration
Friday, September 19, 2014 ● 9:13–9:20 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Nerve

Comparison of Outcomes From Processed Nerve Allograft, Hollow Tube Conduits, and Autograft in Peripheral Nerve Repair

Level 3 Evidence

Gregory M. Buncke, MD
Jason H. Ko, MD
Wesley P. Thayer, MD, PhD
Bauback Safa, MD

Hypothesis: Outcomes from nerve gap repair can be dependent upon the material used to restore the discontinuity. To examine these differences we added contemporary control cohorts to a national nerve registry. Based on scientific evidence and historical controls, we hypothesized that processed nerve allografts would perform similar to nerve autograft and significantly better than tube conduit.

Methods: The RANGER registry is an active database designed to continuously monitor and collect injury, repair, safety and outcomes data for processed nerve allografts (Avance® Nerve Graft, AxoGen, Inc). In 2013, a contemporary control was added to the established registry to allow for comparisons of recovery outcomes between nerve allografts and tube conduits. Initial screening of medical records was conducted at participating centers to identify potential subjects presenting with nerve gap injuries up to 70 mm. Identified records meeting inclusion/exclusion criteria with sufficient follow-up were assigned a unique identifier according to the IRB approved protocol. Three sites contributed data on all types of repairs. Meaningful recovery was defined by the MRCC scale at S3/M3 or greater for sensory and motor function.

Results: Seventy subjects with 104 injuries were included. The groups consisted of processed nerve allograft (n=65), tube conduit (n=27), or nerve autograft (n=12). Subject demographics, medical history, and concomitant injuries were comparable between treatment groups. The processed nerve allograft (PNA) group and conduit group had similar nerve injury and repair variables; however the autograft group had larger gap lengths. The average nerve gap between the groups varied at 19+12mm, 17+7 mm, and 38+15 mm for processed nerve allograft, conduit, and nerve autograft respectively. Available quantitative data reported meaningful levels of recovery in 83% in PNA group as compared to 33% for tube conduit and 58% for nerve autograft. See Table 1 for a summary of treatment groups. Additional analysis was performed to examine matched PNA subgroups to the gap demographics of tube conduit and autograft groups, finding were similar to results above, see Table 2. There were no reported adverse events related to the treatment groups.

Summary Points:

- Reported levels of meaningful recovery at MATCH sites for processed nerve allograft exceed that of tube conduits.
- Outcomes are comparable to nerve autograft and exceed those for nerve conduit in historical controls.

REFERENCES


PAPER 19

Clinical Paper Session 03: Wrist/Reconstruction
Friday, September 19, 2014 ● 10:05–10:12 AM
Category: Treatment, Surgical Technique
Keyword: Hand and Wrist

Consulting Fee: AxoGen Inc (Buncke)

Speaker has nothing of financial value to disclose
Nonrepairable Foveal Avulsions of the TFCC: How to Make the Most of What Is Left
Level 4 Evidence

A Aleksandar Lovic, MD
Sergio Alvarez-Garcia-Peñauela, MD
Jose R. Martinez-Mendez, PhD

Hypothesis: The mainstay of treatment for non-repairable TFCC foveal avulsions are so-called anatomic reconstructions, that discard perfectly viable structures. Reattachment of the TFCC to the fovea using autologous tendon constitutes a feasible alternative that uses the available resources to provide an anatomic reconstruction of the TFCC.

Methods: Technique: DRUJ is exposed through a dorsal longitudinal approach. The remains of the TFCC are dissected and the integrity of its radial insertion is tested. A 2.0 drill bit is used to create an hole on the fovea and two other holes on the dorsal aspect of the ulna. A tendon graft is harvested (palmaris longus or plantaris) and it is woven in and around the TFCC. The two ends of the tendon are passed through the hole on the fovea and each end is taken out through one of the holes on the dorsum of the ulna. Both ends are knotted, adjusting the tension to achieve DRUJ stability without compromising pronosupination, and absorbable sutures are used to secure the knots. After skin closure, postoperative casting is used for 48 h.

We present 16 patients, mean age:36, with a minimum follow-up of 26 months. We have evaluated long-term pronosupination, grip strength, DRUJ laxity, pain (AVS) and pre and postoperative QuickDASH scores.

Results: Mean preoperative QuickDASH was 43, mean postoperative QuickDASH was 7. Mean postoperative pronosupination was 83°/76° and mean grip strength was 31 kg. On postoperative physical examination laxity of the DRUJ was present in 5 patients, however none of them referred symptoms of instability. Mean postoperative AVS was 1, with 12 patients completely pain free.

Summary Points:
- This technique uses the available resources to provide an anatomic reconstruction of the TFCC
- The use of autologous tendon avoids the placement of foreign material within the articular space
- Our long term analysis show that this is a safe and effective procedure to recover painless pronosupination in patients with non repairable TFCC foveal detachments.

REFERENCES

PAPER 20
Clinical Paper Session 03: Wrist/Reconstruction
Friday, September 19, 2014 • 10:19–10:26 AM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist

Herbert Ulnar Head Prosthesis Arthroplasty: Satisfactory Midterm Outcomes
Level 4 Evidence

Peter M. Axelsson, MD

Hypothesis: Reports about short-term results following ulnar head arthroplasties have been promising but there is a paucity of mid- and long-term data. To address the concerns about lasting results and late complications we conducted the present study.

Methods: We reviewed a consecutive series of 22 Herbert Ulnar head prosthesis (UHP) arthroplasties that had been performed at our department between 2000 and 2011. These procedures were evaluated at a mean time of 7.5 years after their date of surgery. 5 of the arthroplasties were primary procedures and the average numbers of previous surgeries carried out in the other 17 wrists were 2. Postoperative assessment was carried out using radiography, clinical examination and questionnaires. These included: Disabilities of the arm shoulder and hand (DASH), Patient rated wrist evaluation (PRWE) and the Mayo wrist score. A 10 cm visual analogue scale (VAS), was used to evaluate Pain and satisfaction. Measurements of Range of Motion (ROM) and grip strength were also recorded. Values for ROM were compared with preoperative values and analyzed by Wilcoxon signed rank test.

Results: Wrist ROM was only slightly affected by the arthroplasty except for supination, which was, significantly improved from 68 to 75 degrees (P= .030). Grip Strength averaged 25 kg compared with 30 kg on the non-operated side. Pain during activity averaged 2.9 cm and Satisfaction reached 8.9 cm on a 10 cm VAS. Five patients had considerable residual pain been previously studied for spine, shoulder, and foot surgery. However, the normal flora of the hand may differ from these surgical sites and the ideal preparation solution has not been determined. The purpose of this study is to determine the effectiveness of three commonly used surgical preparation solutions (Chloraprep, Duraprep, and Betadine) in eliminating bacteria from the skin prior to incision.

Methods: After IRB approval was obtained, 119 patients undergoing clean, elective hand surgery were randomized to one of three surgical preparation solutions (Chloraprep, Duraprep, and Betadine). Aerobic and anaerobic cultures were taken over a 1-cm area of skin adjacent to the planned incision site prior to skin prep and immediately after the prep solution had dried. A neutralization agent was used to neutralize the antiseptic solution and cultures were held for 14 days. All patients were followed for 30 days post-operatively to document any evidence of post-operative infection, defined as need for antibiotics or surgical intervention.

Results: Post prep cultures were positive in 10/50 (20%) patients using Chloraprep, 1/33 (3%) patients using Duraprep, and 0/36 (0%) patients prepped with Betadine, P=0.07. The most common pre-prep bacteria cultured were coagulase negative staphylococcus and bacillus species. The most common post-prep bacteria cultured were bacillus and coagulase negative staphylococcus. There were no infections within 30 days of surgery.

Summary Points:
- In this prospective randomized trial, there was a trend towards more positive cultures in the Chloraprep group, but no statistical difference in the effectiveness of surgical prep solutions to eliminate bacteria from the skin of patients undergoing clean, elective hand surgery.
- Only 45/119 patients had positive pre-pre cultures, suggesting hand washing with antibacterial soap has a major impact on skin flora.
- As increasing focus shifts to healthcare costs, the less expensive agent may be considered if the antiseptic properties are similar.
(VAS > 5.0 cm) but only one patient was dissatisfied and regretted having undergone arthroplasty.

Mean DASH averaged 27 points; PRWE 31 points and the MAYO wrist score 70.

Radiographic evaluation showed resorption at the distal part of the Ulna and erosion of the radius for most patients. These changes had come to a halt for all patients but one at the latest follow-up. No signs of aseptic loosening were encountered.

One patient required a capsuloplasty, nine month after the arthroplasty, due to painful instability. Full stability was not achieved but the pain receded.

Summary Points:
- We conclude that mid-term results for the Herbert UHP were satisfactory.
- We found the risk for aseptic loosening and other complications to be low.

In selected cases, where soft tissues at the DRUJ are assessed as adequate, we believe that Herbert UHP should be considered as a primary option for revision of resection arthroplasties. The Herbert implant also appears to be a viable option for primary procedures of DRUJ- arthritis but larger long-term studies needs to confirm that.

REFERENCES

Results:
1. In the registry, signs of implant loosening were reported in 6 of 52 cases seen at follow-up 5-9 years after operation and PPO without implant loosening in another 11 cases.
2. In the systematic analysis, we found significant PPO (> 2mm) at the radial component side in 16 of 44 wrists and at the carpal side in 7. In most cases, it stabilized after 1-3 years, but in a few cases it progressed to a markedly larger area (figure 1). In general PPO was not related to evident loosening.
3. Some metallic debris was seen in 21 of 24 specimens by at least one of two pathologists and (sparse) polyethylene particles in 19. There was no positive correlation between the amount of debris and the width of the radiolucent zones. Even in cases with pronounced radiolucency there could be no polyethylene particles at all and in cases with a relatively high amount of debris there could be no visible osteolysis (figure 2). Neither was there histopathological evidence of infectious or rheumatoid activity in any of the specimens or blood samples. The level of metallic ions in blood was within normal ranges. PPO was not related to a specific diagnosis.

Summary Points: PPO was a common occurrence. In most cases, it was stable and of no concern in terms of implant loosening. In few cases it was progressive. It was not correlated with the occurrence of particulate debris.

REFERENCES
**PAPER 24**

Clinical Paper Session 04: Pediatrics  
Friday, September 19, 2014  
10:05—10:12 AM

Category: Treatment, Prognosis/Outcomes, Patient Education, Medical/Legal

Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Congenital and Pediatric Problems, General Principles

**Appropriateness and Adequacy of Splints Applied for Pediatric Upper Extremity Fractures in an Emergency Department/Urgent Care Environment**

Level 2 Evidence

- **Brandon S. Schwartz, MPH**
  - Joshua Abzug, MD

**Hypothesis:** A significant number of splints placed for pediatric upper extremity fractures in emergency departments and urgent care settings are inappropriately or inadequately applied, leading to adverse outcomes.

**Methods:** All pediatric patients who presented to the pediatric orthopaedic clinic for evaluation, with a splint in place, were enrolled in the study after obtaining consent. Demographic information, type of splint applied, facility type placing the splint, practitioner type placing the splint, and time from splint application to orthopaedic evaluation were recorded. Following splint removal, the patient was examined and any adverse findings were documented.

**Results:** Splints were placed improperly in 89% (143/161) of the patients evaluated. The most prevalent factor contributing to poor splint placement involved application of an elastic bandage to the skin leading to excessive swelling, seen in 85% (136/160) of patients evaluated. Additionally, 31% (50/160) of splints were not in a position of function, and 30% (48/160) of splints were the improper length. Complications of improperly placed splints included significant edema in the hands and fingers in 26% of patients (37/142), areas of pressure on the skin beneath the splint in 18% of patients (26/142), and other skin complications such as bruising, abrasions, blistering, and ulcerations in 16% of patients (23/142). No patients required invasive intervention as a result of the inadequate splint placement, however, several patients required local wound care.

**Summary Points:**
- A significant number of splints for pediatric upper extremity fractures are placed improperly in emergency departments and urgent care settings.
- Improper splint placement may lead to several adverse outcomes, including edema and skin complications such as bruising, abrasions, blistering, and ulcerations.
- Healthcare professionals in urgent care settings and emergency departments may need formal education in appropriate splint application.
- Royalties/Honoraria received from: Springer (Abzug)
- Consulting Fec: Axogen (Abzug)

**PAPER 25**

Clinical Paper Session 04: Pediatrics  
Friday, September 19, 2014  
10:12—10:19 AM

Category: Treatment, Prognosis/Outcomes

Keyword: Hand and Wrist, Congenital and Pediatric Problems

**Outcomes of Opening Wedge Osteotomy to Correct Angular Deformation in Clinodactyly**

Level 4 Evidence

- **Samantha L. Piper, MD**
  - Charles A. Goldfarb, MD
  - Lindley Wall, MD

**Hypothesis:** Clinodactyly, a congenital coronal angulation of the finger, is caused by tethered growth from an abnormal longitudinal epiphyseal bracket of the middle phalanx or a trapezoidal shaped phalanx. When severe, this can result in unsatisfactory appearance and functional limitation. Surgical options include physiologic with fat interposition of the bracketed epiphysis, and closing, reverse, or opening wedge osteotomies of the middle phalanx. Opening wedge osteotomy has the benefit of preserving finger length. This is the first report describing the clinical and radiographic outcomes after opening wedge osteotomy for congenital clinodactyly.

**Methods:** A retrospective chart and radiograph review was performed of all patients with isolated clinodactyly treated with opening wedge osteotomy by a single surgeon at St. Louis Children’s and Shriners Hospitals. Primary procedures only were included, and patients with syndactyly or other conditions involving the operative finger were excluded. Preoperative and postoperative data were compared.

**Results:** Fourteen fingers in ten patients were treated between 2003 and 2011. Five were female and the average age at surgery was nine years. Thirteen small fingers and one index finger were involved, all with radial deviation. Average follow up was eight months. Average preoperative clinical angle was 34 degrees (20-45 degrees), and average postoperative clinical angle was 7 degrees (0-35 degrees). Average preoperative radiographic angle was 35 degrees (27-45 degrees), and average postoperative radiographic angle was 7 degrees (0-30 degrees). Average active total arc of motion preoperatively was 259.3 degrees (225-270 degrees) and postoperatively was 234.5 degrees (110-270 degrees). Average preoperative visual analog score was 0.64 and postoperative score was 0. Two fingers had deformity recurrence after pin removal due to nonunion, and one of these developed significant stiffness.

**Summary Points:**
- Opening wedge osteotomy of the middle phalanx is an effective technique to correct angular deformity in clinodactyly, with an average correction of 27 degrees.
- There was an average 10-degree decrease in arc of motion postoperatively.
- 2 fingers had loss of correction after pin removal, and one of these developed significant stiffness. There were no other complications.

**Preoperative clinical photographs of small finger clinodactyly (top), Intraoperative radiographs before (left; joints have been stabilized with K-wires) and after (right) an opening wedge osteotomy (bottom right).**

- **Speaker has nothing of financial value to disclose**
PAPER 26

Clinical Paper Session 04: Pediatrics
Friday, September 19, 2014 ● 10:19—10:26 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Congenital and Pediatric Problems

Long-Term Outcomes Following Radial Polydactyly Reconstruction

Level 4 Evidence

◆ Chris Stutz, MD

Hypothesis: Radial polydactyly is a common congenital condition that largely occurs in a sporadic distribution. It is generally accepted that reconstruction rather than simple excision is the treatment of choice in the majority of cases, but few long-term outcome studies exist in the literature. The purpose of the current investigation is to report long-term outcomes (greater than 10 years) following radial polydactyly reconstruction.

Methods: We evaluated 43 surgically reconstructed thumbs in 41 patients with radial polydactyly who had follow-up greater than 10 years. The study group included 12 Flatt type II, 8 type III, 17 type IV, and 6 type V. The average age of surgery was 1 year, with a mean follow-up of 17 years. Objective outcome values as well as validated patient-oriented outcome evaluations were obtained.

Results: No early post-surgical complications were encountered. 8 patients had 10 revision procedures at an average of 8 years following the initial procedure. 5 patients had interphalangeal joint fusion, all for angulation with accompanying pain. The average Tada score was 4.1, lateral pinch was 86% of the unaffected side, and tip pinch was 92% of the unaffected side. As a group, operative thumbs had significantly weaker tip and tripod pinch strengths than nonoperative thumbs. The average DASH score was 4.5 and the average PedSQ score was 87 when administered to the patient and 86.8 when administered to the parent.

Summary: We found that long-term results following surgical reconstruction for radial polydactyly are excellent, but the revision rate trends upward over time despite maintaining favorable scores on the objective outcome measures utilized.

REFERENCES


PAPER 27

Clinical Paper Session 04: Pediatrics
Friday, September 19, 2014 ● 10:26—10:33 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Congenital and Pediatric Problems, Diseases and Disorders

Hyaluronic Acid Scaffold for Skin Defects Closure in Congenital Syndactyly Release Surgery

Level 4 Evidence

◆ Lorenzo Garagnani, MD
◆ Mario Lando, MD
◆ Andrea Leti Acciaro, MD
◆ Antonio Landi, MD

Hypothesis: Several techniques for congenital syndactyly release have been described. Some techniques require skin grafting, which might lead to poor cosmetic outcomes and complications. A graftless technique with an advanced Hyaluronic Acid (HA) scaffold used to cover the bare areas has been developed.

Methods: Between December 2008 and December 2012, release of 42 webs in 38 hands of 36 children with different types of complete syndactyly was performed using an advanced HA scaffold to cover the skin defects. Mean age at surgery was 38 months. One patient was excluded due to early postoperative infection that required HA scaffold removal. Mean follow-up of the remaining group was 28 months. Web creep, secondary deformities, scar quality and patients and parental satisfaction were assessed.

Results: All patients had close to normal pigmentation and good pliability at the sites of HA scaffold application. There were no secondary deformities and minimal degree of web creep at follow-up. There were no hypertrophic scars or keloids. All patients and parents stated to be satisfied by the avoidance of skin grafts.

Summary Points:
- this technique allows to avoid skin grafting (absent donor site morbidity)
- this is a time effective procedure, with a reduced anaesthetic and operating time, that may contribute to reduce the related risks and social costs
- any size skin defects may be covered with the HA scaffold
- the results confirm the use of a HA scaffold as a promising alternative to skin grafting in syndactyly release surgery.

REFERENCES


PAPER 28

Clinical Paper Session 04: Pediatrics
Friday, September 19, 2014 ● 10:33—10:40 AM
Category: Treatment, Historical Information, Prognosis/Outcomes
Keyword: Congenital and Pediatric Problems

The Natural History of Pediatric Trigger Thumb

Level 4 Evidence

◆ Douglas T. Hutchinson, MD
◆ Sarah Al-Obaydi, MBChB, MPH

Hypothesis: Observational treatment of pediatric trigger thumbs has merit and should be offered to families though the cure rate in USA patients is far different from that of our Korean colleagues.

Methods: We prospectively followed a nearly consecutive group (only 6 declined) of 101 patients with 122 pediatric trigger thumbs for 4-5 years. Data included goniometric evaluation of the IP flexion and angulation contracture and MPJ hyperextension of both affected and unaffected
thumbs, presence or absence of triggering, VAS pain scale, and hand dysfunction. All patients were allowed to drop out and have surgery at anytime for any reason.

Results: The average age at presentation was 22.5 months and there is a 20% family history. 6 patients began as unilateral but changed to bilateral all before 24 months of age. Hyperextension of the MPJ was the same in affected and unaffected thumbs. Most patients went through a period of increased pain associated with triggering that decreased with further time. No patient felt their hand function was compromised in any way. There were generally two groups of patients, those that progressively improved (70%) and those that did not. 30 patients over several years decided to have surgery and all did well. 33% of patients were cured. Most of the rest ended up with minimal contracture associated with mostly infrequent, nonpainful, triggering and felt leaving it that way was better than having surgery.

Summary Points:
- Observational treatment of pediatric trigger thumb does result in a majority of patients avoiding surgery but few are cured.
- A group of patients do not progressively improve and most elect surgery.
- Neither hyperextension of the MPJ, or hand dysfunction occurs and are not therefore reasons for surgery.
- Unilateral trigger thumbs should at least be observed until age three to avoid duplicate surgery.

REFERENCES

PAPER 29

Clinical Paper Session 05: The Thumb: Trauma, Arthritis, and Injury
Friday, September 19, 2014 • 11:25–11:32 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist

Effect of Interposition Following Arthroscopic Resection Arthroplasty for Thumb Carpometacarpal Osteoarthritis
Level 3 Evidence

Anna L. Walden, DC
Tyson K. Cobb, MD
Ying Cao, MSc

Hypothesis: Interposition following arthroscopic resection arthroplasty (ARA) for thumb carpometacarpal (CMC) osteoarthritis (OA) does not affect outcome with respect to pain, pinch, grip, and satisfaction. The purpose of this study was to compare the subjective and objective outcomes following ARA for basal joint arthritis to determine differences between two groups: those who received interposition versus those who did not.

Methods: Patients were prospectively enrolled and data were collected preoperatively and postoperatively at 1, 3, 6, and 12 months and annually thereafter. IRB approval and signed consents were obtained. One hundred seventy eight cases underwent ARA for thumb CMC OA between 2004-2011. Patients were excluded if they had less than 1-year follow-up or underwent concomitant surgical procedures that would likely interfere with the assessment of the variable of interest (interposition). GRAFTJACKET® (Wright Medical Technology, Inc.) interposition was used most often therefore atypical types of interposition (19 cases) were excluded. This left 125 cases, 52 ‘with’ interposition and 73 ‘without.’ Mean follow-up was 26 and 19 months for the ‘with’ and ‘without’ interposition groups respectively. Patient-rated satisfaction was evaluated at final follow-up (0 = ‘completely dissatisfied’, 5 = ‘completely satisfied’). Pinch and grip measurements were obtained by an occupational hand therapist.

Descriptive statistics were evaluated on all baseline variables. Raw change scores of grip, pinch, and pain outcomes were evaluated. Confounding variables at a significance level of P<0.05 were adjusted for in linear mixed models and an analysis of covariance was employed through an unstructured type of variance-covariance matrix.

Results: Baseline data for both groups are shown in Table 1. Changes in outcome from preoperative to final postoperative follow-up (minimum 1-year) for pain, pinch, and grip scores are shown in Table 2. Hand dominance, work comp, work type, and pre-op symptom length significantly affected outcomes and were controlled for in the analyses between the ‘with’ versus ‘without’ interposition groups. Raw and adjusted data (corrected for confounding variables) show no difference when comparing ‘with’ and ‘without’ interposition in pain (P=0.86), pinch (P=0.32), and grip (P=0.51). Mean final satisfaction was 4.65 (range 1-5) and 4.39 (range 1-5) for the ‘with’ and ‘without’ interposition groups respectively. There were 4 failures in the ‘with’ and 2 in the ‘without’ interposition group.

Summary Points:
- This study suggests interposition is not warranted following ARA for thumb CMC OA.
- The routine use of expensive interposition products should be abandoned or closely evaluated with a prospective randomized controlled trial

Table 1: Baseline characteristics of patients who underwent arthroscopic resection arthroplasty of the thumb carpometacarpal joint.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>CMC ‘With’ (n=52)</th>
<th>CMC ‘Without’ (n=73)</th>
<th>Total (n=125)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male-n (%)</td>
<td>12 (23)</td>
<td>16 (22)</td>
<td>28 (22)</td>
</tr>
<tr>
<td>Female-n (%)</td>
<td>40 (77)</td>
<td>57 (78)</td>
<td>97 (78)</td>
</tr>
<tr>
<td>Age-mean (range)</td>
<td>59 (42-72)</td>
<td>52 (35-83)</td>
<td>60 (35-83)</td>
</tr>
<tr>
<td>Dominant Side Involved-n (%)</td>
<td>26 (50)</td>
<td>39 (53)</td>
<td>65 (52)</td>
</tr>
<tr>
<td>Work Comp Cases-n (%)</td>
<td>15 (29)</td>
<td>6 (8)</td>
<td>21 (17)</td>
</tr>
<tr>
<td>Pain-mean (range)</td>
<td>6.50 (4-10)</td>
<td>6.31 (1-10)</td>
<td>6.41 (1-10)</td>
</tr>
<tr>
<td>Pinch (kg)-mean (range)</td>
<td>4.14 (0-17)</td>
<td>5.14 (1-12)</td>
<td>4.64 (0-17)</td>
</tr>
<tr>
<td>Grip (kg)-mean (range)</td>
<td>21 (0-86)</td>
<td>20 (0-47)</td>
<td>20.5 (0-86)</td>
</tr>
</tbody>
</table>

Table 2: Mean changes in pain, pinch and grip.

