The effect of orthotics on ankle and subtalar joint orientation and load distribution utilizing a novel system to simulate weight bearing in a cadaveric model

Naven Duggal, M.D.¹, Aron Lechtig, M.D.²*, Patrick Williamson, BSc.²,³*, Philip Hanna, M.D.²*, Stephen Okajima, BSc ², Peter Biggane, BSc ², Michael Nasr, M.D.², Ara Nazarian, Ph.D.²

1. Syracuse Orthopedic Specialists, Syracuse, NY
2. Center for Advanced Orthopaedic Studies, Department of Orthopaedic Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA
3. Department of Mechanical Engineering, Boston University, Boston, MA, USA

*Authors contributed equally to the project
Conflict of Interest

Naven Duggal, M.D.

My disclosure is in the Final AOFAS Program Book.

All authors in this study have no potential conflicts with this presentation.
Introduction

• Foot orthotics are commonly prescribed to address the hindfoot and midfoot deformities *. By 2020 its market size will be 30% larger than today

• A large population uses over the counter orthoses without prescription as a means to alleviate lower limb pain and discomfort

• Lower limb mechanics, orientation, and force distribution comprise a well-balanced and highly correlated system. This system may be altered by changing the foot habitus

• IndustryARC. Foot Orthotic Insoles Market to Reach 3.5 USD Billion By 2020. 2016.
Introduction

• Unless the proper evaluation is conducted, followed by the prescription of the right insoles, long-term use of orthoses could have a negative impact on articular cartilage

• This study aims to use TekScan pressure mapping to compare the intra-articular pressure distribution in a cadaveric ankle and subtalar joints with and without orthotics to explore changes seen in each

• We hypothesize that changes in the center of force, the peak pressure and mean pressures will be evident with the placement of orthotics beneath the medial arch as compared to baseline
Methods

- Five lower limb cadaveric specimens were used in this study.

- The femoral head was potted with PMMA and fingers of a TekScan pressure mapping sensor (Model: 6900 Tekscan, Boston, MA) were inserted into the ankle and subtalar joint.

- Specimens were placed in a biomechanical testing jig designed to simulate weight bearing.

- A scissor jack was used to apply 75lb load to the femoral head while the foot was fixed with the ankle in neutral position.
Methods

- Testing was achieved by placing orthotic postings of two specific sizes underneath the talonavicular joint.

- Mean pressure (MP), peak pressure (PP), contact area (CA), and center of force (COF) were measured in ankle and subtalar joints under three conditions; barefoot (BASE), with a 1.5cm (ORT1) and 3cm (ORT2) height orthotics.

- Each condition was tested three times per specimen; results were averaged per specimen and used for final analysis.

- Displacement of COF was calculated relative to its location at baseline.
Results

- With ORT1 and ORT2, the center of force was significantly displaced from its location at BASE at the ankle by $3.8 \pm 2.4\text{mm}$ and $3.0 \pm 1.2\text{mm}$ (Mean ± SD) respectively ($p < 0.05$), and at the subtalar joint by $2.3 \pm 1.8\text{mm}$ and $7.6 \pm 4.8\text{mm}$ (Mean ± SD) respectively ($p < 0.05$).

Mean and SD of the absolute displacement values from baseline (0) of the center of force in the Ankle and Subtalar joint under ORT1 and ORT2 conditions.
Results

- Representative 2D-interpolated TekScan pressure data (MPa)

Annotations:
- BASE
- ORT1
- ORT2
- Ankle
- Subtalar Joint
Results

- There was a significant difference (*p*-Value < 0.05) in CA between BASE and ORT2 (*p* = 0.014) and between ORT1 and ORT2 (*p* = 0.046).
- There was no significant difference (*p* > 0.350) for any other measure in either joint.

<table>
<thead>
<tr>
<th></th>
<th>BASE (Mean ± SD)</th>
<th>ORT1 (Mean ± SD)</th>
<th>ORT2 (Mean ± SD)</th>
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</thead>
<tbody>
<tr>
<td><strong>Mean Pressure</strong></td>
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<td></td>
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<tr>
<td>(MPa)</td>
<td></td>
<td></td>
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<tr>
<td>Ankle</td>
<td>0.46 ± 0.31</td>
<td>0.41 ± 0.20</td>
<td>0.39 ± 0.16</td>
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<tr>
<td>Subtalar</td>
<td>0.45 ± 0.20</td>
<td>0.42 ± 0.21</td>
<td>0.42 ± 0.26</td>
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<tr>
<td><strong>Peak Pressure</strong></td>
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<tr>
<td>(MPa)</td>
<td></td>
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<tr>
<td>Ankle</td>
<td>1.03 ± 0.78</td>
<td>0.99 ± 0.54</td>
<td>0.95 ± 0.27</td>
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<tr>
<td>Subtalar</td>
<td>1.21 ± 0.67</td>
<td>1.10 ± 0.67</td>
<td>0.97 ± 0.61</td>
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<tr>
<td><strong>Contact Area</strong></td>
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<td>(mm²)</td>
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<tr>
<td>Ankle</td>
<td>107.7 ± 47.2</td>
<td>106.1 ± 47.9</td>
<td>107.2 ± 52.5</td>
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<tr>
<td>Subtalar</td>
<td>166.8 ±24.8*</td>
<td>164.4 ± 26.5#</td>
<td>151.1 ± 28.8*/#</td>
</tr>
</tbody>
</table>

Contact Area, Mean Pressure, and Peak Pressure values

* *p*-Value <0.05, Statistical difference found between these two conditions.

# *p*-Value <0.05, Statistical difference found between these two conditions.
Conclusions

- Our study demonstrates that orthotics of varying sizes may change the mean pressure, peak pressure, contact area center of force in the ankle and subtalar joint.

- Our results also agree with previous studies about the role of foot deformity on the distribution of body-weight forces and its consequences across the ankle and subtalar joint *

- Further studies with larger sample are encouraged for better understanding of this phenomenon.

- This study proves the feasibility of its design for studying intra-articular pressure changes in the lower limb.