Impact of Ethnicity on Tibial Morphometrics Relevant to Total Ankle Replacement

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\end{itemize}
Disclosure

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• Our disclosures are in the final AOFAS program book.

• We have a potential conflict with this presentation due to: Authors are employees of (JEB, SB, SS) or consultants with (PR, TMP, JCC) Zimmer Biomet, Inc.
Total ankle replacement (TAR) success has improved since first-generation implants, but revision rates remain worse than knee and hip replacements [1].

Several studies have sought to characterize talar morphometry [2-3], but relatively little is currently known about the morphometry of the distal tibia [4-5], and differences between genders and ethnicities.

It is unclear the extent to which current TAR prostheses accommodate global variability in patient size and shape.
Hypotheses:

1. The anterior-posterior (AP) location of the dwell point of the tibia is centralized
2. The sagittal radius of curvature of the tibial articulation increases with bone size
3. Differences in dwell point or sagittal radii between genders and ethnicities can be attributed to size differences between those populations

Study goal: Quantify distal tibia morphometrics relevant to TAR design, and assess differences between ethnicities and genders.
Data Acquisition

• CT scans of the tibia were obtained from cadavers or individuals with no indications of arthritis or previous surgeries of the tibiotalar joint

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>62M / 42F</td>
</tr>
<tr>
<td>Korean</td>
<td>37M / 40F</td>
</tr>
<tr>
<td>Japanese</td>
<td>46M / 63F</td>
</tr>
<tr>
<td>Indian</td>
<td>48M / 49F</td>
</tr>
<tr>
<td>Chinese</td>
<td>45M / 49F</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>238M / 243F</strong></td>
</tr>
</tbody>
</table>

• Digital models of the tibia constructed via image segmentation
Methods

• **Medial and lateral edges** of the articulation surface were defined

• **Sagittal contours** were determined at various cross-sections across the articulation, and the center of each contour was defined

• The **articulation center** was defined as the average center point of all contours

• Metrics:
  – **AP length**: Distance between most anterior and posterior points at the TAR resection level
  – **AP center**: Midpoint at the TAR resection level
  – **AP offset**: Difference in AP location of the articulation center relative to AP center
• Differences in metrics for each ethnic and gender group were determined using a one-way Anova (P<.05) with Tukey’s method for differentiating groups.

• Regression fits of AP offset, average medial radius, and average lateral radius were determined.

• Utilizing AP length as a covariate, ANCOVA was utilized to assess differences in AP offset and sagittal radii between gender and ethnic groups (P<.05).
<table>
<thead>
<tr>
<th>Metric (mm)</th>
<th>Caucasian</th>
<th>Korean</th>
<th>Indian</th>
<th>Chinese</th>
<th>Japanese</th>
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<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP length</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Male</td>
<td>41.7 (2.7)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.3 (2.4)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>38.6 (2.6)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>40.4 (2.2)&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>38.9 (1.9)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Female</td>
<td>40.1 (2.1)&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>34.9 (2.0)&lt;sup&gt;ef&lt;/sup&gt;</td>
<td>33.8 (2.6)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>35.8 (1.8)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>33.7 (1.8)&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>AP offset</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.0 (1.9)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.0 (1.6)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.0 (1.5)&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
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<td>1.3 (1.5)&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>Med. radius</td>
<td></td>
<td></td>
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<td>26.7 (2.8)&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Female</td>
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<td>26.6 (10.6)&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
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<td></td>
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<tr>
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<td>28.3 (6.7)&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>28.3 (2.6)&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>26.5 (3.9)&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>23.5 (5.1)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>25.2 (3.6)&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>25.7 (3.3)&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- Superscripts indicate Tukey groupings (specific to each metric)
- AP length is not a significant covariate for AP offset
Results – Ethnic and Gender Influence

- **AP length** is significant covariate for **lateral radius**
- Ethnicity is significant factor (P<.001) (Tukey groupings shown in legend)
- Gender is not (P=.067)
Results – Ethnic and Gender Influence

- **AP length** is significant covariate for **medial radius**
- Both ethnicity (P=.01) and gender (P<.03) are significant factors
- Tukey groupings for ethnicity shown in legend
Discussion

• This study illustrates for the first time the complexity of anatomical variation of the distal tibia across **ethnic groups** and between **genders**.
• The location of the articulation center is **invariant to tibia size** across each ethnicity.
• **Medial** and **lateral sagittal radii** generally increase with bone size
• The **relative radii** of the medial and lateral compartments are not consistent across ethnicities.

**Clinical Significance:**
Increased anatomic understanding of the distal tibia can contribute to improvements in TAR design and technique.
References