<table>
<thead>
<tr>
<th>Changes in Outcomes from Preoperative to Final Follow-up</th>
<th>With Interposition (n=52)</th>
<th>Without Interposition (n=73)</th>
<th>With Interposition vs Without Interposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum 1-year Mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Pain (pre- to post-op)</td>
<td>5.79 (2.15)</td>
<td>4.98 (2.24)</td>
<td>0.86 (1.0, 1.3)</td>
</tr>
<tr>
<td>Change in Pinch (kg)</td>
<td>1.54 (2.28)</td>
<td>0.96 (2.30)</td>
<td>0.32 (2.0, 2.0)</td>
</tr>
<tr>
<td>Change in Grip (kg)</td>
<td>3.21 (11.31)</td>
<td>3.79 (7.42)</td>
<td>0.51 (4.1, 7.1)</td>
</tr>
</tbody>
</table>

PAPER 30

Clinical Paper Session 05: The Thumb: Trauma, Arthritis, and Injury
Friday, September 19, 2014 • 11:32–11:39 AM
Category: Prognosis/Outcomes
Keyword: Hand and Wrist

Determining Disability After Finger and Thumb Revision Amputations
Level 3 Evidence

Aviram M. Giladi, MD
Evan McGlinn, BS
Melissa J. Shauver, MPH
Kevin C. Chung, MD, MS

Hypothesis: Impairment and disability ratings after finger amputations are based on anatomic injury patterns as outlined in the American Medical Association’s Guides to the Evaluation of Permanent Impairment (AMA

Table 1: Results from Pearson’s correlation analysis between patient-reported outcomes, functional tests, and impairment scores.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Grip Strength</th>
<th>2-point pinch</th>
<th>JTT</th>
<th>PCS</th>
<th>MCS</th>
<th>AMA Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>bMQH</td>
<td>0.32*</td>
<td>0.26*</td>
<td>0.44*</td>
<td>0.51*</td>
<td>0.25*</td>
<td>–0.21</td>
</tr>
<tr>
<td>quickDASH</td>
<td>–0.49*</td>
<td>–0.35*</td>
<td>0.37*</td>
<td>–0.56*</td>
<td>–0.17</td>
<td>0.13</td>
</tr>
<tr>
<td>AMA score</td>
<td>–0.08</td>
<td>0.10</td>
<td>0.47*</td>
<td>–0.06</td>
<td>0.2</td>
<td>__</td>
</tr>
</tbody>
</table>

*significant correlation with p ≤ 0.05

Speaker has nothing of financial value to disclose
Guides). These ratings determine disability status and compensation, without considering validated methods for measuring outcomes. We hypothesize that patient-reported outcome questionnaires (PROs) will reflect functional and health-related quality-of-life (QoL) outcomes after traumatic finger amputations, and that AMA Guides scoring does not accurately rate post-amputation disability.

**Methods:** Patients were placed into one of four groups: single finger amputation, thumb amputation, multi-finger amputation, and multi-finger plus thumb amputation. 82 patients completed functional tests (grip and pinch strength), Jebsen-Taylor composite functional test (JTT), and three PROs — Brief Michigan Hand Questionnaire (bMHQ), Quick Disability of Arm, Shoulder, and Hand questionnaire (quickDASH), and Short-Form 36 (SF-36) QoL questionnaire. Patients were given anatomic impairment scores according to the AMA Guides. Correlations between outcomes metrics were evaluated with Pearson’s correlation coefficients, and linear regression modeling evaluated associations between amputation group, AMA impairment score, and outcomes measures.

**Results:** Both bMHQ and quickDASH had significant correlation with functional tests, JTT, and physical component summary (PCS) of SF-36 (Table 1). Only bMHQ correlated with mental component summary (MCS) of SF-36 ($r = 0.25, P = 0.02$). AMA impairment score only showed correlation with JTT ($r = 0.47, P < 0.001$). Regression results indicate that bMHQ, quickDASH, and AMA score all predict JTT results; however, amputation group and AMA score do not predict PRO results (Table 2).

**Summary Points:**
- AMA score, the current standard for impairment rating, only represents anatomic and functional outcomes without addressing mental health and other components of disability, and is inadequate for determining post-amputation disability
- Anatomic level of amputation does not predict PRO scores, indicating other factors determine outcomes after traumatic finger and thumb amputations aside from injury pattern
- Brief MHQ outperformed other outcomes metrics, correlating with physical and mental health scores

**Hypothesis:** Trapeziectomy with Thompson suspensionplasty (TS) and prosthetic arthroplasty with pyolytic carbon hemiarthroplasty (PH) are two procedures which have been used to treat thumb trapezial-metacarpal (TM) joint arthritis. We hypothesized that patients treated with PH would have less radiographic thumb metacarpal subsidence and superior range of motion (ROM), pinch strength and subjective patient outcome scores compared to complete trapeziectomy and soft-tissue suspension with TH.

**Methods:** A retrospective review compared patients treated with PH versus TH for TM arthritis. Patients were assessed for thumb metacarpal subsidence, ROM, grip and pinch strengths and patient-rated outcomes, including a visual analogue scale (VAS) for pain, satisfaction, disability, and the Nelson score — a thumb basal joint specific questionnaire.

**Results:** Eighty-four patients (69 with osteoarthritis, 9 with inflammatory arthritis and 6 with post-traumatic arthritis) were included. Forty-three were treated with PH and 41 with TS, followed for an average of 3.3 years (SD = 2.2) and 5.5 years (SD = 3.1) respectively. Preoperatively patients in both treatment cohorts were similar with regards to age, type of arthritis, ROM, and preoperative pinch strength. There was no difference in metacarpal subsidence between groups from immediate postoperative to final follow-up radiographs. There was no difference in postoperative radial abduction or palmar abduction between groups. There was greater opposition pinch strength in those undergoing PH ($P = 0.1$, SD = 2.5) versus TS ($P = 0.01$) and greater opposition apophyseal pinch strength in those undergoing PH ($P = 0.01$, SD = 2.5) versus TS ($P = 0.003$). There were no differences in VAS pain scores or surgery satisfaction scores, but there were significantly higher Nelson scores in patients undergoing PH ($P = 0.01$, SD = 2.5) versus TS ($P = 0.04$). There was a higher mean number of complications per year in patients undergoing PH ($P = 0.01$, SD = 2.5) versus TH ($P = 0.01$, SD = 2.5).

**PAPER 31**

Clinical Paper Session 05: The Thumb: Trauma, Arthritis, and Injury
Friday, September 19, 2014 11:39—11:46 AM
Category: Treatment, Surgical Technique
Keyword: Hand and Wrist

**Comparison of Thompson Suspensionplasty Versus Pyrolytic Carbon Implant Hemiarthroplasty in the Treatment of Trapeziometacarpal Arthritis of the Thumb**

**Level 3 Evidence**
- Mark A. Vitale, MD, MPH
- Marco Rizzo, MD
- Steven L. Moran, MD

**Speaker has nothing of financial value to disclose**

---

**Table 2:** Results from multiple linear regression models correlating patient-reported outcomes, functional tests, and impairment scores.

<table>
<thead>
<tr>
<th></th>
<th>JTT</th>
<th>Brief MHQ</th>
<th>Quick DASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef ($P$)</td>
<td>Coef ($P$)</td>
<td>Coef ($P$)</td>
<td>Coef ($P$)</td>
</tr>
<tr>
<td>Brief MHQ</td>
<td>$-0.18 (0.001)^*$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quick DASH</td>
<td>$-0.15 (0.01)^*$</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AMA Score</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>$-0.16 (0.01)^*$</td>
<td>$-0.15 (0.01)^*$</td>
<td>$-0.16 (0.02)^*$</td>
</tr>
<tr>
<td>Gender</td>
<td>$-2.41 (0.32)$</td>
<td>$-1.96 (0.43)$</td>
<td>$-2.88 (0.25)$</td>
</tr>
<tr>
<td>Amputation Group</td>
<td>$-1.95 (0.05)^*$</td>
<td>$-2.21 (0.03)^*$</td>
<td>$-2.58 (0.22)$</td>
</tr>
<tr>
<td>Workers’ Compensation</td>
<td>-$0.26 (0.90)$</td>
<td>-$0.16 (0.94)$</td>
<td>-$1.15 (0.80)$</td>
</tr>
<tr>
<td>Household Income</td>
<td>$-$</td>
<td>$-$</td>
<td>$-$</td>
</tr>
<tr>
<td>Less than $30,000</td>
<td>$-$</td>
<td>$-$</td>
<td>$-$</td>
</tr>
<tr>
<td>$30,000 - $69,999</td>
<td>$1.75 (0.46)$</td>
<td>$-2.03 (0.41)$</td>
<td>$-1.18 (0.63)$</td>
</tr>
<tr>
<td>Over $70,000</td>
<td>$-1.99 (0.44)$</td>
<td>$-1.95 (0.46)$</td>
<td>$-3.90 (0.13)$</td>
</tr>
</tbody>
</table>

$^*$ regression coefficient
$^*$ $P$ value for regression coefficient
*significant result with $P < 0.05$
who underwent PH relative to TS were at significantly increased risk of complication \( (P<0.01) \), reoperation \( (P<0.01) \) and joint revision surgery \( (P<0.01) \).

**Summary Points:**
- PH provided superior postoperative pinch strength and subtle improvements in subjective outcome as evidenced by Nelson scores.
- TS provided a lower risk of complications, reoperation or joint revision surgery.
- The decision to perform prosthetic arthroplasty with PH versus soft-tissue suspension with TS for TM joint arthritis should be made with patient goals in mind and in light of the higher risk of complications associated with prosthetic arthroplasty.

**REFERENCES**


**PAPER 32**

Clinical Paper Session 05: The Thumb: Trauma, Arthritis, and Injury
Friday, September 19, 2014 ● 11:46–11:53 AM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Diseases and Disorders

**Locking Plate Arthrodesis Versus LRTI for Thumb CMC Arthrosis: Early Outcomes From a Longitudinal Cohort Study**

Level 3 Evidence
◆ Nikolas H. Kazmers, MD, MSE
◆ K.J. Hippensteel, MD
◆ Ryan Patrick Calfee, MD
◆ Lindley Wall, MD
◆ Richard H. Gelberman, MD
◆ Daniel A. Osei, MD

**Hypothesis:** Trapeziozmetacarpal arthrodesis (TMA) has been complicated by nonunion, hardware failure, and pin track infection when performed with Kirschner wires. Based on renewed interest in TMA within our practice, we hypothesized that TMA with a locking plate construct (TMA) would afford reliable bony union while producing greater hand function than LRTI at early follow up.

**Methods:** We enrolled 30 consecutive patients with a diagnosis of trapeziometacarpal osteoarthritis over 7 months (14 TMA patients [15 thumbs], 16 LRTI patients [16 thumbs]). The study was powered to detect a minimal clinically important difference (MCID) on the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire between the treatment groups. Secondary outcomes included the Michigan Hand Questionnaire (MHQ), Visual Analog Pain (VAS-pain), and EQ-5D-3L scores. Additionally, patients were examined to evaluate thumb motion, grip strength, and lateral pinch strength. TMA patients were examined for fusion site tenderness and underwent radiographs to evaluate for union. Complications were recorded in each group.

**Results:** Mean follow-up was 4.9 months (5.2 months for TMA, 4.6 months for LRTI), and the mean age was 59.2 years (61.9 for TMA, 56.1 for LRTI). Union was achieved by all 15 TMA thumbs at latest follow-up. Patient-rated disability on the QuickDASH demonstrated similar improvement after TMA and LRTI (48 to 36, 50 to 34 respectively; Figure 1). Postoperative patient-rated health status, upper extremity function, pain levels and objective measures of thumb motion were similar between groups (Table 1).

**Figure 1 – Primary outcome data: mean change in QuickDASH score. Bars represent standard error of the mean.**

**Table 1 - Analysis of secondary outcomes.**

◆ Speaker has nothing of financial value to disclose
Both pinch strength (4.9 vs 3.6 kg, \( P=0.029 \)) and grip strength (26.3 vs 19.0 kg, \( P=0.012 \)) were significantly greater in the TMA group. There were no early complications in either group.

Summary Points:
- At early follow up, patient-rated disability and function were similar among patients who underwent TMA and LRTI.
- TMA produced significantly greater pinch and grip strength compared to LRTI.
- Locking plate technology affords rigid fixation for TMA with promising early results noting reliable bony union while minimizing complications.

References:


Consulting Fee: DePuy/Synthes (Calfee, Osei)

PAPER 33

Clinical Paper Session 05: The Thumb: Trauma, Arthritis, and Injury
Friday, September 19, 2014 • 11:53 AM–12:00 PM
Category: Therapy/Rehabilitation, Anatomy, Basic Science
Keyword: Hand and Wrist

Muscle Control of the First Carpometacarpal Joint

N/A - Not a clinical study

- Mireia Esplugas, MD
- Nathalie Mobargha, MD
- Alex Lluch, MD
- Marc Garcia-Elias, MD, PhD
- Elizabeth Hagert, MD, PhD

Hypothesis: Biomechanical studies have highlighted the importance of osseous and muscle stability for the CMC1 during its wide range of motion to enable both power grips and fine tuned precision tasks.

The purpose of this study is to:
1. Analyze which positions may stabilize or destabilize CMC1 and
2. Examine individual muscle acting on CMC1 during isometric load.

By doing so, we may yield a greater understanding of the osseous stability and the neuromuscular balance of CMC1 joint.

Methods: 10 fresh frozen cadavers with no signs of CMC1 osteoarthritis were used. The specimens were dissected, leaving the 4 extrinsic muscle tendons and the 5 intrinsic muscles with impact on CMC1: abductor pollicis brevis (APB), flexor pollicis brevis (FPB), opponens pollicis (OPP), flexor pollicis longus (FPL), adductor pollicis (AddP), abductor pollicis longus (APL), extensor pollicis brevis (EPB), extensor pollicis longus (EPL) and the first dorsal interosseous muscle (FDI).

CMC1 joint ligaments were preserved.

The specimens were tested in a special apparatus designed for biomechanical studies. They were adjusted in seven planes of thumb opposition. Strings were attached to the specific tendons allowing individual muscle testing, providing data for each specific thumb position.

The data were collected using sensors (Fast-Track System), enabling us to calculate and analyze spatial changes in relation to CMC-1. Statistical analysis was performed using SPSS. Independent samples and paired samples T-tests were performed. Significance was set at \( P<0.05 \).

Results:
1. The most stable CMC1 position was the one combining full thumb extension and full adduction. The least stable CMC1 position was the one combining neutral thumb flexion with full abduction. These findings were statistically significant (\( P<0.05 \)).
2. The muscle with the most stabilizing effect on CMC1 was FDI. On the other hand, APL had overall the most destabilizing effect on CMC1. These findings were statistically significant (\( P<0.05 \)) when comparing FDI and APL by using Student’s T-Test.

Summary Points:
- CMC1 joint most stable position should be taken into account during its mobilization for pain control.
- Brand and Hollister described the role of FDI as a CMC1 stabilizer in 1985. Boutan et al. studied the interrelationship between FDI and OPP to stabilize the CMC1. Our biomechanical study confirms their results.
- Dynamic stability rehabilitation approach to conservative intervention for persons with a painful or hypermobile CMC1 should emphasize in FDI and OPP. APL strengthening should be avoided.
- Calder et al. found that persons with hand OA have weaker FDI muscle strength; is it the cause or the consequence?

Figure 1: Intrinscit thumb muscles insertions were replicated through bone perforations; their function with pulleys.
REFERENCES

PAPER 34
Clinical Paper Session 06: Arthritis
Friday, September 19, 2014 • 11:25—11:32 AM
Category: Treatment, Surgical Technique, Historical Information, Prognosis/Outcomes
Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Diseases and Disorders
The Incidence of Upper Extremity Surgery for Rheumatoid Arthritis: A National, Population-Based Longitudinal Cohort Study
Level 3 Evidence
Jennifer F. Waljee, MD, MS
Lin Zhong, MD, MPH
Hyungjin M. Kim, ScD
Onur Baser, PhD
David A. Fox, MD
Kevin C. Chung, MD, MS
Hypothesis: Globally, rates of surgery for rheumatoid arthritis (RA) are declining due to advances in medical therapy and the early initiation of disease-modifying anti-rheumatic agents. However, for many elderly RA patients, aggressive immunosuppressive agents are difficult to tolerate due to the frequency of comorbid conditions and the risk profile of these medications. For these patients, surgery remains an important treatment option to alleviate joint pain and deformity. Yet, the epidemiology of upper limb surgical reconstruction for RA among older individuals with RA is not known.
Methods: We identified 11,352 Medicare beneficiaries diagnosed with RA between 2000 and 2005. In this cohort, 258 upper extremity procedures were performed among 123 patients, and 56 (45.5%) underwent multiple procedures. The most common initial procedure performed was MCP arthroplasty (20%) followed by tendon reconstruction (16%), and synovectomy of the hand (16%). Table 1 Shoulder arthroplasty (13%) was performed less commonly, followed by wrist arthroplasty (11%). The average time to surgery following diagnosis was 1.4 years. Overall, younger patients underwent surgery much more quickly compared with older patients. The probability of undergoing surgery for RA within 2 years of diagnosis was higher for younger individuals, with 1% of patients aged 65 to 69 years, compared with less than 0.5% of individuals aged 80 and older (Figure 1).

Summary Points:
- Joint replacement and soft tissue reconstruction of the hand remain the most common initial procedures, within the first two years following the diagnosis.
- Younger individuals are more likely to undergo upper extremity procedures for RA compared with older patients. These findings suggest that although younger patients may be more likely to tolerate aggressive medical regimens, the need for upper extremity reconstruction remains prevalent among RA patients.

Figure 1: Cumulative probability of undergoing upper extremity surgery for rheumatoid arthritis following diagnosis.

PAPER 35
Clinical Paper Session 06: Arthritis
Friday, September 19, 2014 • 11:32—11:39 AM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist

Table 1: Initial upper extremity surgical procedures among RA patients newly diagnosed between 2001 and 2005.

<table>
<thead>
<tr>
<th>Procedures</th>
<th>N</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP arthroplasty</td>
<td>31</td>
<td>20</td>
</tr>
<tr>
<td>Tendon Reconstruction</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Hand synovectomy</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>PIP arthrodesis</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>MCP arthrodesis</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>PIP arthroplasty</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>CMC arthroplasty</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>CMC arthrodesis</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist arthrodesis</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Wrist arthroplasty</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Wrist synovectomy</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow arthroplasty</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Shoulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder arthroplasty</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

Total: 158 initial procedures

Results: We identified 11,352 Medicare beneficiaries diagnosed with RA between 2000 and 2005. In this cohort, 258 upper extremity procedures were performed among 123 patients, and 56 (45.5%) underwent multiple procedures. The most common initial procedure performed was MCP arthroplasty (20%) followed by tendon reconstruction (16%), and synovectomy of the hand (16%). Table 1 Shoulder arthroplasty (13%) was performed less commonly, followed by wrist arthroplasty (11%). The average time to surgery following diagnosis was 1.4 years. Overall, younger patients underwent surgery much more quickly compared with older patients. The probability of undergoing surgery for RA within 2 years of diagnosis was higher for younger individuals, with 1% of patients aged 65 to 69 years, compared with less than 0.5% of individuals aged 80 and older (Figure 1).

Summary Points:
- Joint replacement and soft tissue reconstruction of the hand remain the most common initial procedures, within the first two years following the diagnosis.
- Younger individuals are more likely to undergo upper extremity procedures for RA compared with older patients. These findings suggest that although younger patients may be more likely to tolerate aggressive medical regimens, the need for upper extremity reconstruction remains prevalent among RA patients.

Figure 2: The muscle fibers of the First Dorsal Interosseous (FDI) do not cross the CMC joint. Therefore, it has long been overlooked as an important muscle in the study of CMC1 joint.

Figure 3: The muscle fibers of the First Dorsal Interosseous (FDI) do not cross the CMC joint. Therefore, it has long been overlooked as an important muscle in the study of CMC1 joint.
Hypothesis: Arthroplasty remains an established motion preserving treatment for proximal interphalangeal (PIP) joint arthritis. The aim of this report is to review clinical, subjective and radiographic results of pyrocarbon hemiarthroplasty in the treatment of PIP arthritis.

Methods: 45 fingers in 40 patients underwent hemiarthroplasty between 2005 and 2011. Preoperative diagnoses included 30 with osteo or post-traumatic arthritis and 10 with inflammatory arthritis. The female to male ratio was 33:7. The average age at time of surgery was 56 years. The average follow-up period was 4.62 years. A student’s t-test was used to assess statistical significance.

Results: To date there has been significant improvement in patient satisfaction measures including COPM (performance and satisfaction) scores and DASH as well as VAS pain scores. There was no significant change in ROM, grip and pinch strength following surgery. Four joints were revised for failure: 3 underwent salvage to successful arthrodesis and another was converted to a silicone hinged PIP arthroplasty. Radiographic positions of the implant demonstrate a Sweets and Stern grade 0 in 44 implants to date and grade 3 in one.

Summary Points: PIP pyrocarbon hemiarthroplasty appears to be a viable alternative to PIP arthroplasty in the treatment of PIP joint arthritis. Clinical and patient satisfaction outcomes compare favorably with published outcomes of arthroplasty. Radiographic outcomes are encouraging with respect to implant positioning and loosening. Hemiarthroplasty affords a simpler procedure that preserves more bone stock which hopefully allows for better success of salvage options such as fusion and revision arthroplasty. Indications are still being refined and longer term outcomes will better validate its use.

REFERENCES

Patient Expectations and Long-Term Outcomes in Rheumatoid Arthritis Patients

Hypothesis: The purpose of this paper is to compare expectations regarding hand function/appearance with the long-term experiences for a surgical and nonsurgical cohort of rheumatoid arthritis (RA) patients. We hypothesize those surgical patients with greater pre-operative expectations will report better outcomes at follow up compared to nonsurgical patients.

Methods: Patients were recruited as a part of a larger NIH-funded prospective cohort study evaluating the outcome of silicone metacarpophalangeal arthroplasty (SMPA). Patients selected whether or not to undergo SMPA. A total of 169 RA patients with severe deformities at the metacarpophalangeal joint.
joints were recruited in the original study from 2004 to 2009. All patients, regardless of treatment, were asked to complete the baseline expectation questionnaire as if they were going to undergo SMPA. Patients were asked to evaluate their treatment experience a minimum of 3 years following enrollment in a follow-up questionnaire.

Results: Baseline expectation questionnaires were collected from 142 patients (61 surgical and 81 nonsurgical), and follow-up data from 84 patients. Patients were contacted at an average of 6.7 years after enrollment in the study. At baseline, a significantly higher percent of surgical patients expected to do “Anything I want” or “More activities than I do now” one year from enrollment than non-surgical patients (85% vs. 54%; \(P < 0.001\)). At follow-up, surgical patients remained more likely to indicate that they were currently able to do “Anything” or “More activities” than non-surgical patients (60% vs. 9%, \(P < 0.001\)). The results for work, pain and appearance showed similar results with a greater percentage of surgical patients both anticipating and experiencing more desirable outcomes than the non-surgical group. In surgical patients (N=30), 83% were “very satisfied” or “quite satisfied” with their treatment, compared to 63% of nonsurgical patients (N=54).

