3D Computational Position Analysis based on the Articular Surface of Tarsal Bone: A Preliminary Study

Dong Yeon Lee, MD, Tae Ho Kim¹, MS, Sang Gyo Seo, MD, Eo Jin Kim, MD, Woo-Chun Lee², MD, Keith L. Wapner³, MD, Jinah Park¹, PhD

Dept. of Orthopedic Surgery, Seoul National University Hospital, Korea
¹Dept. of Computational Science, KAIST, Korea
²Dept. of Orthopedic Surgery, Inje University Seoul Paik Hospital, Korea
³Dept. of Orthopedic Surgery, University of Pennsylvania, PA
3D Computational Position Analysis based on the Articular Surface of Tarsal Bone: A Preliminary Study

Dong Yeon Lee

My disclosure is in the Final AOFAS Mobile App. I have no potential conflicts with this presentation.
Assessment of Tarsal Bone Alignment

• Standing Simple Radiographs - primary assessment method

• Radiographic assessment of hindfoot pathologies is lacking reliable & validated methods.  
  (Nosewicz TL et al., Skeletal Radiol, 2012)

• Alignment of the hindfoot significantly changes in the upright weight-bearing (WB) CT position CT. Differences can be visualized and measured using WB CT.  
  (Hirschmann A et al., Eur Radiol, 2014)
Material & Methods

- **7 patients** (5 pts w/ flatfoot w/ heel valgus and 2 pts w/ Ankle OA)

- **Conventional NWB CT in neutral position:**
  Conventional 64 channel, Aquilion TSX-101A, Toshiba Medical System, Tokyo, Japan

- **WB CT:** Cone beam, Planmed Verity R, Planmed, Helsinki, Finland

- **Controls:** NWB CT from the contralateral limb of previously symptom-free trauma patients (n=10)

- **Talonavicular joint & post. Talocalcaneal joint**
Data Acquisition Process

Segmentation & 3D Reconstruction

Distance Measurement

Distance Mapping

Inter-articular Angle

Alignment Measurement

The angle weighted pseudonormal technique based on articular surface (IEEE Trans Vis Comput Graph. 2005)

NWB WB

Distance Mapping

Distance Measurement

Inter-articular Angle
Results

- Talonavicular Joint
# Talonavicular Joint

<table>
<thead>
<tr>
<th></th>
<th>Normal NWB (N=10)</th>
<th>Patients (N=7)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NWB</td>
<td>WB</td>
</tr>
<tr>
<td>Talonavicular Distance</td>
<td></td>
<td>NWB</td>
<td>WB</td>
</tr>
<tr>
<td>Mean distance (mm)</td>
<td>2.00±0.2</td>
<td>1.90±0.2</td>
<td>1.79±0.2</td>
</tr>
<tr>
<td>Minimal distance (mm)</td>
<td>1.21±0.3</td>
<td>0.96±0.2</td>
<td>0.67±0.4</td>
</tr>
<tr>
<td>Talonavicular Angle</td>
<td></td>
<td>NWB</td>
<td>WB</td>
</tr>
<tr>
<td>Angle btw vectors (°)</td>
<td>19.03±10.4</td>
<td>21.60±9.8</td>
<td>17.63±20.8</td>
</tr>
<tr>
<td>Angle in Sagittal plane (°)</td>
<td>-14.04±9.0</td>
<td>-8.03±14.9</td>
<td>3.29±16.9</td>
</tr>
<tr>
<td>Angle in Coronal plane (°)</td>
<td>-11.56±6.0</td>
<td>17.64±25.9</td>
<td>41.99±58.0</td>
</tr>
<tr>
<td>Angle in Transverse plane (°)</td>
<td>-13.92±9.4</td>
<td>5.99±20.5</td>
<td>22.76±19.2</td>
</tr>
</tbody>
</table>

* Wilcoxon signed-rank test
Results

- Posterior Talocalcaneal Joint
# Posterior Talocalcaneal Joint

<table>
<thead>
<tr>
<th></th>
<th>Normal NWB (N=10)</th>
<th>Patients (N=7)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NWB</td>
<td>WB</td>
<td></td>
</tr>
<tr>
<td>Talocalcaneal Distance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean distance (mm)</td>
<td>2.53±0.4</td>
<td>2.56±0.4</td>
<td>2.36±0.4</td>
</tr>
<tr>
<td>Minimal distance (mm)</td>
<td>1.84±0.3</td>
<td>1.34±0.5</td>
<td>0.73±0.6</td>
</tr>
<tr>
<td>Talocalcaneal Angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle btw vectors (°)</td>
<td>7.95±4.1</td>
<td>8.33±5.9</td>
<td>6.59±4.2</td>
</tr>
<tr>
<td>Angle in Sagittal plane (°)</td>
<td>-4.15±5.5</td>
<td>0.02±4.8</td>
<td>4.79±3.6</td>
</tr>
<tr>
<td>Angle in Coronal plane (°)</td>
<td>-5.19±3.5</td>
<td>-5.87±6.1</td>
<td>-1.7±7.9</td>
</tr>
<tr>
<td>Angle in Transverse plane (°)</td>
<td>11.11±8.3</td>
<td>14.1±18.0</td>
<td>-0.3±17.6</td>
</tr>
</tbody>
</table>

* Wilcoxon signed-rank test
Using our measurement technique, navicular articular axis deviation by weight bearing was well demonstrated quantitatively in pts w/ flatfoot.

NWB

WB

Sagittally  +17.99°
Coronally   +36.66°
Transversely +17.74°

Deviated!!!
Conclusion

• A 3D analysis technique using articular surface might be useful to assess changes in alignment of the tarsal bones.

• The information of SWB CT was substantially different from that of NWB CT in the same subject, which might justify the extended use of SWB CT in foot and ankle clinics.
References


