INTRODUCTION:
In total ankle replacement (TAR), proper positioning of the talus under the tibia is considered vital to good long-term outcomes. Previous experimental studies suggested possible unfavorable effects of anteroposterior (AP) malpositioning of TAR prosthesis.[1,2] Although AP malalignment in highly degenerated ankles is thought to lead to this problem, the reliable clinical evaluation has been limited because of lack of a reproducible measure to quantify the AP ankle alignment. Moreover, without a method to identify tibio-talar position, intraoperative and postoperative assessment of component alignment cannot be performed.

In particular, with ankle joint disease, determining tibiotalar alignment is challenging. Most joints with end-stage arthritis have severe joint destruction, displacement and osteophyte formation. As a result, radiographic articular landmarks are often useless.

This study aimed to develop a reliable measure to quantify the AP relationship between the talus and tibia using non-articular landmarks. Three radiographic measures were trialed and compared for reproducibility, by exploring the sensitivity to ankle positional changes during radiographic exposure.

METHODS:
Ten normal cadaver ankles were subjected to a series of lateral radiographs at 9 ankle positions in the transverse plane and at 7 positions in the sagittal plane, to simulate various ankle positions on standing radiographs. The transverse ankle positions were in -20º, -15º, -10º, -5º, 0º, +5º, +10º, and +20º internal rotation; while the sagittal ankle positions were in -10º, -5º, 0º, 5º, 10º, 15º, and 20º plantarflexion. The position of 5º internal rotation and 0º flexion was defined as the standard position.

The posterior talar point (point A in Fig.1) was identified as the intersection between the posterior subtalar surface and the posterosuperior calcaneal cortex. A line was drawn though point A parallel to the floor. Point B is the vertical projection of the most anterior aspect of the talus onto this line; length of line AB is defined as the talar length.

The distal tibia axis (DTA) was defined as a line through two tibia shaft bisection points 5 and 10 cm above the ankle; while the posterior tibia line (PTL) was defined by posterior shaft points at those same heights.

In addition to the three lines described above, points C, D, E, and F were defined as follows. Points C and D were intersections of the DTA and PTL with line AB, point E was denoted as the tip of the lateral talar process (LTP), and point F was the point on DTA nearest to point E.

The AP relationship between the tibia and the talus was quantified by three measures: 1) Tibial axis-talar ratio (T-T ratio, Fig.1a), 2) Posterior line-talar ratio (P-T ratio, Fig.1b), and 3) Tibial axis-lateral process distance normalized to the talar length AB (T-L distance: Fig.1c).

Fig. 1  Measures of anteroposterior tibio-talar position
a) T-T ratio (%) = (AC / AB) x 100
b) P-T ratio (%) = (AD / AB) x 100
c) T-L distance normalized to the talar length AB (%) = (EF / AB) x 100

SENSITIVITY OF THREE MEASURES TO ANKLE POSITIONAL CHANGES

Table 1  Experimental results (mean ± SD, n = 10)

<table>
<thead>
<tr>
<th>Type of measure</th>
<th>Outcome in standard position</th>
<th>Sensitivity to transverse positional changes</th>
<th>Sensitivity to sagittal positional changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-T ratio</td>
<td>33.4 ± 3.3</td>
<td>8.0 ± 2.3</td>
<td>6.0 ± 2.5</td>
</tr>
<tr>
<td>P-T ratio</td>
<td>9.9 ± 4.5</td>
<td>10.0 ± 4.0</td>
<td>5.5 ± 1.9</td>
</tr>
<tr>
<td>distance</td>
<td>8.6 ± 4.6</td>
<td>26.5 ± 4.5</td>
<td>17.4 ± 3.7</td>
</tr>
</tbody>
</table>

Sensitivity to transverse positional changes was quantified as the greatest difference across the nine transverse positions, and this value was compared across the measures. The mean value of the absolute errors with 10º internal-or external rotation from the standard position was recorded as the error with 10º malpositioning. This outcome was averaged across specimens and utilized to indicate the amount of possible error that occurs with small malpositioning. Sensitivity to sagittal positional changes was similarly analyzed.

All measurements were conducted twice by a single orthopaedic surgeon, and the average was recorded as the measure. Comparisons across the three measures for each outcome and for the transverse-sagittal differences were performed by a repeated measures MANOVA; pairwise comparisons are reported only if the global test is significant at p = 0.05.

RESULTS:
In the standard position, the AP tibial-talar measure averaged 33.4 ± 3.3% (mean ± standard deviation) for the T-T ratio, 9.9 ± 4.5% for the P-T ratio, and 8.6 ± 4.6% for the T-L distance (Table 1).

Sensitivity to transverse positional changes was smallest on the T-T ratio and second smallest on the P-T ratio, and worst on the T-L distance (p< 0.02, for each pairwise comparison). Error with 10º malpositioning was 2.1% with the T-T ratio, 2.8% with the P-T ratio, and 5.8% with the T-L distance.

The sensitivity to sagittal positional changes of either the T-T ratio or the P-T ratio was less than the T-L distance (each p<0.001). Error with 10º malpositioning was 2.3% with the T-T ratio, 2.4% with the P-T ratio, and 6.0% with T-L distance.

DISCUSSION:
Among the measures tested in this study, the T-T ratio appears to most reliably describe AP tibial-talar alignment, though approximately 2% error may be involved with 10º of ankle malpositioning. This measure has potential clinical applicability for scientific investigations to monitor the natural history of ankle joint degeneration or to determine the importance of AP tibial-talar alignment with total ankle replacement. The P-T ratio will serve as a quick measure to assess AP tibial-talar alignment in the clinic, especially when focusing on the intersection of the posterior tibial line with the posterior subtalar facet. The lateral-talar alignment process appears to be unfavorable for measurement of AP alignment when ankle position is not perfectly controlled. For either of the two superior measures, possible errors with 10º malpositioning are approximately 2.0 to 3.0%.

REFERENCES

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