Summary Points:
- RA subjects who had SMPA reported greater expectations prior to surgery and also greater levels of hand function and satisfaction at long-term follow up.
- Nonsurgical subjects had significantly lower expectations at baseline and lower levels of desirable outcomes for hand function, work, pain and appearance at follow up.

Table 1: Percent of patients with more desirable outcome expected at baseline and realized at follow-up for all patients and by treatment group*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Total</th>
<th>Surgical</th>
<th>Non-Surgical</th>
<th>p-value**</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipated a</td>
<td>67% (95/141)</td>
<td>85% (52/61)</td>
<td>54% (43/80)</td>
<td>&lt;.001</td>
<td>5.0 (2.2, 11.4)</td>
</tr>
<tr>
<td>Experienced b</td>
<td>27% (23/84)</td>
<td>60% (18/30)</td>
<td>9% (5/54)</td>
<td>&lt;.001</td>
<td>14.7 (4.5, 47.6)</td>
</tr>
<tr>
<td>Work</td>
<td>67% (94/141)</td>
<td>89% (54/62)</td>
<td>50% (40/80)</td>
<td>&lt;.001</td>
<td>7.7 (3.1, 19.0)</td>
</tr>
<tr>
<td>Anticipated</td>
<td>30% (25/84)</td>
<td>47% (14/30)</td>
<td>20% (11/54)</td>
<td>.01</td>
<td>3.4 (1.3, 9.1)</td>
</tr>
<tr>
<td>Experienced</td>
<td>72% (101/140)</td>
<td>92% (56/61)</td>
<td>57% (45/79)</td>
<td>&lt;.001</td>
<td>8.5 (3.1, 23.4)</td>
</tr>
<tr>
<td>Pain</td>
<td>65% (54/83)</td>
<td>83% (25/30)</td>
<td>55% (29/53)</td>
<td>.009</td>
<td>4.1 (1.4, 12.5)</td>
</tr>
<tr>
<td>Anticipated</td>
<td>70% (98/141)</td>
<td>93% (57/61)</td>
<td>51% (41/80)</td>
<td>&lt;.001</td>
<td>13.6 (4.5, 40.9)</td>
</tr>
<tr>
<td>Experienced</td>
<td>33% (28/84)</td>
<td>80% (24/30)</td>
<td>7% (4/54)</td>
<td>&lt;.001</td>
<td>50.0 (12.9, 193.9)</td>
</tr>
</tbody>
</table>

* Both baseline hand outcome expectation and follow-up responses are dichotomized to more desirable outcomes versus not corresponding to scores of 1, 2 vs. 3, 4 or 5. For example, for activity domain, anything I want/need to do or more activities than I could do (1 or 2) vs. less desirable outcomes (3, 4, or 5).

** From comparison between surgical vs. non-surgical group

a Outcomes anticipated from baseline expectation questionnaire
b Outcomes experienced from follow-up questionnaire

Methods: Utilizing the institutional Joint Registry Database, 128 revision MCP arthroplasties were performed in 64 patients at our institution from 1998 to 2012. The average age at surgery was 62.2 years, average BMI 31.5, with 69% involving the dominant extremity, 84% females, 8% smokers, and 8%

---

**Table 1: Hazard Ratios for Implant Failure in Revision MCP Arthroplasty**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at Surgery</td>
<td>0.99</td>
<td>0.94 – 1.03</td>
<td>.63</td>
</tr>
<tr>
<td>BMI</td>
<td>0.99</td>
<td>0.99 – 1.01</td>
<td>.64</td>
</tr>
<tr>
<td>Female</td>
<td>0.68</td>
<td>0.33 – 2.95</td>
<td>.57</td>
</tr>
<tr>
<td>Dominant Extremity</td>
<td>1.60</td>
<td>0.53 – 5.87</td>
<td>.43</td>
</tr>
<tr>
<td>Smoker</td>
<td>0.58</td>
<td>0.03 – 3.27</td>
<td>.29</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>0.90</td>
<td>0.90 – 0.91</td>
<td>.04</td>
</tr>
<tr>
<td>Rheumatoid Arthritis</td>
<td>0.52</td>
<td>0.02 – 1.48</td>
<td>.20</td>
</tr>
<tr>
<td>Prednisone use</td>
<td>0.73</td>
<td>0.26 – 1.86</td>
<td>.52</td>
</tr>
<tr>
<td>Methotrexate use</td>
<td>0.41</td>
<td>0.07 – 1.44</td>
<td>.19</td>
</tr>
<tr>
<td>Varus/Valgus Instability</td>
<td>5.31</td>
<td>0.82 – 32.19</td>
<td>.86</td>
</tr>
<tr>
<td>History of Dislocation</td>
<td>10</td>
<td>6.87 – 8.97</td>
<td>.34</td>
</tr>
<tr>
<td>Flexion Contracture</td>
<td>0.54</td>
<td>0.03 – 2.90</td>
<td>.67</td>
</tr>
<tr>
<td>Pyrolytic implant</td>
<td>1.08</td>
<td>0.51 – 2.16</td>
<td>.65</td>
</tr>
<tr>
<td>Silicone implant</td>
<td>0.58</td>
<td>0.23 – 1.46</td>
<td>.52</td>
</tr>
<tr>
<td>SRA</td>
<td>2.09</td>
<td>0.67 – 5.70</td>
<td>.21</td>
</tr>
<tr>
<td>Prior ORIF</td>
<td>10</td>
<td>3.19 – 31.30</td>
<td>.08</td>
</tr>
<tr>
<td>Bone Graft</td>
<td>0.47</td>
<td>0.07 – 3.78</td>
<td>.52</td>
</tr>
<tr>
<td>Cemented implant</td>
<td>0.47</td>
<td>0.04 – 4.60</td>
<td>.21</td>
</tr>
</tbody>
</table>

---

**PAPER 37**

Clinical Paper Session 06: Arthritis
Friday, September 19, 2014 • 11:46—11:53 AM
Category: Evaluation/Diagnosis, Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Diseases and Disorders, General Principles

Revision Metacarpophalangeal Arthroplasty: A Longitudinal Study of 128 Cases
Level 3 Evidence

Eric R. Wagner, MD  
Matthew T. Houdek, MD  
Steven L. Moran, MD  
Marco Rizzo, MD

Hypothesis: As primary metacarpophalangeal (MCP) arthroplasty continues to rise in its incidence, the need for revision surgery will also rise. There is a paucity of literature examining MCP revision arthroplasty. The objective of this study was to assess the results revision MCP arthroplasty, identifying factors associated with improved outcomes.
with diabetes mellitus (DM). There were 83 with patient’s rheumatoid arthritis (RA) and 6 with Juvenile RA, while 46 patients were using prednisone and 31 methotrexate at the time of surgery. There were 50 were non-constrained implants (30 pyrocarbon and 19 metal-plastic) and 78 were silicone. Cement was used in 20 and bone graft in 9. 13 patients had a history of preoperative flexion contractures, while 8 had MCP instability. Univariate logistic regression and Kaplan-Meier survival analyses were performed.

**Results:** At an average 5.1 years of follow-up, there were 19 (15%) repeat revision surgeries performed. Reasons for revision surgery included dislocation (11), pain with limited motion (4), silicone synovitis and bone resorption (2), infection (1), and metacarpal component loosening (1). The 2, 5 and 10 year survival rates were 89%, 80%, and 78%, respectively (Figure 1). Patients that had a history of DM and prior instability had an increased risk of implant failure ($P<0.01$). There were 3 intraoperative complications involving periprosthetic fractures, including 2 in the proximal phalanx and 1 in the metacarpal. Only 1 of the fractures required circumferential suture stabilization.

**Summary Points:** Revision MCP arthroplasty is a challenging procedure with peri-prosthetic fractures, including 2 in the proximal phalanx and 1 in the metacarpal. Only 1 of the fractures required circumferential suture stabilization. There were 11 (9%) postoperative complications, including 8 MCP dislocations, 1 heterotopic ossification, 1 postoperative fracture and 1 infection. Furthermore, 31 (24%) developed flexion contractures. SRA implants ($P<0.05$) and instability ($P<0.02$) increased the rates of infection, while implants in the dominant extremity ($P<0.04$) increased the rate of flexion contractures. The rates of postoperative dislocation were increased in female patients ($P<0.04$), smokers ($P<0.02$), and SRA implants ($P<0.03$).

**Summary Points:** Revision MCP arthroplasty is a challenging procedure with a 5 year survival of 80% and a relatively high rate of complications and flexion contractures. Worse outcomes are seen in patients with a history of MCP dislocations, smokers, and SRA implants. With increasing use of MCP arthroplasty, there is a need for innovative strategies to optimize long-term outcomes in revision MCP arthroplasty.

---

**PAPER 38**

Clinical Paper Session 06: Arthritis
Friday, September 19, 2014 • 11:53 AM—12:00 PM
Category: Treatment, Surgical Technique
Keyword: Hand and Wrist

**Long-Term Outcomes of Scaphoid Hemi-Resection and Arthrodesis of the Radiocarpal Joint (the SHARC Procedure) for Isolated Radiocarpal Arthritis**
Level 4 Evidence

*William H. Seitz, Jr, MD
A.J. Julka, MD

**Hypothesis:** Arthrodesis of the radiocarpal joint with distal scaphoid hemicresentation can reduce pain and provide functional motion through the midcarpal joint.

**Methods:** Twenty-four patients with isolated radiocarpal arthritis were treated with a procedure to recess the lunate and proximal pole of scaphoid into the metaphyseal bone of the distal radius, resection of the distal one half of the scaphoid was also performed to allow enhanced motion of the capitate head within the midcarpal joint as a “universal joint”. Fixation of the lunate and proximal scaphoid was achieved through flexible tension plates. Controlled early active motion was begun one week after surgery (patients have been followed for an average of 8.8 years, range 5-12 years).

**Results:** All 24 patients developed a stable union at the arthrodesis site. None had hardware problems and there were no infections. Range of motion increased from an average preoperative total arc of flexion-extension of 32 to a total arc of flexion-extension of 68 degrees (range 42 to 110 degrees). Pain ratings on a visual analog scale decreased from an average of 8.7 to 1.2. Twenty-two of 24 patients demonstrated significant increase ability in their activities of daily living. Of the ten patients who had been gainfully employed prior to surgery, nine had returned to work at their regular job. Patients who participated in recreational activities and had been prevented from doing so prior to surgery (tennis, golf, fishing, bowling) were able to resume their recreational athletic activities. One patient had persistent stiffness and was not pleased with his limited motion but had significant pain relief. One patient developed mid Carpal arthritis and was converted to a total wrist arthroplasty. Radiographic analysis has shown deterioration of the mid carpal articular surfaces in only this one patient.

**Summary Points:** Scaphoid Hemi Resection and Limited arthrodesis of the Radiocarpal joint is a viable motion sparing procedure for isolated radiocarpal arthritis. Although there are limitations in the total degree of movement, the motion which persists is functional, pain relief has been substantial and the long term outcomes and follow-up suggest minimal deterioration. This procedure is technically straight forward and appears to be a viable alternative to total wrist arthrodesis when the mid carpal joint is reasonably spared.

---

**PAPER 39**

Clinical Paper Session 07: Carpal Tunnel Syndrome/Cubital Tunnel Syndrome
Friday, September 19, 2014 • 1:45—1:52 PM
Category: Evaluation/Diagnosis, Therapy/Rehabilitation, Medical/Legal
Keyword: Hand and Wrist, Nerve

**Work-Related Factors Associated With Carpal Tunnel Syndrome: Analysis of Pooled Prospective Data From 2532 Workers**
Level 4 Evidence

*David Rempel, MD

**Hypothesis:** Work-related biomechanical factors are related to the development of new cases of carpal tunnel syndrome (CTS) among production and service workers.

**Methods:** Prospective data on 3515 workers, followed for up to 7 years, from 50 companies were pooled from 6 research groups (Dale 2013). Data on workplace exposure to 9 biomechanical factors was collected at baseline for each subject using task level observations and video analysis by researchers blinded to symptom status (Kapellusch 2013). Symptom reports consistent with CTS and electrophysiological measures of median nerve function were collected at regular intervals during the follow-up period by researchers blinded to exposure status. The diagnosis of CTS required symptoms of numbness, tingling, burning or pain in at least one of the first three digits of the hand plus abnormal median nerve latency. Subjects with CTS or polyneuropathy at baseline were excluded from analysis. Continuous exposure variables were split into categories by tertiles. Hazard ratios (HR) were estimated using Cox proportional Hazards models for the dominant hand for each of the exposure variables with adjustment for previously confirmed personal risk factors (age, gender, BMI; Harris-Adamson 2013) and research group.

**Results:** A total of 2532 workers free of CTS or polyneuropathy at baseline had exposure and health outcome data necessary for inclusion in the analyses. During the follow-up period, 182 new cases of CTS were observed. Force estimates (Worker and Analyst Borg CR-10), Repetition Rate of Forceful Hand Exertions, and % Duration Forceful Exertion were significantly related to incident CTS (Table 1). Two of the repetition variables (Total Repetition Rate, HAL Scale: Analyst), % Duration All Exertions, and the two posture variables were not associated with incident CTS.

**Summary Points:** Workplace physical factors predictive of CTS in a dose-response pattern were:
- Worker estimates of hand exertion level
- Analyst estimates of hand exertion level
- Repetition rate of forceful hand exertions (video analysis)
- Percent time the hand is applying forceful pinch or grip (video analysis).

Workplace physical factors not predictive of CTS were:
- Analyst repetition rate (HAL scale)
- Total hand repetition rate (video analysis)
- Percent time in wrist extension or flexion greater than 30° (video analysis).

This prospective multi-center study of production and service workers found that several measures of forceful hand exertion at work were significantly associated with future cases of CTS after controlling for age, gender, BMI and research group. These findings may be useful in identifying workplace tasks that increase risk for CTS.

* Speaker has nothing of financial value to disclose
Table 1: Hazard ratios and 95% confidence intervals for dominant hand CTS for 9 work-related biomechanical factors adjusted for age, gender, BMI and study site. Sample sizes of cohort and CTS cases vary based on availability of the exposure measures.

<table>
<thead>
<tr>
<th></th>
<th>Cohort(N)/Cases(N)</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORCED MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Borg CR-10: Worker</td>
<td>2157/153</td>
<td>1.65</td>
<td>1.07</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.99</td>
<td>1.29</td>
<td>3.08</td>
</tr>
<tr>
<td>Peak Borg CR-10: Analyst</td>
<td>2403/174</td>
<td>2.01</td>
<td>1.44</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.83</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td><strong>REPETITION MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAL Scale: Analyst</td>
<td>2412/172</td>
<td>1.47</td>
<td>0.98</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.39</td>
<td>0.94</td>
<td>2.06</td>
</tr>
<tr>
<td><strong>DUTY CYCLE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Duration All Exer.</td>
<td>2031/156</td>
<td>1.04</td>
<td>0.72</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.82</td>
<td>0.51</td>
<td>1.32</td>
</tr>
<tr>
<td><strong>FORCEFUL REPETITION RATE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2303/164</td>
<td>1.49</td>
<td>1.03</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.67</td>
<td>1.08</td>
<td>2.57</td>
</tr>
<tr>
<td><strong>POSTURE MEASURES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Time ≥ 30° Wrist Extension</td>
<td>2294/161</td>
<td>0.97</td>
<td>0.64</td>
<td>1.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.72</td>
<td>0.45</td>
<td>1.13</td>
</tr>
<tr>
<td>% Time ≥ 30° Wrist Flexion</td>
<td>2295/161</td>
<td>0.93</td>
<td>0.61</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.81</td>
<td>0.56</td>
<td>1.16</td>
</tr>
</tbody>
</table>

**REFERENCES**


**PAPER 40**

Clinical Paper Session 07: Carpal Tunnel Syndrome/Cubital Tunnel Syndrome
Friday, September 19, 2014 • 1:52–1:59 PM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Nerve

Simultaneous Bilateral Versus Staged Unilateral Carpal Tunnel Release: A Cost-Effectiveness Analysis

N/A - Not a clinical study

E28

◆ Speaker has nothing of financial value to disclose

Hypothesis: Simultaneous carpal tunnel release (CTR) is more cost effective than staged CTR when surgery is indicated for bilateral carpal tunnel syndrome (CTS).

Methods: A cost effectiveness model (Figure 1) was created to analyze the economic consequences of performing simultaneous bilateral CTR versus staged CTR in a patient with symptomatic bilateral CTS. Probabilities of surgical outcomes (e.g. resolved symptoms, persistent symptoms, pillar pain) were derived from a systematic review of the literature. Direct medical costs were estimated from 2014 Medicare reimbursement rates. To evaluate work absence-related indirect costs after surgery, consecutive patients who underwent simultaneous bilateral CTR (N = 26) or unilateral CTR (N = 27) completed the validated World Health Organization Health Performance Questionnaire. Preference values for health states were derived from a general population using descriptive vignettes and the preference-based SF-6D health questionnaire (N = 50 for each health state). The incremental cost effectiveness ratio (ICER) was calculated to determine the relative cost effectiveness of the treatment options. Sensitivity analysis was performed to assess robustness against parameter uncertainty.

Results: The bilateral simultaneous CTR strategy had an overall cost of $3486 and a total effectiveness of 33.327 QALYs. In comparison, staged bilateral CTR resulted in an additional incremental cost of $1400 and a decrease in effectiveness of 0.803 QALYs (Table 1). Because simultaneous bilateral CTR was both more effective and less costly, this was a dominant strategy when compared to staged bilateral CTR. Patients missed an average of 9.2 days of work after simultaneous bilateral CTR and 9.3 days after the first of staged bilateral CTR. Work absence and work productivity was similar between groups (P = 0.357 and P = 0.208, respectively) despite being similar in sex, age, education and job description (P > 0.05).

In performing a sensitivity analysis, exclusion of work related indirect costs did not affect the outcome of the cost-effectiveness analysis. Bilateral simultaneous CTR remained a cost-effective, dominant treatment strategy compared to staged bilateral CTR.

Summary Points:

- Simultaneous bilateral CTR is more cost effective than staged bilateral CTR, leading to both higher average patient utility and lower total cost.
- Simultaneous bilateral CTR does not increase the time to return to work or decrease work productivity in the early postoperative time period compared with staged bilateral CTR.
- These data may be useful when discussing treatment options for patients with symptomatic bilateral CTS who are considering surgery.

Table 1: Cost effectiveness analysis comparing simultaneous and staged bilateral CTR
Outcomes of Revision Surgical Treatment of the Ulnar Nerve for Cubital Tunnel Syndrome

Clinical Paper Session 07: Carpal Tunnel Syndrome/Cubital Tunnel Syndrome
Friday, September 19, 2014 • 1:59–2:06 PM
Category: Prognosis/Outcomes
Keyword: Elbow and Forearm, Nerve

Hypothesis: Patients undergoing revision surgical treatment of the ulnar nerve at the elbow for cubital tunnel syndrome will have worse results compared to patients successfully treated with primary surgery.

Methods: This case-control investigation enrolled 56 patients treated surgically for cubital tunnel syndrome (28 revision cases, 28 primary controls) at a single tertiary center. Patients with a minimum of two years of follow-up were eligible. All patients completed an in-office study evaluation. Revision participants represented 55% of potential patients in our practice while controls represented 55% of potential patients in our practice to determine if EDX studies predict time to resolution of symptoms after CTR.

Summary Points:
- Revision ulnar nerve surgery at the elbow fails to produce outcomes comparable to primary surgery.
- Revision surgery can be offered in the setting of persistent or recurrent symptoms that are unexplained by an alternative diagnosis, but patients should be counseled that complete symptomatic resolution is unlikely.
- Revision surgery itself, even if transposing the nerve for the first time, may impart a second traumatic insult that renders the nerve less able to recover fully.

Table 1: McGowan grades according to patient group.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Controls</th>
<th>Revisions</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>13 (47%)</td>
<td>13 (47%)</td>
<td>0.26</td>
</tr>
<tr>
<td>II</td>
<td>11 (39%)</td>
<td>9 (32%)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>2 (7%)</td>
<td>6 (21%)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>2 (7%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td>18 (64%)</td>
<td>7 (25%)</td>
<td>0.003</td>
</tr>
<tr>
<td>No Change/Worse</td>
<td>10 (36%)</td>
<td>21 (75%)</td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES


Do Preoperative Nerve Studies Predict Time to Resolution of Symptoms After Carpal Tunnel Release?

Clinical Paper Session 07: Carpal Tunnel Syndrome/Cubital Tunnel Syndrome
Friday, September 19, 2014 • 2:06–2:13 PM
Category: Prognosis/Outcomes
Keyword: Hand and Wrist, Nerve

Hypothesis: Previous studies have found weak or no correlation between pre-operative electrodiagnostic (EDX) studies and functional or subjective outcomes after carpal tunnel release. The purpose of this study is to determine if EDX studies predict time to resolution of symptoms after CTR.

Methods: After IRB approval, patients undergoing open carpal tunnel release (CTR) were prospectively enrolled in this study. Pre-operative presence of symptoms that awaken the patient at night (nocurnal symptoms), and presence of daytime numbness/tingling were documented. The pre-operative EDX studies were reviewed and classified as mild, moderate, or severe. Patients underwent open CTR and then were contacted by phone within 48 hours, at 1...
week, and then at 2 week intervals for up to 3 months or until both night time and day time symptoms had resolved. Kaplan-Meir survival curves were constructed and compared using the Wilcoxon and log rank test. 

**Results:** Daytime numbness and tingling in patients with mild/moderate carpal tunnel syndrome resolved in a mean of 1.6 (95% CI 0.6-2.5) weeks compared to 6.3 (95% CI 3.9-8.8) weeks in patients with severe carpal tunnel syndrome, P = 0.02. Nocturnal symptoms resolved in an average of 0.7 (95% CI 0.5-0.9) weeks for patients with mild/moderate CTS compared to 0.5 (95% CI 0.4-0.7) weeks for patients with severe CTS, P = 0.2. All symptoms resolved in an average of 1.7 (95% CI 0.8-2.7) weeks for patients with mild/moderate CTS compared to 6.3 (95% CI 3.9-8.8) weeks in patients with severe CTS (Figure 3), P = 0.005.

**Summary Points:**
- Patients with mild/moderate CTS, based on preoperative EDX studies, experience a faster time to resolution of daytime numbness and tingling when compared to patients with severe CTS.
- Nocturnal symptoms resolved quickly in both groups.
- These findings allow the surgeon to counsel patients preoperatively on the expected time to resolution of symptoms based on the severity of their CTS.
- The results of this study are in contrast to previous studies that found little to no value of EDX in predicting postoperative functional and subjective outcomes, likely due to the early time points used in the current study.

**REFERENCES**


**PAPER 43**

Clinical Paper Session 07: Carpal Tunnel Syndrome/Cubital Tunnel Syndrome

Friday, September 19, 2014 ● 2:13–2:20 PM

Category: Treatment, Prognosis/Outcomes

Keyword: Hand and Wrist, Nerve

**Postoperative Follow-Up of Extreme Carpal Tunnel Syndrome: How Long Does It Take to Recover Thumb Opposition?**

Level 3 Evidence

- **Tatsuki Ebata, MD**
- **Susumu Tokunaga, MD**
- **Yoshihiro Abe, MD**

**Hypothesis:** In extreme carpal tunnel syndrome (CTS), thumb opposition is impossible due to thenar muscle atrophy. Affected patients demonstrate undetectable compound muscle action potentials of the abductor pollicis brevis (APB-CMAP) following stimulation of the median nerve at the wrist. At the ASH 2012 Annual Meeting, the authors reported that thumb opposition recovered in more than half of extreme CTS patients one year or longer after carpal tunnel release. This study investigated the length of time required to recover thumb opposition and at what time after surgery recovery could be predicted.

