Advancements in Hammertoe Repair

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- Dr. Doug Hale
- Dr. Jeffrey Christensen
- Dr. Mike Vickers
- Dr. DJ Wardle
- Dr. Matthew Williams
Hammertoes: Why do we need a refresher?

- 34.5% of all foot and ankle conditions in adults >65 years of age\(^1\)
- Approximately 550,000 hammertoe procedures in 2012, expected 647,000 procedures in 2017\(^2\)
Complications:

- Recurrent deformity
- Floating toes
- Sausage toes
- Too straight
- Too long
- Too short
- Recurvatum
- Vascular compromise
- Infection

Photo credits: Jeffrey Christensen, DPM
Not all hammertoes are created equal

- Flexion at the PIPJ
- Rigid vs flexible
- Dorsal contracture at the MTPJ
- Medial or lateral deviation at the MTPJ

Photo credit: Dr. Jeffrey Christensen, DPM
Sequential Hammertoe Release:

- IPJ tenotomy/capsulotomy
- Removal of bone from IPJ
- Extensor hood (wing/sling) release
- MTPJ release
- Flexor plate release

Arthrodesis vs Arthroplasty

- Schrier FAI 2016
  - 39 arthroplasties vs 50 arthrodesis
  - RCT study
  - No clinical difference between PIPJ fusion and PIPJ resection

- Coughlin FAI 2000
  - 95/118 toes (81%) PIP arthrodesis
  - 22/118 (19%) fibrous union.
  - No statistical difference in satisfaction between bony union vs fibrous union
Arthroplasty: No implantation

- Sarrafian FAI, 1995
  - Suture extensor tendon into base of proximal phalanx using nylon suture
- O'Kane FAI 2005
  - 100 toes with arthroplasty
  - 2 required revision
  - No other complications
- Yassin Foot and Ankle Spec, 2016
  - 454 K-wire fixation vs 221 coban strapping
  - Infection rates k-wire (4.2%) vs coban correction group (0.9%)
  - Average follow-up 12.8 months (range, 6-65 months).
  - Similar outcomes but coban strapping had fewer infections.
To transfer or not to transfer:

- Boyer, DeOrio FAI 2007
  - 79 digits with FDL transfer with avg follow up 33 months
  - 29 Flexible → no arthroplasty, 50 fixed → with arthroplasty
    - If dorsal subluxation at MPJ, arthroplasty combined with FDL transfer
  - 8/29 flexible dissatisfied (28%) due to recurrent deformity
  - 1/50 with fixed deformity (2%) dissatisfied due to deformity at DIPJ
  - Overall, 70/79 satisfaction rate of 89%
  - Few complications, no floating toes

Flexor tenotomy

- Tamir FAI 2014:
  - 103 tip of toe ulcers with flexible/semi-flexible claw-toe
  - Long flexor tenotomy
  - 101/103 healed (98%)
  - 14 minor complications:
    - 9 with transfer lesions
    - 3 with hyperextension
    - 1 infection
    - 1 with pain

Is an arthroplasty needed?

- DJD of the PIPJ or mechanical process?
- Look for medial or lateral deviation of digit
  - Medial deviation → lateral incision
- Cut FDB and Isolate FDL
- Place a 2.2mm by 4.0 mm micro corkscrew (Arthrex®)
- Place toe in corrected anatomic position
- Suture FDL tendon to anchor
- Can use K-wire

Future research project with Dr. Gregory Grant
K-wire fixation

- First used in hammertoe fixation by Taylor in 1940
- Considered gold standard for hammertoe correction

Advantages:
- Readily available
- Cost effective $10-$20

Disadvantages:
- Multiple complications
- Patient anxiety

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin tract infections</td>
<td>9/2,698 (0.3%)</td>
<td>3/118 (2.5%)</td>
<td>16/156 (10%)</td>
<td>16/87 (18%)</td>
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<tr>
<td>Pins backing out</td>
<td>94/2,698 (3.5%)</td>
<td>1/118 (0.8%)</td>
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<td>Breaking</td>
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<td>0/118 (0%)</td>
<td>33/1002 (3.2%)</td>
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<tr>
<td>Recurrent deformity</td>
<td>150/2,698 (5.6%)</td>
<td>7/118 (5.9%)</td>
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<tr>
<td>Amputation</td>
<td>10/2,698 (0.4%)</td>
<td>1/118 (0.8%)</td>
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</table>
Duration of K-wire fixation:

- Klammer FAI 2012\textsuperscript{15}:
  - Compared length of K-wire fixation times 3 weeks vs 6 weeks
  - At 3 month follow up, recurrent deformity in 3 weeks group (11/26, 47%) versus 6 weeks group (2/26, 8.7%)
  - No increase in complications with longer K-wire duration

Alternative K-wires:

- Clauss Clin Orthop Relat Res 2012:
  - 135 hammertoes (81 SS, 54 Ti)
  - Sonicated wires for biofilm at 6 weeks
  - >500 CFU/mL bacteria: 35 SS vs 10 Ti K wires
  - 9 digits infection/recurrence, 8 were in the SS group
  - Ti group had a lower recurrence rate, less pain, and less swelling

