Tibia Bone Support in Total Ankle Arthroplasty is Maximized Through Use of Anatomic Cuts

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Disclosure

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My disclosure is in the Final AOFAS Program Book.

I have a potential conflict with this presentation due to:
I am a Zimmer employee.
Introduction

• Designs and techniques associated with contemporary total ankle replacement (TAR) involve distal tibia cuts that vary in both shape and depth of resection.

• Initial stability (micromotion) and long-term stability (stress shielding) of the placed prosthesis may depend on the density of the bone at the resulting bone/implant interface.

➢ Stability of contemporary prostheses has been evaluated through cadaveric testing [1] and finite element analysis [2,3], using a limited number of cadavers or patient specific models, respectively.

• The effect of the resection shape and depth on bone density in the distal tibia has not specifically been quantified.
Objective

• The goal of this study was to assess the extent to which resection shape and resection depth impact the density of bone immediately adjacent to TAR prostheses.

Method

• Image-based analysis of tibial bone density in the vicinity of TAR resections using the ZiBRA™ Anatomical Modeling System [4].
Data Acquisition

- CT scans obtained 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>14</td>
</tr>
<tr>
<td>Korean</td>
<td>24</td>
</tr>
<tr>
<td>Japanese</td>
<td>22</td>
</tr>
<tr>
<td>Indian</td>
<td>28</td>
</tr>
</tbody>
</table>

- Digital models of the tibia constructed via image segmentation
Tibial Resection

- A series of flat and anatomic (radius 40mm) TAR resection cuts were performed on each model.
- Cut depth (6-16mm) was measured from the high point of the articular surface in the tibial plafond.
- The tibial malleolus was retained, as it is generally preserved during TAR.

![Illustration of flat and round tibial resections](image1)
![Representative bone density maps for flat (left) and round (right) tibial cuts](image2)
Bone Density Assessment

• Across each resection, the Hounsfield unit (HU) data from the CT image were extracted with a spatial resolution of approximately 1mm.

• HU data were normalized based on the peak HU for each individual specimen, and averaged across the resection to determine a value of normalized density for each resection on a specimen-specific basis.

• An estimate of total available bone support was calculated for each resection as the product of the average density and the area of the resection.

• For each resection level, differences between flat and round cuts were evaluated using a paired Student’s t-test, with significance defined at $P < 0.05$. 

Illustration of HU assignment, with hotter colors representing denser bone.
Results – Bone Density

• Statistically significant differences in average bone density between flat and round cuts were found at resection depths greater than 10mm.

• The average density for round cuts decreased by 4%, 10%, and 18% for resection depths of 8, 10, and 12mm, relative to the 6mm cut; and for flat cuts, by 6%, 17%, and 25%, respectively.
Results – Bone Support

- Statistically significant differences in bone support between flat and round cuts were found at resection depths greater than 8mm.
Discussion

• Use of an anatomic curved resection of the distal tibia within TAR results in a tibial bone bed of greater density than for flat resections at comparable depths.

• The effect of decreasing density of bone with greater resection depth is mitigated by use of an anatomic cut.

Clinical Significance:

• The bone density of the tibia directly adjacent to the prosthesis in total ankle replacement can be maximized through the use of anatomic curved cuts, and may result in improved biomechanical performance of the prosthesis.
References


Thank You.