**Methods:** From November 2006 to June 2012, 41 hands of 36 patients with undetectable APB-CMAP underwent nerve conduction studies at 2-months intervals until 12 months and were evaluated 1.5 years after carpal tunnel release (the mean age, 64.3 years; the mean follow-up period, 26.7 months). Secondary CTS patients or patients associated with other diseases were excluded. All patients were classified into one of three groups: Group A, APB-CMAP appeared within 6 months after surgery; Group B, APB-CMAP appeared from 7 to 12 months after surgery; and Group C, APB-CMAP remained undetectable at 12 months. Thumb opposition was evaluated by performing a pulp pinch between the thumb and little finger. The Mann–Whitney U-test was used for statistical analysis. A P value of <0.05 was considered statistically significant.

**Results:** Thumb opposition recovered in 24 of 41 hands (58.5%). Thumb opposition recovered in all 21 hands (100.0%) in Group A, in 3 of 11 hands (27.3%) in Group B, and in 0 of 9 hands (0.0%) in Group C. The recovery rate was significantly greater in Group A than in Group B. There was no statistically significant difference between Groups B and C. The recovery rate was significantly greater in Group A than in Group B. There was no statistically significant difference between Groups B and C. Thumb opposition recovered in no hands after 6 months surgery. At 12 months after surgery, thumb opposition recovered in 15 of 24 hands (62.5%) that had recovered by the final follow-up.

**Summary Points:** In extreme CTS, function may be reconstructed by opponenseplasty. However, recovery is unpredictable at the time of surgery. Therefore, secondary opponenseplasty may be an option. We used APB-CMAP as an indicator of recovery because it detects re-innervation of the muscle long before thumb opposition recovers. Good recovery can be expected in hands in which APB-CMAP appears within 6 months, but recovery of thumb opposition takes approximately 1 year or more. On the other hand, we believe that opponenseplasty should be considered if APB-CMAP remains undetectable 6 months after surgery.

**Figure 1:** Precision-extension versus radial-ulnar deviation plots during conduction in the flexors and hinged conditions on the left. Circumflex enevelope superimposed at wrist motion during winding, hammering and dart throwing on the right.

**PAPER 44**

Clinical Paper Session 08: Dupuytren

Friday, September 19, 2014 ● 1:45–1:52 PM

Category: Treatment

Keyword: Hand and Wrist, Diseases and Disorders

**Effect of Baseline Severity on the Safety and Efficacy of Concurrent Collagenase Clostridium Histolyticum Injections to Treat 2 Dupuytren Contractures**

Level 2 Evidence

- **Speaker has nothing of financial value to disclose**
Methods: Patients with ≥ 2 contractures in the same hand caused by palpable cords participated in a 60-day, multicenter, open-label phase 3b study. Two CCH doses (each 0.58 mg) were injected into 1 or 2 cords in the palpable cords participated in a 60-day, multicenter, open-label phase 3b study. Two CCH doses (each 0.58 mg) were injected into 1 or 2 cords in the same hand (one injection per affected joint) during the same visit; finger extension was performed 24-72 hours later. Changes in FFC and range of motion (ROM), rates of clinical success (FFC ≥ 50% reduction from baseline FFC) were summarized by joint and baseline contracture severity (low severity: metacarpophalangeal [MP] joint contracture ≤ 50° contracture, PIP > 40° contracture). Adverse events (AEs) were summarized for all patients, by baseline total FFC (FFC sum of both treated joints; lowest quartile = [≤ 120°]).

Results: The study enrolled 715 patients and 725 joint pairs were treated; 714 patients and 724 joint pairs were analyzed for efficacy. A total of 896 MP joints (588 low severity, 308 high severity) and 552 PIP joints (190 low severity, 362 high severity) were analyzed. Changes in FFC and rates of clinical success or improvement following a single injection per joint were generally greater among low-severity MP or PIP joints, while changes in ROM were greater among high-severity joints (Table 1). Rates of common AEs were generally similar regardless of baseline severity (Table 2). Skin lacerations were the exception, which were less common among patients with baseline total FFC = 120° (32.7%); all were treated with wound care or suture placement.

Summary Points:
- Following concurrent CCH injections to two affected joints (one injection per treated joint), FFC reduction and clinical success rates were higher among joints with lower baseline severity.
- While the rate of clinical success (FFC ≤ 5°) following a single injection per joint among high-severity PIP joints was relatively low (16.6%), mean percent improvement in FFC among these joints was nearly 60%.
- Lacerations were more common among patients with more severe pre-treatment contractures, although this is not expected.

Table 1: Efficiency Ounces/30 Days After Concurrent CCH Injections in Treat Two Dupuytren’s Contractures by Baseline Contracture Severity

<table>
<thead>
<tr>
<th>Joint</th>
<th>Low Severity (n=558)</th>
<th>High Severity (n=503)</th>
<th>Low Severity (n=380)</th>
<th>High Severity (n=332)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP Joints</td>
<td>24.7 (67.7)</td>
<td>60.1 (90.9)</td>
<td>20.5 (60.0)</td>
<td>50.8 (91.6)</td>
</tr>
<tr>
<td>PIP Joints</td>
<td>5.9 (51.0)</td>
<td>3.8 (41.9)</td>
<td>5.1 (43.0)</td>
<td>0.9 (11.9)</td>
</tr>
<tr>
<td>% Change, mean (SD)</td>
<td>32.1 (80.3)</td>
<td>34.0 (84.9)</td>
<td>12.2 (81.0)</td>
<td>38.0 (94.9)</td>
</tr>
<tr>
<td>Total ROM, degrees</td>
<td>86.1 (22.9)</td>
<td>76.7 (27.2)</td>
<td>73.8 (21.3)</td>
<td>58.9 (27.7)</td>
</tr>
<tr>
<td>Baseline, mean (SD)</td>
<td>54.7 (13.6)</td>
<td>59.0 (13.9)</td>
<td>68.5 (13.9)</td>
<td>72.9 (20.7)</td>
</tr>
<tr>
<td>Change, mean (SD)</td>
<td>30.1 (14.2)</td>
<td>48.6 (21.3)</td>
<td>21.4 (18.7)</td>
<td>33.8 (18.8)</td>
</tr>
<tr>
<td>Clinical success, n (%)</td>
<td>440 (81.8)</td>
<td>139 (85.1)</td>
<td>95 (75.7)</td>
<td>69 (76.6)</td>
</tr>
<tr>
<td>Clinical improvement, n (%)</td>
<td>542 (99.2)</td>
<td>255 (99.1)</td>
<td>202 (94.0)</td>
<td>108 (94.5)</td>
</tr>
</tbody>
</table>

Table 2: Most Common Treatment-Related Adverse Events by Baseline Total FFC Percentile After Concurrent CCH Injections in Treat Two Patients’ Contractures

<table>
<thead>
<tr>
<th>All n (%)</th>
<th>1st Quartile (n=179)</th>
<th>2nd &amp; 3rd Quartiles (n=357)</th>
<th>4th Quartile (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema, peripheral</td>
<td>139 (77.4)</td>
<td>274 (78.3)</td>
<td>186 (74.5)</td>
</tr>
<tr>
<td>Numbness</td>
<td>114 (64.0)</td>
<td>20 (58.0)</td>
<td>106 (59.6)</td>
</tr>
<tr>
<td>Pain at incision</td>
<td>93 (52.1)</td>
<td>171 (49.4)</td>
<td>97 (42.0)</td>
</tr>
<tr>
<td>Soreness</td>
<td>131 (73.2)</td>
<td>83 (23.7)</td>
<td>64 (29.2)</td>
</tr>
<tr>
<td>Injection site pain</td>
<td>17 (9.3)</td>
<td>57 (16.3)</td>
<td>27 (14.2)</td>
</tr>
<tr>
<td>Pruritus</td>
<td>32 (17.4)</td>
<td>5 (1.4)</td>
<td>14 (7.2)</td>
</tr>
<tr>
<td>Lymphangitis</td>
<td>24 (13.5)</td>
<td>4 (1.2)</td>
<td>23 (13.9)</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>32 (18.0)</td>
<td>4 (1.2)</td>
<td>28 (14.6)</td>
</tr>
</tbody>
</table>

Hypothesis: Pre-treatment severity of Dupuytren’s contracture can influence the extent of correction with collagenase clostridium histolyticum (CCH) treatment. The effect of baseline contracture severity was evaluated in a post-hoc analysis of a study in which patients received two concurrent CCH injections into cords in the same hand to treat two Dupuytren’s fixed flexion contractures (FFCs).

Early Outcome of Needle Fasciotomy and Collagenase Injection in Treatment of Dupuytren Contracture: A 2-Center Prospective Randomized Clinical Trial

Level 2 Evidence

Peter Scherman, PhD
Per Jemmlaen, MD, PhD
Lars B. Dahlin

Hypothesis: Is there any difference in early outcome after treatment with needle fasciotomy and collagenase injection for finger contracture in Dupuytren’s disease?

Methods: Patients with primary Dupuytren’s contracture deemed suitable for fasciotomy (palpable cord and total extension deficit from 30 to 135 degrees) were randomized to treatment with either needle fasciotomy or collagenase injection at two centers. Passive extension deficits for each joint before and after treatment and at 3-months were recorded together with complications. Mann-Whitney U-test* and Chi-Square test were used for statistical analyses.

Results: In ninety-three patients (i.e. 96 rays) 46 rays were randomized to needle fasciotomy and 40 rays to treatment with collagenase injection [5 patients excluded due to medical reasons (n=3) or preference to collagenase treatment (n=2)]. Five patients were lost to 3-month follow-up. The mean (median) extension deficit pre-treatment for the MCP joint was 53 (55) degrees in both groups. In the PIP joints the extension deficits were 14 (5) degrees in the needle fasciotomy group and 7 (0) degrees in the collagenase group (P=0.10). The total extension deficit was reduced by 82 (82) % in the needle fasciotomy group and by 90 (96) % in the collagenase group immediately after treatment (P=0.01) and by 75 (79) % and 75 (78) %, respectively, at 3-months (P=0.94). Four patients in the needle fasciotomy group and 8 patients in the collagenase group had skin ruptures (P=0.13); all healed uneventfully. No sensory disturbance was recorded in any group. Seven patients in the needle fasciotomy group and 8 patients in the collagenase group still had sporadic pain or discomfort at 3 months (P=0.6).

Summary Points: At 3 months, needle fasciotomy and collagenase injection were not different in correction of finger contracture in Dupuytrens disease, with minor complications.

Consulting Fee: Auxilium/Pfizer (Dahlin)
Contracted Research: Auxilium/Pfizer (Dahlin)

PAPER 45

Clinical Paper Session 08: Dupuytren
Friday, September 19, 2014 • 1:52–1:59 PM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist, Diseases and Disorders

Outcome of Collagenase Injection Versus Fasciectomy in Treatment of Dupuytren Disease

Level 3 Evidence

Raghuveer Muppavaram, MD
Mark R. Belsky, MD
Matthew Leibman, MD
David E. Ruchelsman, MD

Hypothesis: Comparing the efficacy of collagenase clostridium histolyticum injection versus fasciectomy in patients with Dupuytren’s contracture.

Methods: This is a case-control retrospective study. The electronic medical record was reviewed from January 2009 through January 2013, identifying consecutive patients who underwent fasciectomy or collagenase injection

Consulting Fee: Auxilium/Verheyden, Freyne, Frazier
Contracted Research: Auxilium (Verheyden, Freyne, Frazier)
Salary: Auxilium (Kaufman, Tursi, Smith)

PAPER 46

Clinical Paper Session 08: Dupuytren
Friday, September 19, 2014 • 1:59–2:06 PM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist, Diseases and Disorders, Practice Management

Outcome of Collagenase Injection Versus Fasciectomy in Treatment of Dupuytren Disease

Level 3 Evidence

Raghuveer Muppavaram, MD
Mark R. Belsky, MD
Matthew Leibman, MD
David E. Ruchelsman, MD

Hypothesis: Comparing the efficacy of collagenase clostridium histolyticum injection versus fasciectomy in patients with Dupuytren’s contracture.

Methods: This is a case-control retrospective study. The electronic medical record was reviewed from January 2009 through January 2013, identifying consecutive patients who underwent fasciectomy or collagenase injection

Consulting Fee: Auxilium/Verheyden, Freyne, Frazier
Contracted Research: Auxilium (Verheyden, Freyne, Frazier)
Salary: Auxilium (Kaufman, Tursi, Smith)
during this time. A total of 44 patients who had undergone fasciectomy (94 joints) and 73 patients who had received collagenase injection (100 joints) were included for analysis. Exclusion criteria included age 45 degrees. PIP joints contracted >45 degrees had a particularly low success rate at latest follow up in both treatment groups (Collagenase 3% vs Fasciectomy 29%, P=0.041)

**Summary Points:**
- Fasciectomy yields a greater mean magnitude of correction for digital contractures at latest follow up when compared to collagenase.
- Both treatments were more effective for treatment of MP joint contracture compared to PIP joint contracture.
- A higher percentage of patients who underwent fasciectomy were able to maintain extension at final follow up.

**Table 1: Baseline Characteristics of the Patients**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Collagenase (n=73)</th>
<th>Fasciectomy (n=44)</th>
<th>All Patients p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total joints treated</td>
<td>100</td>
<td>94</td>
<td>194</td>
</tr>
<tr>
<td>MP</td>
<td>56</td>
<td>53</td>
<td>109</td>
</tr>
<tr>
<td>PIP</td>
<td>44</td>
<td>41</td>
<td>85</td>
</tr>
<tr>
<td>Age-years</td>
<td>64</td>
<td>65</td>
<td>64</td>
</tr>
<tr>
<td>Male sex-no(%)</td>
<td>61 (83.3%)</td>
<td>33 (75%)</td>
<td>94 (80.3%)</td>
</tr>
</tbody>
</table>

**Table 2: Treatment Outcomes**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Collagenase n=100</th>
<th>Fasciectomy n=94</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joints which met primary end-point after 1-2 months (contracture 0-5 degrees):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All joints (MP + PIP)</td>
<td>51/100 (51%)</td>
<td>66/94 (70%)</td>
<td>0.041</td>
</tr>
<tr>
<td>MP</td>
<td>39/56 (70%)</td>
<td>42/53 (79%)</td>
<td>0.23</td>
</tr>
<tr>
<td>MP &gt;45°</td>
<td>18/25 (72%)</td>
<td>19/22 (86%)</td>
<td>0.15</td>
</tr>
<tr>
<td>PIP</td>
<td>12/44 (27%)</td>
<td>24/41 (59%)</td>
<td>0.043</td>
</tr>
<tr>
<td>PIP &gt;45°</td>
<td>7/10 (70%)</td>
<td>15/17 (88%)</td>
<td>0.045</td>
</tr>
<tr>
<td>Range</td>
<td>1-7</td>
<td>1-8</td>
<td>1-8</td>
</tr>
<tr>
<td>Mean Initial Joint Contracture</td>
<td>52.3°</td>
<td>43.2°</td>
<td>47.6°</td>
</tr>
<tr>
<td>MP</td>
<td>50.2°</td>
<td>42.9°</td>
<td>45.9°</td>
</tr>
<tr>
<td>PIP</td>
<td>56.9°</td>
<td>44.7°</td>
<td>50.6°</td>
</tr>
</tbody>
</table>

**REFERENCES**


**PAPER 47**

Clinical Paper Session 08: Dupuytren
Friday, September 19, 2014 • 2:06—2:13 PM
Category: Treatment
Keyword: Hand and Wrist, Diseases and Disorders

Prospective Multicenter, Multinational Study to Evaluate the Safety and Efficacy of Concurrent Collagenase Clostridium Histolyticum Injections to Concurrently Treat 2 Dupuytren Contractures in the Same Hand
Level 3 Evidence
- Lawrence Hurst, MD
- R Glenn Gaston, MD
- Richard A. Brown, MD
- Gregory J. Kaufman, MD
- James P. Tursi, MD
- Ted Smith, PhD

Hypothesis: This study was conducted to evaluate the safety and efficacy of concurrent administration of two collagenase clostridium histolyticum (CCH) injections into cords in the same hand to concurrently treat two joints with Dupuytren's fixed flexion contractures (FFC) with palable cords.

Methods: Patients with ≥ 2 contractures in the same hand caused by palbable cords participated in a 60-day, multicenter, open-label phase 3b study. Two 0.58-mg CCH doses were injected into one or two cords in the same hand (one injection per affected joint) during the same visit; finger extension was performed 24-72 hours later. Changes in FFC and range of motion (ROM), rates of clinical success (FFC ≤1 treatment-emergent SAE; 6 were considered treatment-related or possibly treatment-related, including 1 anaphylactic reaction that resolved with treatment in the emergency room and 1 tendon rupture (fifth finger flexor digitorum profundus rupture that occurred during finger extension).

Summary Points:
- The registry remains ongoing and continues to collect outcomes data on the use of processed nerve allografts for long gap nerve reconstructions.
- Compared with reported results of phase 3 clinical trials (using ≤ 3 injections/joint, administered as single doses sequentially at 4 week intervals), the current study (using a single injection in each of 2 affected joints, administered concurrently) showed similar efficacy and a similar frequency of most AEs except skin lacerations, which were more frequent in this study.
- These results support those of two previously conducted studies, demonstrating that CCH can be used to effectively treat 2 affected joints concurrently, without a greater risk of AEs compared with treatment of a single joint.
- Two concurrent CCH injections may allow more rapid overall treatment of multiple affected joints, without the need to wait ~4 weeks between treatments as required in the approved labeling.

**Table 1:** Change in Joint Contracture at 6 Months After Concurrent Collagenase Injections (Single injection per Affected Joint)

<table>
<thead>
<tr>
<th>Group</th>
<th>Baseline (mean±SD, degrees)</th>
<th>6 Months (mean±SD, degrees)</th>
<th>Change (Improvment from Baseline (mean±SD, degrees)</th>
<th>% Change (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP</td>
<td>42.6±2.3</td>
<td>22.6±3.2</td>
<td>19.9±3.4</td>
<td>47±4</td>
</tr>
<tr>
<td>PIP</td>
<td>47.2±3.5</td>
<td>30.2±2.5</td>
<td>17.0±3.4</td>
<td>36±3</td>
</tr>
<tr>
<td>Both</td>
<td>44.9±3.6</td>
<td>29.3±3.2</td>
<td>15.6±3.4</td>
<td>34±4</td>
</tr>
</tbody>
</table>
This study assessed safety and efficacy of CCH for the treatment of recurrent contractures in joints that were previously effectively treated with CCH.

**Methods:** This open-label, phase 4 study included patients who were previously treated with CCH.

**Assessments:** Changes in contracture and range of motion (ROM); physician assessment of improvement and patient satisfaction with treatment; or no palpable cord. Additional results are summarized in the Table. The AE profile was consistent with what was reported in phase 3 trials. The most frequently reported AEs included edema peripheral, contusion, pain in extremity, injection site pain, and pruritus, all of which were mild or moderate. No tendon injuries were reported; there was 1 mild ligament injury (A2 pulley strain which resolved after 6 months without intervention).

**Results:** The study included 51 patients with 1 treated joint/patient (31 metacarpophalangeal [MP], 20 proximal interphalangeal [PIP] joints). Of 51 joints, 35 (69%) received 1 injection, 12 (24%) received 2 injections, and 4 (8%) received 3 injections. Overall, 44/51 joints (86%) reached a positive endpoint (clinical success; patient satisfied with treatment; or no palpable cord). Specifically, 29/51 joints (57%) achieved contracture correction to ≤ 5° (clinical success); 8/51 (16%) were not treated to ≤ 5° as the patient was satisfied with the result and opted to not have further injections; and 7/51 (14%) did not receive further injections due to lack of a palpable cord. Additional results are summarized in the Table. The AE profile was consistent with what was reported in phase 3 trials. The most frequently reported AEs included edema peripheral, contusion, pain in extremity, injection site pain, and pruritus, all of which were mild or moderate. No tendon injuries were reported; there was 1 mild ligament injury (A2 pulley strain which resolved after 6 months without intervention).

**Summary Points:**
- Results suggest that recurrent contracture in joints that were previously been successfully treated with CCH can be safely and successfully retreated with CCH.
- 86% of joints retreated with CCH reached a positive endpoint.
- AEs were mild to moderate, local, and without tendon injury.
achieved MRC grade 3 or better power. When contralateral C7 was used as a donor for nerve transfer in restoration of shoulder abduction, only 20% (1/5) achieved MRC grade 3 or better shoulder abduction. 80% (4/5) of patients who had nerve grafts for restoration of elbow flexion achieved MRC grade 4 or better power, while 100% (5/5) achieved MRC grade 3 or better power. In patients with nerve transfers for elbow flexion, 75% (9/12) achieved MRC grade 4 or better power, while 91.7% (11/12) achieved MRC grade 3 or better power. There was no statistical difference in outcome (MRC grade 3 or 4) between patients who had nerve grafts or nerve transfers.

Summary Points:
- Nerve grafts can result in similar outcomes to nerve transfers for restoration of shoulder abduction and elbow flexion in traumatic pediatric patients with BPIs.
- The findings of this study do not support the use of contralateral C7 as a donor for nerve transfers in reconstruction of shoulder abduction in pediatric traumatic BPIs.

PAPER 50
Clinical Paper Session 09: Brachial Plexus
Saturday, September 20, 2014 • 8:45–8:52 AM
Category: Evaluation/Diagnosis, Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Congenital and Pediatric Problems, Nerve, Diseases and Disorders

Free-Functioning Gracilis Transfer for Traumatic Brachial Plexus Injuries in Children
Level 4 Evidence
- Harvey Chim, MD

Hypothesis: Traumatic brachial plexus injury in the pediatric age group is extremely rare. Free functioning muscle transfer (FFMT) can be used for reconstruction of upper extremity function in complete brachial plexus injury either as a single stage transfer or a double free muscle technique for restoration of prehension. The aim of this study was to report our technique and experience with use of FFMT in reconstruction of traumatic brachial plexus injuries in children as well as its complications and outcomes.

Methods: Twelve patients with complete brachial plexus injury underwent FFMT for reconstruction between 2000 and 2012 at a single tertiary referral center. Eight had single stage gracilis transfer for restoration of elbow flexion, while 4 children had double free muscle transfer for restoration of elbow flexion and prehension. Mean duration of follow-up was 27.3 months (range 14 to 55).

Results: Eleven out of 12 patients (91.7%) achieved at least M3 elbow flexion, with 8 patients (66.7%) achieving M4 or greater elbow flexion. Mean active elbow range of motion was 79.2 degrees (range 30 to 130 degrees). Two patients aged 8 and 11 with open growth plates developed elbow joint contractures, which limited range of motion but not strength, with M4 and M5– elbow flexion in these patients. Data on elbow extension was available in 10 patients. Of these, two (20%) had M4- or greater elbow extension. The two patients with elbow flexion contracture had limited elbow extension, with grade M1 and M2. Of the 6 patients who underwent nerve transfers to the axillary nerve and SSN, shoulder abduction ranged from M0 to M3. Data on shoulder active range of motion was available in 7 patients, with a mean of 27.1 degrees (range 0 to 90 degrees). Data on MRC grading of finger flexion was available in 8 patients, with two patients achieving M4 or greater (25%). There were no significant neuropathic pain issues.

