First Metatarsophalangeal Contact Properties are Similar Following Proximal Opening Wedge and Scarf Osteotomies

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Official Disclaimer

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Introduction

- Hallux valgus is a common foot deformity with over one hundred described surgical techniques.\textsuperscript{1–3}

- The Proximal Opening Wedge Osteotomy (POWO) utilizes a wedge fixation plate for correction of moderate to severe 1–2 intermetatarsal angle deformities.\textsuperscript{4–7}

- Clinical studies have shown effective healing and corrective reliability with low rates of nonunion at follow-up using POWO.\textsuperscript{4,6}

- A result of using POWO is that it causes first metatarsal lengthening\textsuperscript{4,6,8} which could potentially alter the pressures in the first metatarsophalangeal (MTP) joint.
Purpose

- The purpose of this study was to investigate first MTP joint intra-articular contact properties and range of motion following POWO and scarf osteotomy compared to the native MTP joint.

- Our hypothesis was that the POWO would result in increased intra-articular pressure and contact forces compared to the intact joint and scarf osteotomy.
Materials and Methods

- Eighteen fresh frozen below-the-knee cadaveric limbs were obtained.
- Six of the specimens without deformity were used as control.
- Twelve specimens with hallux valgus were stratified into two surgical groups: POWO group or scarf osteotomy.
- Surgical groups were matched based on hallux valgus angle (HVA) and 1–2 intermetatarsal angle (IMA).

Figure 1. Preoperative specimen with Hallux Valgus
Materials and Methods

- Cadaveric specimens were stabilized in a vise above the ankle joint to allow for adequate motion.

- Contact properties were measured using a pressure transducer (Tekscan I-Scan pressure transducer, Boston, Massachusetts) that was placed within the MTP joint.

- Contact properties were continuously measured while applying a 50N dorsal load across the first toe to simulate weightbearing.

- Data obtained at the peak of the fourth cycle was used for analysis.

- ANOVA analysis comparing peak intra-articular pressure (kPa), force (N), area (mm$^2$) among normal, POWO, and scarf osteotomy groups.

- Unpaired and paired student’s t-test were used for pre- and post-operative comparisons.
Surgical Correction

Figure 3. Plate fixation using POWO.

Figure 4. Screw fixation following scarf osteotomy.
Results

Table 1  Normal vs Preoperative Hallux Valgus Specimens Peak Contact Properties of MTP Joint (mean (sd))

<table>
<thead>
<tr>
<th></th>
<th>Normal (n=6)</th>
<th>Hallux Valgus (n=12)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (kPa)</td>
<td>12410 (11195)</td>
<td>5960 (6800)</td>
<td>0.007*</td>
</tr>
<tr>
<td>Force (N)</td>
<td>1150 (1297)</td>
<td>463 (534)</td>
<td>0.012*</td>
</tr>
<tr>
<td>Area (mm2)</td>
<td>70 (38)</td>
<td>61.8 (21.8)</td>
<td>0.35</td>
</tr>
</tbody>
</table>

*Normal specimen significantly higher compared to mean hallux valgus specimens.

Table 2  Normal vs Postoperative Bunion Peak Contact Properties of MTP Joint (mean (sd))

<table>
<thead>
<tr>
<th></th>
<th>Normal (n=6)</th>
<th>Scarf Group (n=6)</th>
<th>POWO Group (n=6)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (kPa)</td>
<td>12410 (11195)</td>
<td>4724 (5778)</td>
<td>7197 (8042)</td>
<td>0.31</td>
</tr>
<tr>
<td>Force (N)</td>
<td>1150 (1297)</td>
<td>558 (520)</td>
<td>729 (585)</td>
<td>0.3</td>
</tr>
<tr>
<td>Area (mm2)</td>
<td>70 (38)</td>
<td>69 (24)</td>
<td>60 (19.8)</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Table 3  MTP Joint Range of Motion of Postoperative Specimens Compared to Normal (mean (sd))

<table>
<thead>
<tr>
<th></th>
<th>Normal (n=6)</th>
<th>Scarf Group (n=6)</th>
<th>POWO Group (n=6)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Dorsiflexions (degrees)</td>
<td>60.8 (29.9)</td>
<td>72.7 (12)</td>
<td>61.8 (10.1)</td>
<td>0.53</td>
</tr>
<tr>
<td>Absolute Plantarflexion (degrees)</td>
<td>11 (33.8)</td>
<td>19 (26.5)</td>
<td>2.5 (12.9)</td>
<td>0.56</td>
</tr>
</tbody>
</table>

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Results

Figure 5 Mean Pressure of Post-operative Specimens Compared to Normal

Pressure (kPa)

Normal  Scarf Osteotomy  POWO

Error Bar ± Standard Error

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Conclusions

- We found no significant differences in intra-articular pressure, force, or contact area among the three groups.

- Normal specimens had significantly higher intra-articular forces compared to hallux valgus specimens.

- The results suggest that hallux valgus alters the biomechanics within the normal MTP joint.

- We found an average increase in the metatarsal length after POWO of 1.54 mm ± 2.27 and 1.36 mm ± 1.39 after scarf osteotomy, but neither was statistically significant.
Limitations

- Large standard deviation; likely due to variations in joint laxity from long-term hallux valgus and age of specimens were not matched between groups.
- Cadaver study with older (mean 74 y/o) specimens
- Small group sizes (n=6 per group)
- Further long-term clinical studies are needed to identify risk of future arthritis, but our results help confirm that using a POWO for hallux valgus correction does not significantly increase intra-articular pressure within the first MTP joint.
References