- Konkel FAI 2011
  - 47 hammertoes with L-lactate 2-mm absorbable pin for internal fixation Trim-It® pin Arthrex
  - 1/47 infection
  - 39/47 (83%) complete bony union, 6/47 (13%) stable fibrous union with some motion, 2/47 (4%) toes with partial union and no motion
  - Higher fusion rate, less excessive medial/lateral angulation and a high (96.5%) patient satisfaction rate.
Two pin technique

- Boufelli J FAS 2016
  - 91 hammertoe procedures (60 patients) with 2 pin fixation
  - 89 digits (97.80%) had no complications
  - 2 patients (3.33%) loose or broken hardware
  - 1 patient revision for malrotation
  - No infections
  - Low complication rate supports technique as a cost-effective and viable construct for hammertoe repair.

Implants

- Advantages:
  - Fixed construct that helps prevent recurrent deformity
  - Can avoid K-wire fixation if desired
  - Patient satisfaction

- Disadvantages:
  - Cost $500-1500 per implant

- Materials:
  - Titanium
  - Peek

- Construct:
  - 1-piece
  - 2-piece
  - Single screw

Smith and Nephew Hat-Trick Lesser Toe System®

<table>
<thead>
<tr>
<th>Category</th>
<th>Name</th>
<th>Company</th>
<th>Material</th>
<th>No. of sizes available</th>
<th>Plantar angle</th>
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<tbody>
<tr>
<td>Shape memory</td>
<td>Smart Toe® II</td>
<td>Stryker®</td>
<td>Memometal Nitinol</td>
<td>6 + 2 × DIP</td>
<td>0°–10°</td>
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<td></td>
<td>Hammerlock®</td>
<td>BME®</td>
<td>Memometal Nitinol</td>
<td>4 + 1 × DIP</td>
<td>0°–10°</td>
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<td>One-piece solid or cannulated</td>
<td>ProToe VO®</td>
<td>Wright®</td>
<td>Stainless steel</td>
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<td>0°–10°</td>
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<td>Arrow-look™</td>
<td>Arrowhead Medical®</td>
<td>Stainless steel</td>
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<td>Cartiva®</td>
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<td>Wright™</td>
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<tr>
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<td>Digifuse™</td>
<td>Metasurg®</td>
<td>Titanium</td>
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<td>0°–10°</td>
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<td>Two Step Imp. Syst.</td>
<td>Trilliant Surgical LTD®</td>
<td>Titanium</td>
<td>3</td>
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<tr>
<td></td>
<td>DuaFit®</td>
<td>In 2 Bones</td>
<td>PEEK</td>
<td>4</td>
<td>0°–10°–17°</td>
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<td>Toegrip®</td>
<td>Synchro Medical®</td>
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<td>Extremity Medical™</td>
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<td>Tornier®</td>
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<td>Nextremity Solutions®</td>
<td>Titanium</td>
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<td>10°</td>
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<td>Hat-Trick®</td>
<td>Smith and Nephew®</td>
<td>PEEK</td>
<td>4 Prox/2 mid</td>
<td>0°–10°</td>
</tr>
</tbody>
</table>

a 10° and 17° angulated are solid, not cannulated
Combination:

Wright Medical Phalinx® implant
Caterini FAI, 2004

51 toes with titanium intramedullary screw

3/51 asymptomatic non-union, 1 with a broken screw

7/51 hdwr

1/51 infection with malalignment

Compared with K-wire fixation, stabilization with a cannulated screw decreases the risk of infection, radiographic nonunion, and of mallet toe deformity.

Richman, FAI 2017

Table 2. Clinical Outcomes of Toes Fixed With Intramedullary Device and K-Wire.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Intramedullary</th>
<th>K-Wire</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toes, n</td>
<td>54</td>
<td>95</td>
<td></td>
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<tr>
<td>Right, n (%)</td>
<td>29 (54)</td>
<td>58 (61)</td>
<td>.393a</td>
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<tr>
<td>Second, n (%)</td>
<td>35 (65)</td>
<td>28 (30)</td>
<td>&lt;.001a</td>
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<tr>
<td>Third, n (%)</td>
<td>17 (32)</td>
<td>21 (22)</td>
<td></td>
</tr>
<tr>
<td>Fourth, n (%)</td>
<td>2 (4)</td>
<td>21 (22)</td>
<td></td>
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<tr>
<td>Fifth, n (%)</td>
<td>0 (0)</td>
<td>25 (26)</td>
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<tr>
<td>Time to union (mo)b</td>
<td>9.58 ± 6.4</td>
<td>14.3 ± 9.3</td>
<td>.916c</td>
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<tr>
<td>Complications, n (%)</td>
<td>3 (5.6)</td>
<td>18 (19)</td>
<td>.027a</td>
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<tr>
<td>Infection</td>
<td>0 (0)</td>
<td>3 (3.2)</td>
<td>.554a</td>
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<tr>
<td>Symptomatic, n (%)</td>
<td>3 (5.6)</td>
<td>15 (15.8)</td>
<td>.183a</td>
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<td>Revision surgery, n (%)</td>
<td>0 (0)</td>
<td>5 (5.2)</td>
<td>.159a</td>
</tr>
<tr>
<td>Recurrent deformity, n (%)</td>
<td>1 (1.9)</td>
<td>9 (9.5)</td>
<td>.095a</td>
</tr>
</tbody>
</table>