Summary Points:
- FFMT in children following traumatic BPI can reliably restore elbow flexion.
- There is a high likelihood of elbow flexion contracture in growing children with open growth plates risks and benefits involved should be balanced when FFMT are used in this age group.
Effects of Anti-NGF Receptor (p75NTR) Antibody on Nociceptive Behavior and Spinal Glia Activation in the Rat Brachial Plexus Avulsion Model (Second Report)

N/A - Not a clinical study

Tomoko Kobayashi, MD
Kazuki Kuniiyoshi, MD, PhD
Yusuke Matsuura, MD
Masataka Shibayama, MD
Takane Suzuki, MD
Seiji Ohotori, MD, PhD

Hypothesis: We hypothesized that inhibition of the p75 neurotrophin receptor (p75NTR), the low-affinity NGF receptor and common neurotrophin receptor, reduces neuropathic pain in the rat brachial plexus avulsion (BPA) model.

Methods: Twenty male Wistar rats were used. In the BPA group (n=5), the C8–T1 roots were avulsed from the spinal cord at the lower trunk level and saline was administered intraperitoneally. In the anti-p75NTR 1.0 µl and 50 µl groups (n=5 each), the C8–T1 roots were avulsed and 1.0 or 50 µl of anti-p75NTR antibody was administered intraperitoneally. In the sham-operated group (n=5), the lower trunk level was simply exposed and saline was administered intraperitoneally. Spinal pain transmission, was immunohistochemically examined in the ipsilateral dorsal-horn of the spinal cord (C7) using anti-GFAP and anti-Iba1 antibodies 3 and 15 days after administration of anti-p75NTR antibodies or saline. Data between groups were analyzed using a Kruskal–Wallis test, followed by Mann–Whitney U-tests. Bonferroni corrections were also performed.

Results: Rats in the BPA group displayed significant mechanical hypersensitivity compared with the sham group (P < 0.01). Mechanical hypersensitivity in both p75 groups was significantly improved after administration of anti-p75NTR antibodies compared with the BPA group. In the CatWalk gait analysis, rats in the BPA group displayed a significantly greater pain-induced gait pattern compared with the sham group (P < 0.01). Gait pattern was significantly improved in both p75 groups compared with the BPA group. GFAP-immunoreactive astrocytes and Iba1-immunoreactive microglia were significantly increased in the BPA group compared with the sham group both 3 and 15 days after administration. However, GFAP-immunoreactive astrocytes in both p75 groups were significantly reduced compared with the BPA group at both time points, while Iba1-immunoreactive microglia in both p75 groups were significantly reduced compared with the BPA group only 15 days after administration (P < 0.01). There was no significant difference between the 1.0 and 50 µl p75 groups (Figures 1 and 2).

Summary Points:
- Anti-p75NTR antibody administration improved hyperalgesia.
- Anti-p75NTR antibody administration suppressed spinal glia activation.
- Inhibition of p75NTR reduces neuropathic pain, thus making it a potential therapeutic target for the clinical treatment of pain following BPA injury.

REFERENCES


PAPER 52

Clinical Paper Session 09: Brachial Plexus
Saturday, September 20, 2014 ● 9:06–9:13 AM
Category: Evaluation/Diagnosis, Treatment, Prognosis/Outcomes, Patient Education
Keyword: Shoulder and Arm, Nerve, General Principles
Preliminary Study on the Psychological Impact of Brachial Plexus Injury
Level 4 Evidence

◊ Zoe A. Landers, LCSW
◊ Steve K. Lee, MD
◊ Carol A. Mancuso, MD, FACP
◊ Scott W. Wolfe, MD

Hypothesis: We hypothesized that brachial plexus injury (BPI) profoundly impacts patients psychologically. This pilot study collected previously unknown clinical data about the psychological effects of BPI, specific patient psychosocial concerns and associated sources of psychological distress, and subsequently engendered ideas for further investigation.

Methods: Between February 2013 and January of 2014, during scheduled preoperative surgical assessments and/or post-operative appointments, the staff social worker at a major brachial plexus center conducted psychosocial interviews utilizing a mixed methods approach with 39 patients to assess the impact of BPI on psychological functioning. Open-ended interview questions explored how BPI affected perception of self in the context of and ability to function in interpersonal, familial, occupational, discretionary, and necessary daily living situations. Further questions investigated how adapting to and accepting their BPI influenced mood and functioning. Patients (n=14) were evaluated for posttraumatic stress disorder (PTSD), depression, and substance use with the following validated scales: Post Traumatic Stress Disorder Checklist-Specific (PCL-S) Patient Health Questionnaire-8 (PHQ-8), National Institute on Drug Abuse Quick Screen (NIDA Quick Screen).

Results: Mean age was 38 and 71.8% were men. Patients were profoundly affected psychologically as evidenced by patient report and higher prevalence of PTSD and depression compared with US population norms.1 Open-ended interview questions revealed ten principle psychosocial concerns and sources of psychological distress ranging from substantial negative impact on self-worth, to increased dependency, to loss of employment. Strikingly, 8 patients (20.5%) of those interviewed expressed passive suicidal ideation. Severity of suicidal ideation was most prevalent in depressed patients currently experiencing PTSD, which is consistent with other studies investigating the impact of comorbid PTSD and depression on suicidality.2 Results of the PCL-S and PHQ-8 supported clinical data from interviews (Table 1). 28.6% met criterion for PTSD with the following rates of DSM-IV diagnostic PTSD symptom clusters reported: re-experiencing (42.9%); avoidance, (35.7%); and hyper-arousal, (57.1%). Although 50% showed symptoms of depression (21.4% mild; 14.3% moderate; 14.3% moderately severe), only 28.6% exhibited clinical depression. Patients disclosed social alcohol and tobacco use but no significant substance abuse patterns were noted based on the NIDA Quick Screen or the interviews.

Summary Points:
• BPI significantly influences psychological well-being and the ability to function in daily life.
• There is a high prevalence of PTSD, depression, and suicidal ideation as a result of BPI.
• BPI patients have unique psychosocial concerns and psychological challenges that may adversely impact outcome of surgical reconstruction,4 and that require specific attention and further study.

REFERENCES

PAPER 53
Clinical Paper Session 09: Brachial Plexus Saturday, September 20, 2014 • 9:13—9:20 AM
Category: Evaluation/Diagnosis, Treatment, Historical Information, Prognosis/Outcomes
Keyword: Elbow and Forearm, Diseases and Disorders, General Principles

Anatomy and Natural History of the Elbow Joint in Obstetric Brachial Plexus Injuries
Level 4 Evidence

◊ Eric Wagner, MD
◊ Bassem T. Elhassan, MD

Hypothesis: To date, there is a paucity of information on the radiographic anatomy of the elbow, progressive changes and relationship to flexion contracture in patients with obstetric brachial plexus injuries (OBPI). The purpose of this study is to evaluate the radiographic anatomy of the elbow and its relation to flexion contracture in patients with OBPI, and the natural history of the radiographic changes of the elbow. We hypothesize that elbow flexion contracture is not related to bony deformity of the elbow, and there is minimal expected bony changes of the elbow over time.

Methods: We examined all patients at our institution with OBPI who had radiographic evaluation of the elbow for a history of elbow flexion contracture. Patients had to have a recent radiograph as we aimed to determine whether bony abnormalities were underlying flexion contractures in OBPI patients. Radiographic evaluation was performed to determine the presence of bony abnormalities of the elbow and the presence of progressive arthritic changes over time. In addition, a detailed medical review was performed focusing on elbow range of motion and function, and past surgical interventions for elbow contracture.

Results: We identified 59 patients who fit our inclusion criteria. 59% were females, with 55% of the injuries involving the right extremity. Every patient used their un-injured extremity as their dominant extremity. At an average clinical follow-up of 24 years (8-75), the average elbow range of motion was 32-122 degrees (total arc of 90). All patients were treated with therapy and splinting for their elbow flexion contracture at some point in their lives, while 12 patients underwent attempt at surgical release. Although 62% of patients reported pain in their affected extremities, only 7% patients localized the pain to their elbow. Four views radiographs of the elbow were performed for all patients at different intervals during their clinical evaluation. Three patients had pathologies involving their ipsilateral elbows, including 2 radial head dislocations and 1 patient with ulnar nerve compression at the elbow. At an average follow-up of 16.5 (4-75) years, only 3 (5%) patients had radiographic evidence of moderate or severe elbow arthritis. 2 of these patients had congenital anterior radial head dislocations.

Summary Points: Patients with OBPI experience a high rate of flexion contractures. However, only 5% of patients with flexion contractures develop arthritis. This study adds an important consideration for surgeons as they evaluate the need for bony procedures when treating flexion contractures for patients with OBPI.
Optimization of an Injectable Tendon Hydrogel: The Effects of Platelet-Rich Plasma and Adipose-Derived Stem Cells on Tendon Healing

N/A - Not a clinical study

**Hypothesis:** Acute and chronic tendon injuries in the hand and upper extremity would benefit from earlier healing. We hypothesize that supplementation of a biocompatible tendon hydrogel with platelet-rich plasma (PRP) and adipose-derived stem cells (ASCs) would accelerate the tendon healing process.

**Methods:** Using 45 Wistar rats, we investigated five experimental conditions in vivo: 1) phosphate buffered saline (PBS) control (50-mL), 2) hydrogel (50-mL), 3) hydrogel (45-mL) PRP (5-mL), 4) hydrogel (45-mL) with ASCs (2x10^6-cells/mL in 5-mL PBS), and 5) hydrogel (45-mL) PRP and ASCs (2x10^6-cells/mL in 5-mL PRP). Hydrogel was developed from decellularized, human cadaveric tendons. Fresh rat PRP was obtained per Amable et al.’s technique, and green fluorescent protein/luciferase-positive rat ASCs were prepared. A full-thickness defect was created within the mid-substance of each Achilles tendon, followed by addition of one of the five conditions. Rats were sacrificed at weeks 2, 4, and 8.

Real-time, in vivo bioluminescence imaging of groups with ASCs was performed. Upon sacrifice, each Achilles tendon underwent biomechanical evaluation. Comparisons across groups were analyzed using the 2-sample Z-test for proportions and the Student t-test for independent samples. Significance was set at P<0.05.

**Results:** Bioluminescence Imaging: 1) Successful ASC implantation was achieved in 35% of defects containing hydrogel with ASCs alone (Group 4) compared to 93% of defects containing hydrogel with ASCs supplemented with PRP (Group 5) (P<0.0001). 2) In vivo, Group 5 attained greater ASC proliferation on post-operative days 1 through 6, in comparison to Group 4 (P<0.05). (Figure 1)

Biomechanical Testing: 1) Mean ultimate failure load (UFL) was increased for optimized hydrogel (Groups 3-5) versus non-optimized hydrogel (Group 2) at week 2 (63.3-64.5 N vs. 54.9-N; P<0.03). By week 4, Group 2 reached a similar mean UFL (75.1-N) to Groups 3-5. However, at week 8, Group 5 demonstrated strength over Group 2 (86.8-N vs. 78.5-N; P<0.04). 2) Mean elastic modulus (EM) was increased in Groups 3-5 versus Group 2 at week 4 (5.9-6.5-kPa vs. 4.6-kPa; P<0.03). At week 8, Group 5 persisted to demonstrate an increase over Group 2 (7.9-kPa vs. 5.6-kPa; P<0.04). (Figure 2)

**Summary Points:**
- PRP is an easily accessible way of maintaining ASC survival in tendon hydrogel ex vivo.
- PRP promotes prolonged ASC cell proliferation and survival in vivo.
- Tendon hydrogel optimized with PRP and ASCs demonstrates superior biomechanical strength at an early time point.
- This optimized tendon hydrogel with PRP and ASCs is a promising agent for accelerating the tendon healing process after injury.

**REFERENCES**

**Evaluation of Loop Suture Knot Elongation and Breaking Strength for Tendon Repair**

N/A - Not a clinical study

**Hypothesis:** Successful flexor tendon repair in Zone II remains vexing. Repair techniques have increased the number of strands crossing the repair site in order to strengthen repair. Polyamide looped suture (Supramid, S Jackson, Inc, Alexandria, VA) doubles the number of core strands for every needle path. This simplifies repair and decreases time. A potential weakness of the repair is the knot itself. Our hypothesis is that the more bulky knot of looped suture may potentially be weaker and result in greater slippage and plastic deformation than non-looped suture.

**Methods:** Using machined steel rods to hold our suture constructs, we compared four different knot configurations using both non-looped and looped suture in 3-0 and 4-0 varieties. In all four constructs, four core strands crossed the construct gap. Each construct was then tested under increasing cyclic loading, which allowed us to record changes in force applied and suture construct lengthening (correlating to clinical gapping), and ultimately to breaking strength.

**Results:** We recorded permanent laxity during cyclic loading: permanent deformation of the construct, resulting in no recoverable change after force is removed. (Figure 1) We defined clinical failure as 2 mm of permanent rod separation. We also determined ultimate load to knot failure.

With regard to permanent laxity, both 3-0 and 4-0 looped sutures fared worse than non-looped suture with 2 mm laxity at 39.9 N and 27.1 N. Non-looped suture single knot fared best at 60.7 N and 41.3 N for 3-0 and 4-0 sutures (Figure 2). Ultimate strength to breaking showed similar results with 3-0 looped suture breaking at the knot at 50.3 N and non-looped suture at 61.5 N. For 4-0 suture, these values were 32.4 N and 41.8 N respectively. All differences were significant statistically.

**PAPER 55**

Clinical Paper Session 10: Tendon
Saturday, September 20, 2014 8:52–8:59 AM
Category: Surgical Technique
Keyword: Hand and Wrist

**REFERENCES**
Summary Points:
- Many innovations aim to increase the number of strands (and hence repair strength) for Zone II repairs to enable postoperative motion protocols and minimize adhesions.
- Loop suture increases the number of repair suture strands and retains simplicity.
- Few studies have evaluated the role of the knot in repair strength.
- The more bulky knot of looped suture may result in repairs of inadequate strength for active motion rehabilitation protocols (roughly accepted at 35 N).

PAPER 56
Clinical Paper Session 10: Tendon Saturday, September 20, 2014 8:59—9:06 AM
Category: Basic Science Keyword: Hand and Wrist

Smart Collagen-Specific Anchors for Tendon-Targeted Delivery of Therapeutic Cells

Hypothesis: Fibrosis after tendon injury and repair remains a vexing clinical problem, and current molecular strategies to improve tendon healing have focused on modulating cellular responses at the injury site. Limitations of previously explored methods include the inefficient therapeutic cell delivery, failure to retain cells within the injury site, and potential safety concerns of cell-based treatment. Our laboratory has engineered a novel artificial collagen-specific anchor (ACSA), enabling the controlled targeting of therapeutic cells to collagen-specific sites. Potential benefits of the ACSA include an inducible collagen-targeting anchor, controlled delivery and retention of cells within an injury site, and decreased requirement of therapeutic cells and duration of treatment. The purpose of this study is to test the hypothesis that 1) GFP-tagged ACSA is expressed on the surface of engineered cells in a promoter dependent fashion, and 2) ACSA expression enhances the attachment of the cell construct to collagen, and that this expression does not interfere with cell proliferation.

Methods: The engineered construct includes the following features: Murine fibroblasts (NIH 3T3), specific anchoring to human type I collagen (C-terminus, a2 chain), tetracycline (Tet)-responsive promoter, and GFP tag for localization. The stable expression of the ACSA-GFP construct was confirmed by culturing the selected transfected cells in the presence or the absence of doxycycline (Dox). The presence of the ACSA-GFP was confirmed by Western blot and microscopy. Cell attachment assays were performed on cells expressing the ACSA construct (Tet-On) and non-induced cells (Tet-Off). Cells were seeded on human collagen I-coated plates. Proliferation assays were performed colorimetrically (Sigma-Aldrich).

Results: GFP-tagged ACSA is expressed on the surface of engineered cells in a Tet promoter-dependent fashion (Fig. 1). Specific antibodies identified the following: the extracellular fragment of the construct (RED), the GFP portion (GREEN), and DAPI-stained nuclei (BLUE). ACSA enhances the attachment of the cell construct to collagen, and this expression does not interfere with cell proliferation (Fig. 2).

Summary Points:
- Fibrosis after tendon injury remains a vexing clinical problem, and current molecular strategies for improving tendon healing are limited by inefficient and non-specific therapeutic delivery.
- This novel cellular construct enables the controlled expression of collagen-targeting anchors at the surface of therapeutic cells, enhancing cellular attachment to collagen-rich sites without disrupting cell proliferation.
- Potential benefits may include the controlled targeting of therapeutic cells to the injury site, improved tendon healing efficiency, and the reduced dispersion of cells into surrounding tissue.
In seven of eight patients, we confirmed active contraction of the flexor or extensor muscles and adequate tension of the transferred tendons during surgery. In one patient, the expected active motion of the flexor pollicis longus did not occur during surgery because the anesthetic effect had spread too widely, involving the motor branch of the median nerve. In two patients, we additionally infiltrated 2 to 3 mL of local anesthetic because of local wound pain. All patients gained satisfactory function of the transferred tendons after the surgery, and there were no remarkable perioperative complications related to local anesthetic systemic toxicity.

Summary Points:
- Selective administration of an anesthetic agent to sensory nerve branches and the subfascial layer enables the performance of wide-awake forearm tendon surgery with a lower amount of local anesthetic than the original wide-awake technique.
- The current ultrasound-guided injection technique provides safe and effective regional anesthesia for wide-awake surgery.

REFERENCES
Zone II Flexor Tendon Repair Using Knotless Barbed Suture: A Comparative Biomechanical Study Evaluating Effect on Tendon Bulking, Gliding Resistance, and Work of Flexion

Résumé Points:

- Repaired FDP tendon CSA, GR and WF increased significantly for both suture repairs compared to the intact; no significant difference between biomechanical outcomes of suture type for any repaired condition

Hypothesis: Knotless barbed suture repairs for zone II laceration are biomechanically equivalent to, or superior than traditional sutures in reducing tendon repair site bulking, gliding resistance, and work of flexion.

Methods: The ring, long and index fingers from six matched pairs of cadaveric hands (2M/4F) were disarticulated at the CMC joint and denuded of soft tissue keeping the FDP, FDS tendons and A1-A2 pulley attachments intact. An equal number of digits from each matched pair were allocated for repair using either a) barbed (2-0 Quill™, Angiotech, Vancouver, CA) or b) traditional suture (3-0 Fiberwire®, Arthrex, Naples, FL).

Specimens were biomechanically evaluated in following test conditions: 1) Intact (INT), 2) Repaired (REP), 3) Repair + Partial FDS Slip (PFDS), 4) Repair + Full FDS Resection (FFDS).

Tendon Cross Sectional Area (CSA) was measured 10mm distal to the A2 pulley at the laceration site for the intact condition, followed by measurement of the flexion-extension Gliding Resistance (GR) (N) and Work of Flexion (WF) (N-mm). Following complete FDP tendon laceration, tendons were repaired using barbed suture (n= 18; 4 strand, knotless modified Kessler) or traditional suture (n=18, 4 strand, traditional Kessler) Both repairs were reinforced with a circumferential running epitenodous 6-0 monofilament (SurgiPro II, Covidien, Mansfield, MA). Following tendon repair, CSA, GR and WF were measured for the remaining test conditions. All statistical analysis were performed using SPSS (IBM, Armonk, NY) non-parametric, Wilcoxon signed rank test with a P value set at 0.05.

Results: Repair site CSA increased by 49% & 47% for the traditional and knotless barbed suture groups, respectively (P<0.001). GR significantly increased (P<0.001) by 109% & 135% (REP, P=0.546), 88% & 97% (PFDS, P=0.603) and 51% & 66% (FFDS, P=0.249) for the barbed and traditional suture groups, respectively. Work of flexion also significantly increased (P<0.006) by 14.4% & 11.2% (REPP=0.472), 10% & 9.9% (PFDS, P=0.862) and 6.4% & 7.5% (FFDS, P=0.778) for the barbed and traditional suture groups.

References:

PAPER 59

Clinical Paper Session 11: Scaphoid/Carpus
Saturday, September 20, 2014 • 10:05–10:12 AM
Category: Basic Science
Keyword: Hand and Wrist

Central Threadless Shaft Screw is Better Than Fully Threaded Variable Pitch Screw for Unstable Scaphoid Nonunion: A Biomechanical Study

Résumé Points:

- From a surgical standpoint, ease or speed of repair (time) with the use of knotless barbed sutures was similar
- In vivo studies may determine if the lack of pliability of the barbed sutures could potentially expose barbs along repaired tendons causing unnecessary irritation within the pulley.
- Cost of such sutures maybe worth considering

Hypothesis: An interpositional wedge bone graft is a procedure to restore carpal height and scaphoid length for displaced scaphoid nonunions with carpal instability. However, it is unclear which headless screw design (central threadless shaft screws or full threaded variable pitch compression screw) is biomechanically preferred when an interpositional bone graft is needed. We therefore analyzed the relative biomechanical stability and compression forces at different interfragmentary gaps using an interpositional bone graft model of scaphoid nonunion.

Methods: To measure the relative biomechanical stability, 24 cadaveric scaphoids were collected. Then, the interpositional bone graft model was made by cutting each cadaveric scaphoid into three equal pieces perpendicular to the long axis of the scaphoid. Three groups of eight cadaveric scaphoids were each cut with either AO HCS® screws, Herbert-Whipple® screw, or Mini-Acutrak® screws. The specimens were tested using an Instron® tensile testing machine by applying force to the distal pole of the scaphoid to calculate stiffness and load at 2mm of displacement. To measure compression forces at different interfragmentary gaps, 24 interpositional bone graft models were made.
with three pieces of cancellous sawbone block. Then, two custom-made load-cells were inserted in each gap. Three groups of eight interpositional bone graft models were each internally fixed with either AO HCS® screw, Herbert-Whipple® screw, or Mini-Acutrak® screws, respectively for each group. Compression forces at different interfragmentary gaps were measured immediately and 30 minutes after screw fixation.

**Results:** The average stiffness and load at 2mm of displacement were similar among the three different groups of screw fixation (P > 0.05). The average compression force measured at each interfragmentary gap was highest in the group with AO HCS® screw fixation, followed by the group with Herbert-Whipple® screw fixation and the group with Mini-Acutrak® screw fixation both immediately after screw fixation and after 30 minutes despite a significant decrease of the force 30 minutes after fixation. The compression forces measured at different interfragmentary gaps were almost identical in the groups with AO HCS® screw fixation and Herbert-Whipple® screw fixation; however, the force measured at the far interfragmentary gap to screw entry was significantly lower than that measured at the near gap to screw entry.

**Summary Points:** Based on our data, we conclude that the central threadless shaft screw design, especially AO HCS® screw, is preferred over the fully threaded variable pitch screw design.

**REFERENCES**


Benefits of a Double Antirotation Screw Fixation Performed With Arthroscopy for Scaphoid Fractures: A Prospective Series of 9 Cases

Level 4 Evidence

© Pierre Croutzet, MD
© Benjamin Ferreira, MD
© Alexa Gaston-Nouvel, MD
© Jean Kany, MD
© Colin de Cheveigne, MD
© Regis Guinand, MD

Hypothesis: Consolidation is the main problem of scaphoid fractures. Percutaneous fixations have demonstrated benefits on the one hand and wrist arthroscopy has improved reduction and has prevented osteosynthesis morbidity on the other hand. Fixation is mostly performed with one cannulated screw and the screw’s compression is supposed to avoid rotation. Despite these recent improvements, nonunions still occur and we consider this is partly due to persistent rotation mobility at the fracture site.

This prospective series proposes to assess a double screw fixation to maximize compression and avoid rotation, performed with arthroscopy in order to control reduction and to prevent fixation morbidity.

Methods: Over a period of one year, 9 isolated recent (<3 months) scaphoid fractures were operated on with double compression screws under wrist arthroscopy.

We used cannulated (Ø 2 mm) compression screws, a 1.9 mm arthroscope with three portals: a midcarpal radial, a radiocarpal 3-4, and an occasional 2-3 instrumental portal.

A splint was kept for 3 weeks followed by an active/passive physiotherapy.

Physical examination and X-ray were performed after 3, 6 and 12 weeks, a CT-scan after 12 weeks.

Analysis criteria were:
- perioperative: ligament injuries, duration of surgery.
- postoperative: pain, wrist motion (F/E; Inclinations; P/S), grasp strength, time off work and sports, radiographic analysis (reduction, ct-scan consolidation, secondary displacement).

Results: All patients were reviewed three times.

Duration of surgery was 45 minutes (30-70), none scapho-lunate ligament injury was noticed.

About strength and mobility:
- After 3 weeks: F/E : 70/60°, Γ′R/Γ′C 5°/20°, P/S 70°/75°, Grasp 30%
- After 6 weeks: F/E : 80/75°, Γ′R/Γ′C 10°/25°, P/S 75°/85°, Grasp 65%
- After 12 weeks: F/E : 85/80°, Γ′R/Γ′C 10°/25°, P/S 75°/85°, Grasp 90%

We noticed 9 anatomic reductions and consolidation in all cases after 12 weeks.

Summary Points:
- Functional mobility was regained after 6 weeks, accompanied by a good strength.
- The double antirotation screw fixation with arthroscopy seems to be a reliable and efficient procedure for scaphoid fractures enabling rapid recovery and safe results.
- Arthroscopic double-screw scaphoid is a reliable and an effective technique that provides a short convalescence with a lasting result.
- We considered this procedure as pertinent enough to be used in certain recent scaphoid nonunions.

We noticed 9 anatomic reductions and consolidation in all cases after 12 weeks.

Time off work was 3 weeks (0-7).

Summary Points:
- Functional mobility was regained after 6 weeks, accompanied by a good strength.
- The double antirotation screw fixation with arthroscopy seems to be a reliable and efficient procedure for scaphoid fractures enabling rapid recovery and safe results.
- Arthroscopic double-screw scaphoid is a reliable and an effective technique that provides a short convalescence with a lasting result.
- We considered this procedure as pertinent enough to be used in certain recent scaphoid nonunions.
Methods: Over a period of one year, 9 isolated recent (<3months) scaphoid fractures were operated on with double compression screws under wrist arthroscopy.

We used cannulated (Ø 2 mm) compression screws, a 1.9 mm arthroscope with three portals: a midcarpal radial, a radiocarpal 3-4, and an occasional 2-3 instrumental portal.

A splint was kept for 3 weeks followed by an active/passive physiotherapy.

Physical examination and X-ray were performed after 3, 6, and 12 weeks, a CT-scan after 12 weeks.

Analysis criteria were:
- preoperative: ligament injuries, duration of surgery.
- postoperative: pain, wrist motion (F/E°; Inclinations; P/S°), grasp strength, time off work and sports, radiographic analysis (reduction, ct-scan consolidation, secondary displacement).

Results: All patients were reviewed three times.

Duration of surgery was 45 minutes (30-70), none scapho-lunate ligament injury was noticed.

About strength and mobility:

After 3 weeks: F/E : 70/60°, I/R/I/C 5°/20°, P/S 70°/75°, Grasp 30%

After 6 weeks: F/E : 80/75°, I/R/I/C 10°/25, P/S 75°/85°, Grasp 65%

After 12 weeks: F/E : 85/80°, I/R/I/C 10°/25, P/S 75°/85°, Grasp 90%

We noticed 9 anatomic reductions and consolidation in all cases after 12 weeks.

Time off work was 3 weeks (0-7).

Summary Points:
- Functional mobility was regained after 6 weeks, accompanied by a good strength.
- The double antirotation screw fixation with arthroscopy seems to be a reliable and efficient procedure for scaphoid fractures enabling rapid recovery and safe results
- Arthroscopic double-screw scaphoid is a reliable and an effective technique that provides a short convalescence with a lasting result.

We considered this procedure as pertinent enough to be used in certain recent scaphoid nonunions.

References


Epidemiology and Patterns of Perilunate Fracture Dislocations Over a 17-Year Period

Level 4 Evidence

Sophia Leung, MD
W. Andrew Eglseder, MD
Joshua Abzug, MD

Hypothesis: Perilunate fracture-dislocations comprise a spectrum of disruptions to the carpal anatomy. Although the patterns of injury are variable, they are always severe, debilitating, and difficult to correct surgically. These injuries are rare, and are often grouped together as one entity. The purpose of this study was to assess all perilunate types by classifying injury patterns and identifying associated injuries.

Methods: A 17 year period at a Level I Trauma center was retrospectively reviewed. Injuries were divided into three groups for analysis; Group 1 comprised transscaphoid perilunate injuries, Group 2 were pure ligamentous perilunate injuries. Group 3 included all other perilunate fracture dislocations that involved a fracture to any other carpal bone, distal radius, or ulna. Demographic data including age, gender, and medical history were obtained, as well as type of injury, mechanism, concomitant injuries, ipsilateral upper extremity injuries, and median nerve symptoms.

Results: Between 1991 and 2008, a total of 140 perilunate fracture/dislocations were treated at our trauma center; 131 patients had complete data. There were 117 males and 14 females; average age 37.4 years (range 17-85). Group 1 consisted of 42 patients, Group 2 had 43 patients and Group 3 had 46 patients. 68 patients (48.6%) had a scaphoid fracture as injury component. Amongst the complex fractures, 22 different injury pattern variations were identified. The most common were trans-radial styloid (n=11), transscaphoid/trans-radial styloid (n=9), transscaphoid/trans-capitate (n=6), associated distal radius fracture (n=5), transtriquetral (n=4), and transscaphoid/transtriquetral (n=3). Open fractures were relatively rare, seen in only 4 of 131 cases (3%). Acute median nerve symptoms, including one median nerve transection, was seen in 20 patients (15.2%). Four patients developed late onset carpal tunnel syndrome (3%). Nineteen patients sustained additional ipsilateral upper extremity injuries (14.5%), and 50 patients sustained major non-orthopaedic injuries (38.2%). The most common mechanism of injury was fall from height (n=59), followed by motor vehicle collision (n=27), and motorcycle collision (n=22).

Summary Points:
- Perilunate fracture-dislocations occur most commonly in middle-aged men after falls from height.
- A perilunate injury with a transscaphoid component is the most common injury pattern, comprising nearly half of all injuries.
- More than twenty different perilunate injury patterns have been identified, and concomitant ipsilateral upper extremity injuries are common.
- Median neuropathy, whether as a result of direct compression or by swelling, can occur in 15% of patients.
- Careful physical examination should be undertaken to diagnose acute carpal tunnel syndrome, as it may affect surgical approach.

References


Paper 63

Clinical Paper Session 11: Scaphoid/Carpus
Saturday, September 20, 2014 • 10:33–10:40 AM
Category: Historical Information, Anatomy
Keyword: Hand and Wrist

Speaker has nothing of financial value to disclose
PAPER 64

Clinical Paper Session 12: Tumor/Infection/Miscellaneous
Saturday, September 20, 2014 ● 10:05—10:12 AM
Category: Evaluation/Diagnosis, Treatment, Surgical Technique
Keyword: Hand and Wrist, Diseases and Disorders, General Principles, Practice Management

Timing of Debridement and Infection Rates in Open Fractures of the Hand: A Systematic Review
Level 3 Evidence

♦ Joseph Dwyer, MD
♦ Asif Illyas, MD
♦ Constantinos Ketonis, MD

Hypothesis: Existing literature on open fracture infection rates and treatment guidelines has focused primarily on long bone fractures, with limited guidelines available for open fractures of the hand. The aim of this study was to systematically review the available literature on open fractures of the hand (including phalangeal, metacarpal, and carpal fractures) to determine infection rates and the effect of timing of debridement and antibiotic administration.

Methods: Searches of the MEDLINE, EMBASE, and Cochrane computerized literature databases and manual searches of bibliographies were performed. All studies (retrospective and prospective) which included relevant data for open fractures of the hand were included. Descriptive and quantitative data were extracted. A meta-analysis of different patient cohorts and data for open fractures of the hand were included. Descriptive and quantitative data were extracted. A meta-analysis of different patient cohorts and data for open fractures of the hand were included.

Results: The initial search yielded 61 references. Twelve of the articles (four prospective and eight retrospective cohort studies) that included specific information regarding open fractures of the hand were included. A total of 1669 open fractures of the hand were included. There were 77 infections (4.6% infection rate). Of the 1391 patients who received antibiotics in the perioperative period, there were 61 infections (4.4% infection rate). Of the 171 patients who did not receive antibiotics perioperatively, there were 16 infections (9.4% infection rate). Six studies (1206 open fractures) included information regarding deep vs. superficial infections. Superficial infections (requiring oral antibiotics only) accounted for 86%, whereas deep infections (requiring repeat irrigation and debridement) accounted for 14%. Debridement within 6 hours of injury was clearly defined in two studies, including 188 fractures, with an infection rate of 4.2%. Debridement within 12 hours of injury (one study, 193 fractures) resulted in a 3.6% infection rate. Two studies looked specifically at timing to debridement, showing no correlation to the incidence of infection.

Summary Points:
- The available literature indicates that the overall infection rate for open fractures of the hand is relatively low.
- There is a correlation between the administration of antibiotics and infection rate.
- The majority of infections encountered after an open fracture in the hand can be treated successfully with antibiotics alone.

- The data suggests that timing of debridement in open hand fractures has not been shown to alter infection rates.

REFERENCES


PAPER 65

Clinical Paper Session 12: Tumor/Infection/Miscellaneous
Saturday, September 20, 2014 ● 10:12—10:19 AM
Category: Prognosis/Outcomes
Keyword: Hand and Wrist, General Principles

Risk of Postoperative Infection Following Carpal Tunnel Release in Patients With Diabetes Mellitus: A Review of 658 Surgeries
Level 3 Evidence

♦ Samantha Zwiebel, MA
♦ Devra Becker, MD

Hypothesis: Diabetic and non-diabetic patients do not experience significantly different rates of postoperative surgical site infection following carpal tunnel release. Neither prophylactic antibiotics nor perioperative control of HbA1c to less than 7% are associated with a significantly lower risk of SSI.

Methods: The electronic charts of all patients undergoing carpal tunnel release from January 2002 to September 2012 at the Louis Stokes Cleveland VAMC were reviewed for incidence of postoperative infection. Infection was defined as any wound complication requiring the administration of antibiotics, excluding prophylactic antibiotics, or a diagnosis code of postoperative infection. The progress notes of any patient who received antibiotics perioperatively were further reviewed to determine the indication and subsequently classified as having a postoperative infection if appropriate. Charts were also reviewed for age at time of surgery, sex, diabetic status at time of surgery, and wound cultures if available. Statistics were performed with chi square and descriptive statistics.

Results: 528 patients underwent 658 surgeries. 260 (35.1%) cases had DM at the time of surgery. 92.2% of cases were male with a mean age of 62.2 years. Of all cases, 177 (26.9%) received perioperative antibiotics: 88 (49.7%) received these antibiotics as prophylaxis and 27 (15.3%) for SSI. The cases that received prophylactic antibiotics included 57 cases with DM and 31 without DM. Of patients with SSI, 8 (29.6%) were diabetic versus 19 (70.4%) non-diabetic (P<0.05). Overall, 3.1% of diabetic and 4.8% of non-diabetic patients experienced SSI. When patients with prophylactic antibiotics were excluded, 3.8% of diabetic and 4.9% of non-diabetic patients experienced SSI (P>0.05). Incidence of infection in diabetic patients was not significantly lower in patients on prophylactic antibiotics (P>0.05), nor in non-diabetic patients. Diabetic patients with HbA1c greater than or
equal to 7% did not have significantly different risk of SSI compared to those with HbA1c less than 7% (P>0.05).

**Summary Points:** 1. No significant differences were observed in the incidence of SSI following CTR in diabetic versus non-diabetic patients. 2. The observations persisted when patients on prophylactic antibiotics were excluded from statistical analysis. 3. Neither prophylactic antibiotic use nor strict glycemic control in diabetics is associated with a significantly decreased risk of SSI.

**REFERENCES**


**PAPER 66**

Clinical Paper Session 12: Tumor/Infection/Miscellaneous

Saturday, September 20, 2014 • 10:19–10:26 AM

Category: Treatment, Therapy/Rehabilitation, Prognosis/Outcomes

Keyword: Hand and Wrist, Diseases and Disorders

**PXL01 in Sodium Hyaluronate for Improvement of Hand Recovery After Flexor Tendon Repair Surgery: Randomized Controlled Trial**

Level 1 Evidence

- Monica Wiig, MD, PhD
- Lars B. Dahlin, MD, PhD
- Jan Fridén, MD, PhD
- Lars Hagberg, MD, PhD
- Sören Larsen, MD, PhD
- Margit Mahlapuu, PhD

**Hypothesis:** The aim of the study was to evaluate the efficacy and safety of the synthetic peptide PXL01 in carrier sodium hyaluronate (HA) for prevention of adhesion formation, and correspondingly improving hand function, in connection to flexor tendon repair surgery after injury of the hand.

**Methods:** This prospective, randomised, double-blind, multicentre trial included 138 patients admitted for flexor tendon repair surgery. PXL01 in HA, or placebo was administered locally around the repaired tendon. Efficacy was assessed by measurements of total active motion of the injured finger, tip-to-crease distance, rate of tenolysis and grip strength, and safety parameters were followed, for up to 12 months post-surgery.

All statistical calculations were performed using SAS® by Pharma Consulting Group, Uppsala, Sweden. Active motion, tip-to-crease distance and grip strength were tested using analysis of covariance (ANCOVA) with values of the injured hand as dependent variable and the values of the contralateral hand as covariate. The frequency of recommended tenolysis was analysed using extended Mantel-Haenszel method. Exploratory statistical analyses (chi-square) were used when active motion values graded according to Strickland’s classification was performed.

**Results:** The most pronounced difference between the PXL01 and placebo groups was observed at 6 months post-surgery. At this time point, the total active motion of the distal finger joint was statistically significant improved in the PXL01 group compared to the placebo group (P=0.016 in per-protocol analysis set (PPAS)). The number of patients, categorized as having excellent/good mobility of the injured digit, was higher in the PXL01 group (P=0.0499 in PPAS). Consistently, the patients in the PXL01 group presented improved tip-to-crease distance (P=0.048 in PPAS). At 12 months post-surgery, a higher proportion of patients in the placebo group was considered to benefit from tenolysis (30% vs. 12%, P=0.006 in PPAS). The treatment was safe, well tolerated, and did not increase the rate of tendon rupture.

**Summary Points:** Treatment with PXL01 in HA improves the outcome of the flexor tendon repair surgery in terms of recovery of hand function, such as active motion of the DIP joint, total active motion using Strickland’s classification system and tip-to-crease distance. Further clinical trials are warranted to determine the most efficient dose and health economic benefits of the treatment. EudraCT: 2009-012703-25, ClinicalTrials.gov: NCT01022242

- Salary: Pergamum AB (Mahlapuu)

**PAPER 67**

Clinical Paper Session 12: Tumor/Infection/Miscellaneous

Saturday, September 20, 2014 • 10:26–10:33 AM

Category: Evaluation/Diagnosis, Treatment

Keyword: Hand and Wrist

**Intraneural Ganglions of the Hand and Wrist**

Level 4 Evidence

- Nash H. Naam, MD

**Hypothesis:** Intraneural ganglions of the upper extremity are rare and they usually originate within the epineurium of the peripheral nerve as nonneoplastic mucinous cysts. Initially, most authors have supported the de novo theory of formation. However, recently, a unifying articular (synovial) theory has been proposed suggesting that the intraneural ganglions has connections to the adjacent joints via the articular branches of the involved nerve.

**Methods:** Between 1990 and 2012, 15 patients were treated for intraneural ganglion of the hand and wrist. The 9 female and 6 male patients averaged 42 years of age (27-69). Ten patients presented with mass and 5 presented with symptoms of entrapment neuropathy. The ganglions involved the ulnar nerve at the wrist in 5 patients, the dorsal branch of the ulnar nerve in 2, superficial radial nerve in 2, the digital nerves in 4; (1 thumb, 2 ring fingers and 1 long finger) and the dorsal branch of the digital nerve in 2; (one ring finger and one small finger).

Eleven patients had magnetic resonance imaging (MRI) which showed the cystic masses but was not diagnostic of intraneural ganglions. In all patients the ganglion was excised by intraneural dissection of the nerve fascicles with complete excision of the ganglion. In 8 patients the articular branches were identified and excised.

**Results:** Post operative follow-up averaged 57 months (11-235 months). There were no operative or postoperative complications. There were no recurrences. 5 patients had transient paraesthesia that improved after an average of 2 months (1-3). All the preoperative symptoms improved. Patients returned to normal daily and work activities in an average of 10 days (7-27 days). Pathological examination demonstrated findings consistent with ganglion cyst. Grip and pinch strength averaged 98% of the contralateral side.

**Summary Points:**

- Intraneural ganglions should be considered in the differential diagnosis of a mass in the vicinity of a nerve.
- Surgical excision is usually curative with good functional outcome.
- Every attempt should be made to identify and excise the articular branch of the involved nerve.

**REFERENCES**


- Consulting Fee: Auxillium (Naame)
- Speakers Bureau: Auxillium (Naame)
Characteristics of Glomus Tumors in the Hand Missed on MRI

Level 4 Evidence

Samir K. Trehan, MD
Edward A. Athanasian, MD
Aaron Daluiski, MD

Hypothesis: Failure to diagnose glomus tumors of the hand on magnetic resonance imaging (MRI) is associated with smaller tumor size, atypical glomus tumor pathology and atypical location.

Methods: We retrospectively reviewed 77 patients at our institution who had pathologically confirmed glomus tumors of the hand between 1995 and 2013. Pathology reports were reviewed for diagnosis and tumor size. Of these, 38 patients had a pre-operative MRI at our institution. MRI images and reports were reviewed for diagnosis, tumor location, associated bone erosion and specific imaging sequences utilized. Patients were subdivided as either “positive” (radiology report consistent with glomus tumor diagnosis), “negative” (report did not mention possible diagnosis of glomus tumor) or “indeterminate” (report mentioned glomus tumor as possible differential diagnosis). Two-tailed Fisher’s exact test was utilized for comparison between “positive” studies and those that were either “negative” or “indeterminate.”

Results: Of 38 patients with pre-operative MRI, 25 were “positive,” six were “indeterminate” and seven were “negative.” Six tumors had atypical pathology including one glomus body, two glomangiomas, one symplastic glomus tumor, one glomangiomyoma and one glomangiopericytoma. Two patients had recurrent glomus tumors and one had a multifocal glomus tumor. Two patients had extra-digital glomus tumors in the hand. Failure to diagnose glomus tumors on MRI (i.e. not located in subungal region) (<P 0.01) and absence of associated bone erosion on MRI (<P 0.01) (see Table). Pathologic size of excised glomus tumors ranged from two to 15 millimeters and was not associated with “positive” MRI diagnosis.

Summary Points:
- Successful diagnosis of glomus tumors of the hand requires clinical suspicion given its low incidence. MRI is frequently utilized to aid in diagnosis.
- In this retrospective review of 38 pathology-confirmed glomus tumors of the hand, seven cases had “negative” and six had “indeterminate” MRIs. These 13 cases were more likely to be atypical, pathologically or anatomically, and without bone erosion. In contrast to older case series, there was no correlation between pathologic size of excised tumors and failure of MRI diagnosis, suggesting interval improvement in MRI technology.
- Nonetheless, 34.2% (13/38) of MRIs were not diagnostic of hand glomus tumors and highlight the limitations of MRI and continued importance of clinical suspicion in glomus tumor diagnosis.

Table 1: Association between MRI glomus tumor diagnosis and pathologic, anatomic (i.e. subungal location) and radiographic (i.e. bone erosions) tumor characteristics.

<table>
<thead>
<tr>
<th>MRI Diagnosis</th>
<th>Atypical Pathology</th>
<th>Subungal Location</th>
<th>Bone Erosion Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indeterminate</td>
<td>33% (2/6)</td>
<td>43% (3/7)</td>
<td>33% (2/6)</td>
</tr>
<tr>
<td>Negative</td>
<td>43% (3/7)</td>
<td>17% (1/6)</td>
<td>0% (0/6)</td>
</tr>
<tr>
<td>Positive</td>
<td>4% (1/25)</td>
<td>100% (25/25)</td>
<td>80% (20/25)</td>
</tr>
</tbody>
</table>

[Note: two patients with extra-digital glomus tumors of hand who had a “negative” and “indeterminate” MRI were excluded from location subgroup analysis.] [Note: presence or absence of bone erosion was not mentioned in MRI report for one patient with “negative” MRI]
Results: The mean age of the specimens was 65.8 +/- 11.2 yr. The average length of the lateral ligamentous insertion onto the ulna was 17.2 +/- 4.1 mm. There was no perfectly isometric point along the humerus or ulna. However, in 13/13 specimens, the COR was the most isometric point for the humeral reconstruction site with an average graft elongation of 1.14 mm. Differences in humeral tunnel position dramatically affected graft elongation at all 3 ulnar points (P<0.0001). The most an isometric point was that of the humeral location posterior to the center of rotation with a mean graft elongation of 5.1 +/- 0.07 mm. Mean difference in elongation between the least and most isometric point was 4.28 +/- 0.53mm (P<0.0001). Overall the ulnar position had minimal effect on graft elongation (P = 0.05), with mean differences between ulnar positions all less than 1mm regardless of statistical significance.

Summary Points: Although no perfectly isometric points were found, the humeral center of rotation consistently reproduced the most isometry when assessing graft elongation over range of motion. Differences in ulnar tunnel placement did not result in significant changes in graft elongation. This data will assist surgeons in proper tunnel placement in LUCL reconstruction. Humeral tunnels placed at the center of rotation will optimize graft isometry. Placement of ulnar tunnels are less critical and lack a single, optimal isometric point along the ulna, supporting the use of double or single limbed grafts depending on surgeon preference.

REFERENCES

Figure 1: This figure displays the 2-screw fixation construct.

Methods: Ten matched-pair cadaver arms were skeletonized and the radii were removed. X-ray and visual inspection were performed to ensure absence of preexisting trauma. DEXA scans were obtained to measure bone density. A transverse osteotomy was created at the neck of each radius, which was subsequently fixed by one fellowship-trained upper
extremity surgeon. All right-sided radii were fixed with two oblique headless compression screws across the fracture site; all left-sided radii were fixed with a radial neck plate and screws. The distal aspect of each radius was potted in polymethylmethacrylate bone cement, with approximately 60mm of proximal radius exposed. The radial head was loaded in cantilever bending in 4 different planes, 90 degrees apart and orthogonal to the radial shaft using an MTS machine (MTS Systems Corp., Eden Prairie, MN). Stiffness and load to failure were recorded for each specimen.

**Results:** All ten radii were free of preexisting injury or fracture. The stiffness of both constructs was similar in all planes except for loading from medial to lateral (opposite of the plate) where the screw construct was 1.8 times stiffer. Ultimate failure occurred at 229N for the plate and 206N for the screws. Failure mode for the plate was plate bending while the screws failed by pullout and fracture.

**Summary Points:**
- The two strategies for internal fixation of radial neck fractures provide similar strength and stiffness to transverse, noncomminuted fractures.
- While plate-and-screw constructs are more appropriate when there is bone loss or comminution, this study supports the utilization of two oblique screws in simple transverse neck fractures, especially since screw fixation requires less exposure and the hardware is buried and unobtrusive.
- The two strategies fail in different modes when they are loaded to failure.