- K wire group 16 patients (27%) were not completely satisfied by outcome
- Implant group 3 patients (7.7%) were not completely satisfied by outcome
- CannuLink® Wright medical intramedullary device decreased recurrent deformity, less need for revision surgery, fewer complications, and no hardware failure.
- No conflicts of interest or funding

58 Smart-toe compared with 28 k-wire fixation

The mean follow-up period was 388.6 +/- 285.9 (range 94 to 1130) days

Fracture of internal fixation occurred in 12 (20.7%) of the Smart Toe implants and 2 (7.1%) of the buried K-wires.

Revision surgery was needed in 5 (8.6%) of the Smart Toe and 3 (10.7%) of the buried intramedullary K-wire implants.
Randomized control trial

45 Dual-component, intramedullary, stainless steel (DCIMSS) implants vs 47 with K-wire fixation

No cases of implant misalignment or instability, infection (pin tract or otherwise), wound dehiscence, recurrent or new digital deformity, persistent pain or other symptoms requiring treatment or a return to the operating room for revision surgery were observed.

Delayed bone union, in the form of clinically stable, fibrous pseudoarthrosis, was observed radiographically in both fixation groups although the fusions remained clinically stable and thus did not warrant additional intervention.

2-piece intramedullary implant group was associated with a greater mean Bristol Foot Score and Foot Function Index score and a greater incidence of fusion.
Level III systematic review

No statistical differences, but cost-benefit studies need to be performed

Table 2 Results of the reviewed articles

<table>
<thead>
<tr>
<th>References</th>
<th>Level of evidence</th>
<th>Device</th>
<th>Toes/no. patients</th>
<th>Patients’ satisfaction (%)</th>
<th>Acceptable alignment (%)</th>
<th>Radiological arthrodesis (%)</th>
<th>AOFAS variation (preoperative/postoperative)</th>
<th>K-wire revision surgery (%)</th>
<th>Device revision surgery (%)</th>
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</thead>
<tbody>
<tr>
<td>Angirasa et al. J Foot Ankle Surg [11]</td>
<td>IV, retrospective case series</td>
<td>Smart Toe®</td>
<td>13/13</td>
<td>98.3</td>
<td>NA</td>
<td>100</td>
<td>NA</td>
<td>19 (52/71)</td>
<td>0</td>
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<tr>
<td>Catena et al. Foot Ank Int [12]</td>
<td>IV, case series</td>
<td>Smart Toe®</td>
<td>42/24</td>
<td>100</td>
<td>81</td>
<td>83.3</td>
<td>45 (40.4/84.3)</td>
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<td>Coillard et al. Foot Ank Int [13]</td>
<td>IV, prospective case series</td>
<td>Ipp-On®</td>
<td>156/117</td>
<td>98</td>
<td>81.6</td>
<td>60.5</td>
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<td>NA</td>
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<td>IV, retrospective case series</td>
<td>Stayfuse®</td>
<td>38/27</td>
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<td>81.6</td>
<td>60.5</td>
<td>NA</td>
<td>NA</td>
<td>7.9</td>
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<td>Fazal et al. Foot Ank Int [15]</td>
<td>IV, retrospective case series</td>
<td>StayFuse®</td>
<td>150/140</td>
<td>95</td>
<td>NA</td>
<td>73</td>
<td>58.7 (22.9/81.6)</td>
<td>NA</td>
<td>3.3</td>
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<td>Roukis et al. Foot Ankle Spec [10]</td>
<td>IV, retrospective case series</td>
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<td>Sandhu et al. Foot Ankle Spec [16]</td>
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<td>93.8</td>
<td>NA</td>
<td>NA</td>
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<td>Scholl et al. J Foot Ankle Surg [17]</td>
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<td>87.9</td>
<td>68.9</td>
<td>NA</td>
<td>10.7</td>
<td>8.6</td>
</tr>
</tbody>
</table>

NA not available, AOFAS American Orthopaedic Foot and Ankle Society Forefoot score

Conclusion:

- Flexible/Semi-flexible deformity:
  - Flexor tenotomy

- Rigid deformity:
  - Healthy patients $\rightarrow$ arthroplasty with K-wires in for 6 weeks to prevent recurrent deformity
  - Anxiety or poor compliance $\rightarrow$ implant or intramedullary screw
  - Older patients with comorbidities $\rightarrow$ arthroplasty with Coban strapping

- Hyperextension at the MPJ:
  - Combine with flexor transfer

- Medial/Lateral subluxation of digit:
  - Flexor to proximal phalanx with anchor
Questions?