![Image](image-url)

**Figure 2:** This figure displays the plate-and-screw fixation construct.

**REFERENCE**

**Time to Surgery in the Treatment of Lateral Epicondylitis: A Cost-Effectiveness Analysis**

N/A - Not a clinical study

- Kevin W. Park, BA
- Aaron M. Chamberlain, MD
- Daniel A. Osei, MD

**Hypothesis:** The optimal time that a patient should undergo non-operative management for recalcitrant lateral epicondylitis remains undefined. Although many physicians offer surgery to patients after 12 months of failed non-operative management, it is unknown whether this is the most cost-effective strategy. Our hypothesis was that surgery after 12 months of failed non-operative management is not as cost-effective when compared to surgery at earlier time points.

**Methods:** A decision analytic model was designed to compare the cost-effectiveness of different durations of non-operative management (1, 2, 3, 6, 9, and 12 months) before pursuing surgery (Figure 1). Non-operative management (orthopedic clinic visits, corticosteroid injections, braces, and occupational therapy visits) followed a model treatment regimen constructed using survey responses from upper extremity surgeons. Direct medical costs were estimated by Medicare reimbursement rates for 2013. Rates of resolution after non-operative treatment were calculated from observational patient data collected at our institution. Preference values for health states were derived from a general population using descriptive vignettes and the preference-based SF-6D health questionnaire. Incremental cost-effectiveness ratios were calculated and sensitivity analyses were performed.

**Results:** Total costs were $2680 for surgery and $600, $1061, $1309, and $1519 for non-operative management (at 3, 6, 9, and 12 months, respectively). A total of 1050 patients who were treated non-operatively for lateral epicondylitis from January 2007 to December 2012 were identified. Rates of resolution were calculated to be 0.710, 0.791, 0.830, 0.886, 0.918, and 0.938 at 1, 2, 3, 6, 9, and 12 months, respectively. Probabilities for surgical outcomes were estimated to be 12% for persistent symptoms and 4% for wound infection. Utility values were estimated to be 0.99 at baseline, 0.87 for symptomatic LE, and 0.82 for wound infection. The 12 month strategy had the lowest total cost, but also the lowest QALYs. Other options were cost-effective with ICERs ranging from $16,773-$96,841 (Figure 1).

Sensitivity analyses revealed that lower rates of resolution and lower total costs of surgery favor earlier surgical intervention.

**Summary Points:**
- In patients with recalcitrant lateral epicondylitis, surgical intervention prior to completing 12 months of failed non-operative management is cost-effective.
- After 3 months of failed non-operative management, the rate of resolution and the ICER for surgery begin to plateau (Figure 2), supporting consideration of surgical intervention in patients whose symptoms do not resolve by this time.
- These data may guide decision-making for physicians and patients when discussing treatment options for recalcitrant lateral epicondylitis.

**REFERENCES**

**Figure 2:** Incremental cost-effectiveness ratios and probabilities of resolution.

**PAPER 73**

Clinical Paper Session 13: Elbow
Saturday, September 20 • 2014, 2:43–2:50 PM
Category: Historical Information, Prognosis/Outcomes
Keyword: Elbow and Forearm

**Complications of Total Elbow Arthroplasty in Nonrheumatoid Patients: Lessons Learned With Application in an Active Population**

**Level 4 Evidence**

- William H. Seitz, Jr, MD
- Peter J. Evans, MD, PhD
- Hisham Bismar, DO
- Sebastian Peers, MD

**Hypothesis:** Total elbow arthroplasty has become an accepted surgical tool for the reconstruction of advanced rheumatoid arthritis involving the elbow. Expanded application has been reported in patients with osteoarthritis, post-traumatic arthritis and in cases of severe trauma precluding fracture reconstruction, with reports of successful outcomes. Such patients, however, tend to...
be younger, more active, and potentially place higher demands and stresses on current less than physiologic implants. We reviewed our institution’s experience in non-rheumatoid patients with the hypothesis of finding poor compliance with activity limitations and a high rate of complications.

**Methods:** Over a ten-year period, the authors implanted 64 linked total elbow arthroplasties in 64 patients (age 38-84, mean 58 years; 39 men, 29 women) with osteo- or posttraumatic arthritis, or unreconstructable fractures. Initial results at two years demonstrated satisfactory results with a high satisfaction rate and a low complication rate with four early re-operations (6.4%), comparable to other published reports. But longer-term follow-up at 4-10 years has demonstrated a higher implant related complication rate. These complications include bushing failure with dissociation in seven, humeral stem failure in two ulnar stem failure in two, ulnar loosening in three, periprosthetic fracture in six with one late infection. Reoperation was required in an additional 21 patients (32.8%). Compliance with physical restrictions was minimal.

**Results:** Total elbow arthroplasty has added immensely to our armamentarium of tools for the treatment of rheumatoid arthritis, especially in low demand patients who lead a sedentary lifestyle. Clearly, as indications for application of this technique have expanded to include a more active patient population, implant stresses and resultant failure rates have been found to increase with longer-term follow-up. These findings suggest a need to rethink implant design to become more responsive to physiologic loads demanded in more active patients and to counsel future patients as well as existing patients with current implants regarding the limits and potential failure of existing implant designs.

**Summary Points:** Future implant designs should incorporate more anatomic load sharing characteristics to accommodate the demands of this more active population of patients.

**PAPER 74**

Clinical Paper Session 14: Vascular/Microsurgery
Saturday, September 20, 2014 ● 2:15—2:22 PM
Category: Evaluation/Diagnosis, Treatment, Therapy/Rehabilitation, Prognosis/Outcomes
Keyword: Hand and Wrist, Elbow and Forearm, Shoulder and Arm, Diseases and Disorders, General Principles

Long-Term Outcomes of Major Upper Extremity Replantations
Level 4 Evidence

* Wendy K.Y. Ng, MD

**Hypothesis:** Long term outcomes of major upper extremity replantations are infrequently reported. It is believed that replantation is indicated for amputations at all levels in children, and for all distal amputations in adults. Replantations of arm or proximal forearm amputations in adults are controversial. In our study, we evaluate results of major upper extremity replantations — defined as those that are transmetacarpal, through the wrist, forearm, elbow or arm.

**Methods:** We reviewed such replantations from 2002 to 2012. Patients’ strength, range of motion, and 2 point discrimination were assessed. Patients completed the Disabilities of the Arm, Shoulder and Hand (DASH), the Michigan Hand Questionnaire (MHQ), and the Hospital Anxiety and Depression scale (HADS). Cross-sectional descriptive statistics were calculated comparing patient characteristics, upper extremity injury, intervention, and clinical follow-up. Ten patients were available for longer-term follow-up; nine patients had sustained vascular injuries associated with supracondylar humerus fractures and one had a brachial artery laceration. Pain at rest, pain with exercise, and temperature intolerance were assessed with visual analogue scale (VAS) (range 0-5). Functional outcomes were assessed using the Pediatric Outcomes Data Collection Instrument (PODCI) and Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaires. Graft patency and brachial arterial flow were characterized via Doppler ultrasonography. Peak flow velocity (PFV) and resistive index (RI) were recorded and compared to the contralateral extremity. Mean patient age at the time of injury was 7.5 years (range 4.6 to 11.5 years). Mean clinical and radiographic follow-up was 2.7 years (range 0.3 to 6.3 years).

**Results:** All patients had perfused hands with palpable radial pulses at follow-up. Two-point discrimination was less than 7mm in all hands. There were no clinically meaningful differences in elbow or forearm motion or strength between affected and unaffected limbs. Mean VAS scores for pain at rest, pain with exercise and temperature intolerance were 0.4, 0.4 and 0.6. Mean global PODCI and DASH scores were 98.0 and 5.1. For the 10 patients with ultrasound follow-up, 9 had patent arteries with normal flow patterns. In one patient with graft occlusion, there was collateralization around the elbow with normal reconstitution of the distal vessels. Mean PFV proximal and distal to the graft were 77.7 and 66.5, respectively. Mean RI of the graft were 0.84 and 0.77, respectively.

**Summary Points:** Arterial reconstruction using interpositional vein graft and microsurgical technique is safe and effective in the in the treatment of brachial artery injuries in children. At mid-term follow-up, arterial flow is preserved, and little pain or claudicatory symptoms are seen with excellent overall functional outcomes as assessed by the VAS, PODCI and DASH instruments.

**PAPER 75**

Clinical Paper Session 14: Vascular/Microsurgery
Saturday, September 20, 2014 ● 2:22—2:29 PM
Category: Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Elbow and Forearm, Practice Management

Outcomes of Vein Grafting for Reconstruction of Brachial Arterial Injuries in Children
Level 4 Evidence

* Kristin Alves, MD
* Hillard T. Spencer, MD
* Peter M. Waters, MD
* Donald S. Bae, MD

**Hypothesis:** While arterial reconstruction using vein grafts has been well studied in adults, there is little information on the outcomes in children. We hypothesized that with microsurgical technique, vascular reconstruction with interpositional vein grafts is safe and results in sustained patency and excellent long-term outcomes.

**Methods:** Twenty-three children with brachial artery injuries were treated with interpositional vein grafting at a tertiary pediatric hospital from 1995 — 2013. Medical records were evaluated for demographic, clinical, and radiographic data. Cross-sectional descriptive statistics were calculated quantifying patient characteristics, upper extremity injury, intervention, and clinical follow-up. Ten patients were available for longer-term follow-up; nine patients had sustained vascular injuries associated with supracondylar humerus fractures and one had a brachial artery laceration. Pain at rest, pain with exercise, and temperature intolerance were assessed with visual analogue scale (VAS) (range 0-5). Functional outcomes were assessed using the Pediatric Outcomes Data Collection Instrument (PODCI) and Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaires. Graft patency and brachial arterial flow were characterized via Doppler ultrasonography. Peak flow velocity (PFV) and resistive index (RI) were recorded and compared to the contralateral extremity. Mean patient age at the time of injury was 7.5 years (range 4.6 to 11.5 years). Mean clinical and radiographic follow-up was 2.7 years (range 0.3 to 6.3 years).

**Results:** All patients had perfused hands with palpable radial pulses at follow-up. Two-point discrimination was less than 7mm in all hands. There were no clinically meaningful differences in elbow or forearm motion or strength between affected and unaffected limbs. Mean VAS scores for pain at rest, pain with exercise and temperature intolerance were 0.4, 0.4 and 0.6. Mean global PODCI and DASH scores were 98.0 and 5.1. For the 10 patients with ultrasound follow-up, 9 had patent arteries with normal flow patterns. In one patient with graft occlusion, there was collateralization around the elbow with normal reconstitution of the distal vessels. Mean PFV proximal and distal to the graft were 77.7 and 66.5, respectively. Mean RI of the graft were 0.84 and 0.77, respectively.

**Summary Points:** Arterial reconstruction using interpositional vein graft and microsurgical technique is safe and effective in the in the treatment of brachial artery injuries in children. At mid-term follow-up, arterial flow is preserved, and little pain or claudicatory symptoms are seen with excellent overall functional outcomes as assessed by the VAS, PODCI and DASH instruments.

**PAPER 76**

Clinical Paper Session 14: Vascular/Microsurgery
Saturday, September 20, 2014 ● 2:29—2:36 PM
Category: Evaluation/Diagnosis, Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist, General Principles

The Use of Pulse Oximetry for Objective Quantification of Vascular Injuries in the Hand
Level 2 Evidence

* Speaker has nothing of financial value to disclose
Hypothesis: Efficient identification of dysvascular fingers following trauma is critical for triaging surgical care and optimizing patient outcomes. Current methods for evaluating digital perfusion are based on subjective methods. We designed a prospective study evaluating an objective measure of digital hypoxia followed by surgical exploration and correlation with vascular injury.

Methods: Patients with lacerating or penetrating trauma to the hand or digits, including the thumb, were consecutively enrolled. A pulse oximeter was applied to the injured digit, and following equilibration the oxygen saturation was recorded. In the setting of a single injured digit, the ipsilateral middle finger and contralateral middle fingers were recorded as controls. If the affected digit was the middle finger, then the ipsilateral index finger value was also recorded. Patients that did not receive operative exploration were excluded from the study.

As the distribution of pulse oximetry measurements did not approach normality, nonparametric Wilcoxon rank-sum test was used to assess for difference in pulse oximetry for digits with and without an arterial injury that required repair. Receiver operator characteristic curve (ROC) analyses were used to determine cut-points.

Results: Twelve patients with digital lacerations were enrolled, with a total of 49 digit measurements of pulse oximetry. Seven digital artery injuries requiring repair or amputation were confirmed in the operating room. There was a significant difference in pulse oximetry measurement in digits with (76, 95%-CI 64-87) and without (98, 95%-CI 97-99) arterial injury (P<0.001). Injured digits ranged in oximetry from 53 to 92%. The average difference between digits with an operative arterial injury and the patient’s control uninjured digits was 22% (range 6-45%).

ROC analysis demonstrated an area under the curve (AUC) of 0.997. With a cutoff point of 95% or higher, there were no arterial injuries. At 84% or lower, all digits required intervention.

Summary Points:
- Subjective measures for evaluating adequate digital perfusion may falsely depict flow through capillary stasis and refill. The avoidance of unnecessary surgeries or hospital transfers, however, should be based on objective criteria to avoid over-utilization of resources.
- No digit with a pulse oximetry of at least 95% had an arterial injury, and all digits with a pulse oximetry of 84% or lower required operative treatment of the vascular injury. This measure performed well by ROC analysis, with an AUC of 0.997.
- Based on this data, pulse oximetry could be adopted as a routine measure for the evaluation and communication of a potentially dysvascular digit.

PAPER 77

Clinical Paper Session 14: Vascular/Microsurgery
Saturday, September 20, 2014 • 2:36–2:43 PM
Category: Treatment, Surgical Technique
Keyword: Hand and Wrist

Venous Bridge Arterial Grafting for Thumb Replantation
Level 4 Evidence

Eric R. Wagner, MD
Allen T. Bishop, MD
Alexander Y. Shin, MD

Hypothesis: Microsurgical replantation in thumb avulsion injuries is challenging, especially when the proximal digital arteries are not available. The purpose of this study is to describe a novel technique using an interposition vein graft for thumb replantation.

Methods: Over a 10-year period, 8 patients underwent interposition venous bridge grafting from the dorsal radial artery at the anatomic snuffbox to the proper ulnar digital artery (PUDA) of the thumb. All patients had a traumatic thumb amputation with a severe injury to the proximal digital arteries precluding primary arterial repair. Given the difficulty in repairing or grafting vessels on the palmar side of the thumb, this novel technique enables easy access to the repair. The hand rests palm down on the table with the forearm pronated, enabling easy exposure to the proper digital artery and snuffbox radial artery. The reconstruction is carried out with an end-to-side connection of the vein graft to the radial artery, followed by a subcutaneous tunnel to the thumb incision via a mid-lateral incision, and an end-to-end anastomoses of the PUDA.

Results: All 8 patients who underwent the bridge grafting were male, with average age of 42 years, 2 smokers and 7 laborers. All were avulsion-type injuries. The average time to the operating room was 7.4 hours (4-14) and the average time to reperfusion was 9.5 hours (6-16). At 3.1 years follow-up, all 8 thumbs remained viable, without any need for revision procedures. The only complication was a metacarpal shaft nonunion treated successfully with autologous bone grafting. Additional injuries required a FTSG in 2 patients and a free muscle and STSG in another. Of the 5 patients with >1 year of follow-up, all were able to return to work full-time. All patients reported no or mild pain at last follow-up, with an average MCP range of motion of 46.5 degrees. All patients had intact, but diminished 2-point discrimination compared to the other thumb.

Conclusion: This novel technique using an interposition vein graft for thumb replantation has shown promise in thumb replantation associated with severe avulsion injuries.
(1996-2011) were surveyed. All hand surgeons had completed a 5-day microsurgery-training course using the rat model. Patency rates (at 24 hours), additional days spent in the lab, and type of core training (Orthopaedic Surgery [OS] versus Plastic Surgery [PS]) were correlated with responses to a questionnaire regarding their microsurgical confidence and spectrum of their current microsurgical practice.

**Results:** Microsurgical patency rates and questionnaires were available for 100% (61/61) of former fellows. Eighty-one percent of PS’s currently practice digital replants versus 48% OS’s, (odds ratio [OR] 4.7). Free flaps are performed by 81% of PS’s versus 36% of OS’s, OR=7.6. Patency rates 90% and days in the lab >12 were fair predictors of those practicing replants (Table 1). OS’s with patency rates >90% and >7 days in the lab were five times more likely to perform free flaps than other OS’s (Table 2). High microsurgical confidence and an academic practice were strongly correlated with the breadth of a microsurgical practice.

**Summary Points:**
- The routine use of microsurgical laboratory training may enhance the practice of microsurgery.
- Success during and dedication to microsurgical-training in the laboratory setting can be used as a predictor of those who will ultimately practice microsurgery.
- Despite a similar hand fellowship training experience, PS’s are more likely to perform replants and free flaps than OS’s.

### Table 1: Performance of Replantation according to Training Patency Rate (more or less than 90%)

<table>
<thead>
<tr>
<th>Plastic ≥ 90%</th>
<th>Yes</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic &lt; 90%</td>
<td>83%</td>
<td>16.4 (1.6-165.1)</td>
<td>0.02</td>
</tr>
<tr>
<td>Ortho ≥ 90%</td>
<td>64%</td>
<td>5.9 (1.5-23.6)</td>
<td>0.01</td>
</tr>
<tr>
<td>Ortho &lt; 90%</td>
<td>40%</td>
<td>1.0 (reference)</td>
<td>—</td>
</tr>
</tbody>
</table>

### Table 2: Performance of Free Flaps according to Patency Rate (more or less than 90%)

<table>
<thead>
<tr>
<th>Plastics ≥ 90%</th>
<th>Yes</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastics &lt; 90%</td>
<td>80%</td>
<td>13.1 (2.2-76.8)</td>
<td>0.004</td>
</tr>
<tr>
<td>Ortho ≥ 90%</td>
<td>64%</td>
<td>2.7 (0.7-10.0)</td>
<td>0.14</td>
</tr>
<tr>
<td>Ortho &lt; 90%</td>
<td>40%</td>
<td>1.0 (reference)</td>
<td>—</td>
</tr>
</tbody>
</table>

### References

**Predictors of Postoperative Finger Stiffness After Treatment of Unstable Proximal Phalangeal Fractures With Titanium Plates And/Or Screws**

**Level 2 Evidence**

- **Tadanobu Onishi, MD**
- **Shohei Omokawa, MD, PhD**
- **Takamasa Shimizu, MD**
- **Ryotaro Fujitani, MD**
- **Koji Shigematsu, MD, PhD**
- **Yasuhiro Tanaka, MD/PhD**

**Hypothesis:** The purpose of this prospective cohort study was to identify postoperative complications of and independent prognostic factors for finger stiffness after treatment of proximal phalangeal fractures with titanium plates and/or screws. We hypothesized that the implant placement location affects the postoperative active range of finger motion.

**Methods:** Seventy consecutive patients (50 male, 20 female; average age, 40 years) with 75 unstable proximal phalangeal fractures treated with titanium plates and/or screws (Figure 1) were evaluated at a minimum follow-up of 1 year. There were 36 comminuted fractures and 24 intra-articular fractures. Sixteen fractures had associated soft tissue injuries. The mean duration from injury to surgery was 8 days. Plate fixation was performed in 59 fractures, and the remaining 16 were fixed with screws only. The implants (plates and screw heads) were placed in a dorsal location in 29 fractures and a lateral or volar location in 41. Postoperative complications including finger stiffness, osteoarthritic change, delayed union (>6 months), infection, and fracture malunion were evaluated. Finger stiffness was defined as a total active range of finger motion (%TAM) of <80% that of the contralateral side. Univariable analyses included seven variables related to patient characteristics (age and sex), fracture characteristics (degree of fracture comminution, joint involvement, and associated soft tissue injury), and surgical variables (type and location of implants). Multiple logistic regression analysis was used to identify which variables affected the postoperative %TAM at the final follow-up.

**Results:** Postoperative finger stiffness occurred in 32 fractures, osteoarthritic change in 6, delayed union in 3, superficial infection in 1, and fracture malunion in 7. Finger stiffness was more likely to develop with plate fixation of unstable fractures and be associated with comminution. Finger stiffness was less likely to develop with the use of titanium implants compared to other implants.

**Intra-articular bicondylar fracture of the proximal phalanx fixed with lateral plating.**
fixation than screw fixation and with dorsal implant placement than lateral or volar fixation; the differences were statistically significant ($P = 0.006$ and $0.020$, respectively). Multiple logistic regression analysis indicated that the independent risk factors for finger stiffness were plate fixation (OR, 6.7; 95% CI, 1.4–33.0; $P = 0.02$) and dorsal implant placement (OR, 2.8; 95% CI, 1.0–7.6; $P = 0.04$). The implant type and location accounted for approximately 57% of the variance in finger stiffness (Table 1).

**Summary Points:**
- In the current study, postoperative finger stiffness (%TAM < 80%) occurred in 32 (43%) of 75 unstable proximal phalangeal fractures fixed with titanium plates or screws.
- Plate fixation with dorsal placement was an important risk factor for postoperative stiffness in the treatment of unstable proximal phalangeal fractures.

**REFERENCES**

**PAPER 80**

Clinical Paper Session 15: Hand Trauma and Reconstruction  
Saturday, September 20, 2014 ● 3:42–3:49 PM  
Category: Evaluation/Diagnosis, Treatment, Surgical Technique  
Keyword: Nerve

**A Prospective Multicenter Registry of Peripheral Nerve Injuries Associated With Upper and Lower Extremity Orthopedic Trauma**  
N/A - Not a clinical study

◆ Jaimie T. Shores, MD  
◆ Glenn R. Gaston, MD  
◆ Lisa Reider, MHS  
◆ Michael J. Bosse, MDMETRC Investigators

**Hypothesis:** Little is known about the presence and treatment of peripheral nerve injuries associated with extremity upper and lower extremity trauma, though hand surgeons are commonly called upon to manage both. Our purpose was to establish a registry to address these knowledge gaps with a hypothesis that a large number of nerve injuries could be accumulated among multiple trauma centers and demonstrate the feasibility of multi-institutional studies of nerve injuries and their management.

**Methods:** 15 US Level I trauma centers entered registry data prospectively for 6 consecutive months. Nerve injury characteristics, treatment and demographics were collected on patients ages 18-84 between March-August 2013 and entered into a central data repository.

**Results:** Registry data were entered on 353 major nerve injuries in the upper (n=250) and lower (n=103) extremities. Upper limb zones of injury included the brachial plexus (10%), proximal, mid and distal humerus/ elbow (3%, 15%, and 23%, respectively), forearm (32%), and wrist (17%). Lower extremity zones of injury included the lumbar plexus (2%), hip/thigh (17%), Knee (19%) and below the knee (53%). Forty percent of upper extremity nerve injuries and 72% of lower extremity nerve injuries were associated with a fracture. Among the nerve injuries in the upper/lower extremities, 40%/27% were from sharp or laceration mechanism; 10%/5% were from avulsion, 21%/34% were from crush, 18%/10% from blast and 10%/24% from stretch mechanisms, respectively. Sixty seven percent of...
nerve injuries were treated non-operatively and 24% were treated with operative repair during the same admission for treatment of injury (Table 1). The majority that underwent repair/reconstruction were done so with nerve tubes (followed by nerve wraps, allograft, autograft, and nerve transfers (Table 2). Of interest is the large proportion of sharp/lacerated nerve injuries that did not undergo operative repair and that nerve tubes and allograft were more common than autograft for nerve reconstruction. These trends may be due to other injury characteristics, planned reconstruction outside the acute hospitalization, and the convenience of an “off the shelf” nerve product.

**Summary Points:** These data highlight a lack of standardization in care of upper extremity (and lower extremity) nerve injuries. A multi-center registry has demonstrated the potential to gather sufficient numbers for conducting prospective studies to evaluate variation in care and implications for outcomes following repair and reconstruction.

**PAPER 81**
Clinical Paper Session 15: Hand Trauma and Reconstruction
Saturday, September 20, 2014 • 3:49—3:56 PM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist, Congenital and Pediatric Problems

**Is There a Higher Risk of Infection With Delayed Treatment of Pediatric Seymour Fractures?**
Level 3 Evidence

♦ Bryan A. Reyes, MD
♦ Christine A. Ho, MD

**Hypothesis:** The purpose of this study is to describe treatment methods and complication rates of all Seymour fractures (open Salter-Harris III fractures of the distal phalanx of the hand with associated nailbed laceration) treated at or referred to a pediatric trauma center over a ten year time period. We hypothesized that delayed, or inappropriately treated Seymour fractures would be associated with higher infectious complication rates.

**Methods:** All patients treated in the orthopaedic pediatric hand clinic at our institution with an ICD-9 diagnosis of 816.02 or 816.12 (closed or open fracture of distal phalanx or phalanges of hand, respectively) between August 2002 and December 2012 were identified. All charts and radiographs were retrospectively reviewed. 47 patients treated for 48 Seymour fractures were identified. Patients were divided into groups based on timing and quality of treatment. ‘Appropriate’ treatment was defined as irrigation and debridement, fracture reduction, nailbed repair, and antibiotics. ‘Partial’ treatment was defined as any type of incomplete treatment. ‘Acute’ treatment was defined as management within 48 hours of the injury, and ‘Delayed’ as presenting for treatment past 48 hours from time of injury. Statistical comparisons were performed using Fisher’s exact test.

**Results:** Average patient age was 8.7 years (range 1-15 years), with 35 males and 12 females. Most common mechanism of injury was sports (32%, 15/47), followed by closed in door/window (30%, 14/47). 57% (27/47) were treated in an acute, appropriate manner, 15% (7/47) received acute, partial treatment, and 28% (13/47) received delayed treatment. 1 patient initially treated at an outside hospital had inadequate documentation to determine appropriateness of treatment but had no complications. There were 9 complications: 3 superficial infections, 5 osteomyelitis, and 1 malunion. With respect to infectious complications, only 1 superficial infection occurred in the acutely, appropriately treated group (infection rate 3.7%, 1/27), 1 osteomyelitis occurred in the acutely, partially treated group (14%, 1/7) and 6 (2 superficial, 4 osteomyelitis) occurred in the delayed treatment group, (46%, 6/13). Differences in infection rates among the treatment groups were statistically significant (P < 0.003 including all infections; P < 0.007 including osteomyelitis only).

**Summary Points:**
- Timing and quality of treatment of Seymour fractures significantly influences infectious complication rates
- Patients with delayed treatment had a 12-fold risk of infection compared to those treated early and appropriately
- To our knowledge, this study represents the largest reported cohort of Seymour fractures

**REFERENCES**

**PAPER 82**
Clinical Paper Session 15: Hand Trauma and Reconstruction
Saturday, September 20, 2014 • 4:03—4:10 PM
Category: Evaluation/Diagnosis, Treatment, Surgical Technique, Prognosis/Outcomes
Keyword: Hand and Wrist, Diseases and Disorders, General Principles

**An Outcome Analysis of 75 Consecutive Cases of Revision Proximal Interphalangeal Arthroplasty**
Level 3 Evidence

♦ Eric Wagner, MD
♦ Matthew T. Houdek, MD
♦ Steven L. Moran, MD
♦ Marco Rizzo, MD

**Hypothesis:** The incidence of proximal interphalangeal (PIP) arthroplasty has risen with improvements in the surgical techniques and implant technology for primary PIP arthroplasty, and reoperation rates are not inconsequential. The objective of this study was to examine the outcomes and factors that improve the results of revision PIP arthroplasty.

**Methods:** An analysis of 75 consecutive revision PIP arthroplasties in 49 patients was performed using our institution’s Joint Registry Database from 1998 to 2012. There were 61 (81%) females, 3 (4%) smokers, 9 (12%) with diabetes mellitus (DM), and with 43 (57%) arthroplasties performed on the dominant extremity. The average age was 58.1 years and average BMI was 27.5. 16 (21%) patients had rheumatoid arthritis (RA) with 14 on prednisone and 7 on methotrexate at the time of surgery. 34 (45%) had a history of prior MCP trauma. There were 12 (16%) constrained (silicone) implants and 63 (84%) non-constrained implants (34 pyrocarbon and 29 metal-plastic). 25 (33%) implants were cemented, while 14 (19%) were augmented with bone graft. Preoperatively, there were 2 (3%) patients with flexion contractures and 6 (8%) had MCP instability. Univariate logistic regression and Kaplan-Meier survival analyses were performed.

**Results:** At a median of 3.5 years of follow-up, 19 (25%) patients underwent re-revision surgery. Re-revision surgeries were performed for infection, instability, flexion contracture and heterotopic ossification. The 2, 5 and 10 year survival rates were 77%, 64%, 64%, respectively (Figure 1). Factors that had a significant influence on revision surgery were postoperative dislocations, pyrocarbon implants, and use of bone graft during the initial surgery (Table 1). Two operations were complicated by intraoperative fractures occurring during broaching of the proximal phalanx. Neither of these fractures required stabilization. 20% of patients experienced a post-operative complication, including 2 infections, 1 postoperative fracture, 3 cases of heterotopic ossification and 9 MCP dislocations, while another 30 (40%) experienced postoperative flexion contractures. Increasing BMI increased the rate of flexion contractures (P<0.007) and use of a pyrocarbon implant increased the rates of heterotopic ossification (P<0.02).

**Summary Points:** PIP arthroplasty in the revision setting represents a complex challenge for surgeons. With only a 77% 5 year survival and a high rate of
complications, there is a need to continue to search for innovative techniques to improve PIP outcomes in the revision setting. In this series, silicone implants had lower rates of implant failure and other complications.

Methods: We obtained six fresh frozen cadaver arms and eighteen digits were utilized in this investigation. We utilized the protocol developed in our lab that relied on placing each digit through a full active range of motion at the PIP joint by tensioning the common extensor, and capturing the osseous motion using live cine DICOM data from a mini-fluoroscopy unit, described in detail in a prior investigation.

Defects of 40, 60, and 80% were created in the palmar base of P2, simulating an acute PIP joint fracture dislocation. Each defect scenario was then reconstructed with a hemi-hamate arthroplasty followed by a volar plate arthroplasty, DICOM data were collected as above, and compared to both the intact and defect states.

Results: In the injury simulation, the average dorsal displacement of P2 in relation to P1 at the articular surface with the PIP joint in extension as measured on a true lateral was 0.77 mm in the 40% group (SD 0.48), 3.24 mm in the 60% group (SD 0.81), and 3.04 mm in the 80% group (SD 1.28), compared to the intact specimens. The average dorsal displacement of P2 in relation to P1 of the hemi-hamate reconstructed digits was 0.01 mm (SD 0.18), compared to the intact specimens. (Figure 1)

Flexion contractures were noted to occur in each of the specimens reconstructed with volar plate arthroplasty, averaging 20° (SD 14.4°) for the 40% defects, 36° (SD 12.5°) for the 60% defects, and 59° (SD 17.9°) for the 80% defects. There were no flexion contractures measured in the hemi-hamate reconstructions. (Figure 2)

Summary Points:
- Both volar plate arthroplasty and hemi-hamate reconstructive options prevent dorsal subluxation of the middle phalanx in this biomechanical model of PIP joint fracture dislocations involving 20 - 80% of the joint.
- Volar plate arthroplasty induced significant flexion contractures in all defect scenarios that increased in severity as the size of the bony defect at the palmar base of P2 increased.

PAPER 83
Clinical Paper Session 15: Hand Trauma and Reconstruction
Saturday, September 20, 2014 • 4:03—4:10 PM
Category: Evaluation/Diagnosis, Treatment
Keyword: Hand and Wrist

A Biomechanical Comparison of Hemihamate Reconstruction and Volar Plate Arthroplasty in PIP Joint Fracture Dislocations
N/A - Not a clinical study

Andrew Tyser, MD
Brent G. Parks, MSc
Mike Tsai, BS
Kenneth R. Means, MD

Hypothesis: In a biomechanical model, hemi-hamate reconstruction will reduce subluxation of the PIP joint seen in a fracture/defect scenario, and will more successfully normalize PIP joint kinematics when compared to volar plate arthroplasty reconstruction.

REFERENCES
REFERENCES


Use of Integra™ in Traumatic, Nonburn Injuries of the Hand

Level 4 Evidence

John Bracey, MD

Hypothesis: Although acellular dermal substitutes, such as Integra™, are frequently used in the management of complex hand wounds, little information is available regarding its utility in the trauma setting. We hypothesized that Integra™ would be useful in the reconstruction of traumatic, non-burn wounds of the hand.

Methods: Using common CPT codes, we retrospectively identified a cohort of patients with traumatic hand wounds for which the Integra™ bilayer wound matrix was used for reconstruction, excluding burn injuries. In total, 19 patients with a total of 28 traumatic wounds that required coverage with Integra™ were identified from 2009 to 2013. All wounds had exposed tendon, bone, or neurovascular structures. Patients were assessed for wound type and location, number of debridements prior to and after Integra™ placement, wound size, need for grafting, complications and ultimately healing. One patient was entirely lost to follow up, and an additional 2 patients were lost prior to their wounds being completely healed.

Results: The majority of the wounds were the result of a crush or avulsion injury. The average wound size was 15 cm², and wounds equally involved the hand, finger, and fingertip. On average, wounds required 2 surgical debridements prior to placement of the Integra™ bilayer wound matrix. Only 3 wounds required additional debridement in the operating room after Integra™ placement. Four wounds had delayed healing which required substantial wound care. Two of these wounds were secondary to high pressure injection injuries, and one was in an 88 year old with severe dementia. Only one patient required a return to the operating room for failure of wound coverage which had to be salvaged with a local flap. Interestingly, this patient was an insulin-dependent diabetic. The 5 wounds with delayed or failed healing required twice as many debridements prior to placement of Integra™ compared to the wounds that healed well; 4 of the 5 were hand wounds. All of the fingertip and 8 of 9 finger wounds healed unexpectedly. There were no surgical site infections.

Summary Points:
- Overall, this study validates the use of Integra™ in the reconstruction of traumatic, non-burn injuries of the hand.
- Integra™ appears to be particularly effective for finger and fingertip injuries.
- Complications were more common in hand wounds and wounds requiring a greater number of debridements prior to placement of Integra™ due to the severity of the trauma.
- Our data suggests that these hand wounds may be candidates for early flap coverage, rather than placement of Integra™.

PAPER 85

Clinical Paper Session 16: Soft Tissue Coverage
Saturday, September 20 • 2014 • 3:42–3:49 PM
Category: Treatment, Prognosis/Outcomes
Keyword: Hand and Wrist

Microvascular reconstruction using distant free flaps is often required following excision of skin cancers of the hand and the delivered flaps should be chosen with many factors taken into consideration, especially in the hand, where a very thin, pliable, and durable flap is required to maintain both function and cosmetic appearance. Free flaps, such as perforator flaps, however, for distal or small defects of the hand following excision of skin cancer, require the sacrifices of the main arterial pedicle and exhibit potential limitations regarding flap size and instead, arterIALIZED...
venous free flap could be utilized as an alternative reconstructive method for skin cancers of the digits.

Methods: Twelve soft tissue defects of the digits following excision of skin cancers (five cases of noninvasive malignant melanoma and seven cases of low-grade squamous cell carcinoma) were reconstructed using arterIALIZED venous free flaps from January 2009 to May 2011. In all melanoma patients and three squamous cell cancer patients, the tumor was located in the fingertip involving the nail complex area. Flaps ranged in size from 1 x 1.5 cm to 5 x 7 cm. Donor sites were treated with primary closures in five cases and with skin grafts in seven cases.

Results: Flaps completely survived in nine cases. Partial necrosis developed in three cases; skin graft was only necessary for one case. Seven cases in the early phase of our study was inset in the anterograde direction and more recent five cases in the retrograde direction. During a mean follow-up of 26 months, there were no recurrences or metastases. Debulking surgery was not required in all cases and nail fold formation for acrylic nail plate was performed in two cases.

Summary Points: Recently in cases of noninvasive or low-grade skin cancer of the hand, the concept of “preservative surgery” has been a higher priority compared to functional and aesthetic aspects. Particularly in cases of reconstruction of a small sized fingertip defect as one functional unit, arterialized venous free flaps offer several advantages, such as thinness and color similar to the hand, technical ease with a short operative time, less donor site morbidity, applicable to any site, and modifiable to the appropriate size and shape. ArterIALIZED venous free flap could serve as a useful and reliable method for soft tissue reconstruction following excision of skin cancers in the digits.

REFERENCES

PAPER 87
Clinical Paper Session 16: Soft Tissue Coverage
Saturday, September 20, 2014 ● 3:56–4:03 PM
Category: Basic Science
Keyword: Practice Management

Effectiveness of Mesenchymal Stem Cell Sheets to Random Pattern Flap in an Experimental Animal Model
N/A - Not a clinical study

Tatsuhiko Kira, MD
Shohei Omokawa, MD, PhD
Manabu Akahane, MD, PhD
Takamasa Shimizu, MD
Kenichi Nakano, MD
Yasuhiro Tanaka, MD, PhD

Hypothesis: Although mesenchymal stem cells (MSCs) have been applied for therapeutic angiogenesis in many areas, transplantation of MSCs only does not enhance angiogenesis efficiently because of a low probability of cell-fixation. We hypothesized that cell sheets derived from MSCs (MSC-sheet) could improve angiogenesis and the survival of a skin flap in an experimental animal model. The modified extracellular matrix may improve adherence of the sheet and angiogenic factors.

Methods: We cultured primary bone marrow cells aspirated from the femurs of 7-week-old rats in regular medium consisting of Earle’s Minimal Essential Medium with 15% fetal bovine serum and antibiotics for 2 weeks. After reaching confluence, the cells were released and seeded at 1 × 104 cells/cm² onto 10-cm culture dishes in the above medium supplemented with 82 μg/mL ascorbic acid phosphate at 5% oxygen for 2 weeks. We retrieved the MSC-sheets and injected these into the dorsal subcutaneous tissue of rats at four sites in a longitudinal row. Two days after transplantation, we elevated caudally based random pattern skin flaps (12 × 3 cm, n = 10). In a control group, we injected equal volumes of phosphate buffered saline (n = 10), prior to the same surgery. Seven days after the surgery, photographs of random pattern skin flaps in the experimental group (A) and control group (B) on the seventh photographs/day. The necrotic tissue areas were significantly demphasized in the treatment group, compared with the control group.
operation, we evaluated the surviving area of the flaps from digital photographs. The survival area was compared with the total flap area, using image processing software (Image J, Wayne Rasband, National Institutes of Health) and was calculated as a percentage. Both groups were compared using the Mann–Whitney U test, and a p-value less than 0.05 was considered significant.

**Results:** No surgical site infection was found. The area of flap survival was significantly increased in the experimental group (67 ± 8 %) compared with the control group (50 ± 4 %; **P <0.05**).

**Summary Points:**
- MSC-sheet implantation increased the survival area of random pattern skin flaps in rat dorsum.
- Adherence of angiogenic factors such as vascular endothelial growth factor may have contributed to the increased flap survival.

**REFERENCES**


**PAPER 88**

Clinical Paper Session 16: Soft Tissue Coverage  
Saturday, September 20, 2014 4:03—4:10 PM  
Category: Treatment, Surgical Technique, Prognosis/Outcomes, Anatomy  
Keyword: Hand and Wrist, Elbow and Forearm, General Principles

**Posterior Elbow Soft-Tissue Reconstruction Using a Flexor Carpi Ulnaris Muscle Turnover Flap**  
Level 4 Evidence

**Authors:**  
- William Slikker III, MD  
- Christopher Bayne, MD  
- Jianjun Ma, MD, PhD  
- Fraser J. Leversedge, MD  
- Mark S. Cohen, MD  
- Robert W. Wysocki, MD

**Hypothesis:** We hypothesize that a flexor carpi ulnaris (FCU) muscle flap can be used to effectively cover soft-tissue defects of the posterior elbow with low morbidity to the wrist in terms of pain or disability.

**Methods:** A total of 16 patients who developed a soft-tissue defect on the posterior aspect of the elbow were treated with an FCU flap between the years of 2003 and 2011. Mean follow up was 24 months (range, 6-39 months). Outcomes collected included: elbow and forearm range of motion, wound healing; grip strength; isokinetic dynamometry; visual analogue scores (VAS) for pain; disabilities of the arm, shoulder, and hand (DASH) score; and Mayo Elbow Performance Scores (MEPS). Isokinetic strength in wrist flexion and extension was evaluated using the Biodex II dynamometer (Biodex Medical Systems; [CITY], Shirley, New York). Non-parametric statistical methods were used to analyze the data. The Friedman test was used to make side-to-side comparisons between the injured and uninjured sides.

**Results:** Index surgical procedures requiring an FCU flap included fracture reduction and internal fixation or total elbow arthroplasty. All wounds healed after the FCU flap surgery with no reoperations. Average VAS was 2.3 in the operative elbow. Average DASH score was 35 and average MEPS score was 80. Average elbow range of motion was 11° to 140° and forearm range of motion averaged 70° of pronation and 73° of supination. Operative arm grip strength was 97% of the nonoperative arm. Average wrist flexion peak torque of the operative arm was 87% of the nonoperative arm. Fatigue percentage of wrist flexion/extension was 29% for the nonoperative arm and 7% for the operative arm.

**Summary Points:**
- Patients undergoing an FCU flap were found to have little pain as measured by the VAS, good functional outcomes as measured by the DASH and MEPS, and largely preserved grip strength and wrist flexion strength.
- Our results suggest that an FCU muscle flap can be used to effectively cover soft-tissue defects of the posterior elbow with low morbidity to the wrist in terms of pain or disability.

**REFERENCES**


- Royalties/Honoraria received from: Ortholux Surgical Designs
- Consulting Fee: Stryker Orthopaedics, Axogen
- Contracted Research: Axogen, Bioventus (Leversedge)
good category. The patient with the fracture through the drill hole rated in the excellent group. 100% of patients were satisfied with their results, would undergo the same procedure on the other wrist if needed, and would recommend the procedure to others.

Summary Points:
- There is a plethora of short-term results for the surgical treatment of DSI due to a SLIL tear; however, the reported long-term results have not been acceptable(2).
- Long-term failure of previous techniques may be due to a “one procedure fits all” approach without regard to the pathology of the instability(3).
- Fusion creates a static deformity to treat a dynamic instability which is undesirable(4). Tenodesis and capsulodesis also create a static deformity and they stretch and fail in long-term studies(5).
- Based on our long-term (20+ years) prospective outcome study, we recommend Dyna-desis to treat DSI.

Hypothesis: Scapholunate advanced collapse (SLAC) is the most common degenerative pathway of the wrist. It is often treated by scaphoid excision and four-corner-fusion but there is limited information on long-term results of this procedure. We hypothesize that this approach to SLAC wrist reconstruction is a durable surgery with little radiographic or clinical degeneration over time.

Methods: This is a retrospective long-term study of patients treated with scaphoid excision and four-corner-fusion. A retrospective chart review and long-term follow-up were obtained. Evaluation included standard wrist radiographs, wrist active range of motion (AROM), and the DASH questionnaire. Radiographs were subjectively evaluated and organized into five (5) categories based on joint space preservation/destruction.

Results: A total of 470 patients underwent a scaphoid excision and four-corner-fusion for SLAC wrist reconstruction between 1982 and 2003. Twelve patients (15 wrists) were available for comprehensive follow-up. Of this group, the average age at surgery was 49.1 (range 25-67 years). Average years post surgery was 18 (range 11 to 27 years post-op). SLAC was the etiology in 13 wrists and scaphoid non-union advanced collapse (SNAC) in 2 wrists. Average extension/flexion arc was 68.6 (range 0 to 96 degrees) and average radial/ulnar deviation arc was 32.9 (range 0 – 55 degrees). DASH scores averaged 7.8 (range 0-32.5), with only one score above sixteen. The majority of wrists (67%) demonstrated zero to moderate radio-lunate joint space narrowing, 20% showed advanced joint space narrowing whereas 13% showed total joint space destruction (one wrist with particulate synovitis and one that progressed to require a total wrist fusion).

Summary Points:
- Scaphoid excision and four-corner fusion remains a viable option for patients with advanced wrist arthritis.
- Functional results are reliable, resilient and remain stable over time with preservation of the radio-lunate joint in 67% of patients.
- More importantly, patient satisfaction was very high, with low functional impairment.
- Further studies may be appropriate to quantify radiographic degeneration since pre-operative X-rays were not uniformly available. However, the clinical relevance of this is open to discussion, as radiographic evidence of arthritis does not seem to correlate with patient satisfaction or length of follow-up.

REFERENCES

JOINT PAPER 05
Surgeon-Therapist Joint Paper Session:
Friday, September 20, 2014 • 2:13–2:20 PM
Category: Treatment, Therapy/Rehabilitation, Anatomy, Basic Science
Keyword: Hand and Wrist, Diseases and Disorders

Radiographic Analysis of Simulated First Dorsal Interosseous and Opponens Pollicis Activation Upon Thumb CMC Joint Subluxation: A Cadaver Study

N/A - Not a clinical study

- Julie E. Adams, MD
- Benjamin E. Rosenstein, MS
- Virginia O’Brien, OTR, CHT
- David J. Nuckley, PhD
- Erik A. Magnusson, BS

Hypothesis: Recent studies suggest that selective activation of the first dorsal interosseous (DI) reduces symptoms of thumb CMC joint arthritis and joint subluxation (1- 4). We hypothesize that the DI and opponens pollicis (OP) work concomitantly to decrease subluxation at the CMC joint. Our study investigates the effect of applications of loads to the DI, OP, and DI + OP on joint subluxation in a cadaver model.
Methods: 11 cadaver arms were dissected to identify the FDI and OP which were tagged for application of loads. Capsulotomies of the CMC joint were performed such that the metacarpal could freely subluxate through the incision.

Specimens were fixed in neutral wrist position and a 5kg subluxation load was applied to the first metacarpal. Baseline AP fluoroscan radiographs were taken with subluxation load attached. Subsequently, application of loads were applied to the OP, DI, and OP+DI, and radiographs were taken with at 25, 50, 75 & 100% of maximal loads of OP (40 N) & DI (30N) alone; then with simultaneous loading of OP and DI. CMC subluxation was measured (5) using imageJ (NIH: Bethesda, MD) software.

Results: Average ratio of radial subluxation (RS) to articular width (AQ) with increasing loads of DI, OP and DI-OP shown with standard error in Table 1 and Figure 1. Subluxation at the CMCj is decreased with increasing activation of OP and DI-OP with the OP acting as the predominant reducing force. Results analysis using ANOVA demonstrated a statistically significant result ($P=0.00$) for the overall model but there was no statistical significance for individual loaded states.

The DI-OP curve (Figure 1) suggests that DI acts to counterbalance the overcorrecting force of OP. There is a synergistic effect of DI-OP at the physiological load of 25% as DI-OP is significantly more reduced than OP alone (ratio = 0.348 vs .4074).

Summary Points: Activation of the OP and DI muscles reduces subluxation at the CMC joint in a dose dependent fashion and improved reduction is seen with concomitant activation. Likely the mechanism of action for selective strengthening programs to improve basilar thumb pain and reduce joint subluxation involves concomitant activation of DI and OP.

REFERENCES

- Royalties/Honoraria received from: Biomet (Adams); Elsevier (Adams)
- Consulting Fee: Arthrex, Articulinx (Adams); Zyga Consulting (Nuckley)
- Salary: Employed by Zimmer Spine in Research and Development (Nuckley)

* Speaker has nothing of financial value to disclose