Interobserver Variability of Measurements for Flatfoot Deformity Using High Resolution Weightbearing ConeBeam CT Examination According to Reader Experience

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Disclosures

• The author(s) declare the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article:
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  – Carestream Health

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Adult Acquired Flatfoot Deformity (AAFD)

- Biomechanical derangement involving the three-dimensional (3D) midfoot and hindfoot osseous complex, which can be challenging to be characterized using conventional two-dimensional (2D) weightbearing (WB) plain radiographs.

- Weightbearing Computed Tomography (WBCT) images, including the ConeBeam CT (CBCT), can better demonstrate the AAFD under load.

- Questions remain regarding the interpretation, reliability and reproducibility of AAFD measurements in the acquired 3D images.
Study Objectives

• To evaluate the interobserver reliability among readers of different clinical experience by applying measurements traditionally used for grading AAFD, using high-resolution threedimensional (3D) weightbearing (WB) conebeam CT (CBCT) examination.
Methods

• In this IRB approved prospective study we recruited consecutive patients between October 2014 and October 2015.

• Enrollment criteria included:
  – Clinical diagnosis of symptomatic and flexible AAFD (stages 1 and 2).
  – Agreement to cooperate.
  – Signed informed consent.

• Exclusion criteria included:
  – Inability to bear weight.
  – Standard contra-indications for CT imaging.
Methods

- A total of 20 patients with flexible AAFD were included.
- 12 males and 8 females, with a mean age 54.2 years (range, 20-88 years).
- All patients were scanned with standing WB CBCTs.
- Following a training period, two observers (medical student and a board certified foot and ankle surgeon) applied validated AAFD measurements in an independent, random and blinded fashion.
Results

Measurement Examples

- **Medial Cuneiform-Floor Distance**: 29.93mm
- **Navicular-Floor Distance**: 40.84mm
- **Navicular-Skin Distance**: 28.75mm
- **Calcaneal-Fibular Distance**: 3.66mm
- **Subtalar-Horizontal Angle (SHA)**:
  - 25%: 22.74°
  - 50%: 14.66°
  - 75%: 8.40°
- **Talar-1st Metatarsal Angle**: 16.67°
- **Naviculo-Medial Cuneiform Angle**: 14.66°
- **Calcaneal Inclination Angle**: 12.49°
## Results

### Sagittal View Measurements

<table>
<thead>
<tr>
<th></th>
<th>Pearson Correlation Coefficient (r)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talar-1&lt;sup&gt;st&lt;/sup&gt; Metatarsal Angle</td>
<td>0.553</td>
<td>&lt; 0.0141</td>
</tr>
<tr>
<td>Medial Cuneiform-1&lt;sup&gt;st&lt;/sup&gt; Metatarsal Angle</td>
<td>0.668</td>
<td>&lt; 0.0018</td>
</tr>
<tr>
<td>Navicular-Medial Cuneiform Angle</td>
<td>0.746</td>
<td>&lt; 0.0002</td>
</tr>
<tr>
<td>Navicular to Floor Distance</td>
<td>0.992</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Navicular to Skin Distance</td>
<td>0.900</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Medial Cuneiform to Floor Distance</td>
<td>0.981</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Medial Cuneiform to Skin Distance</td>
<td>0.986</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Cuboid to Floor Distance</td>
<td>0.975</td>
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<tr>
<td>Cuboid to Skin Distance</td>
<td>0.978</td>
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<tr>
<td>Calcaneal Inclination Angle</td>
<td>0.795</td>
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</tbody>
</table>
## Results

### Coronal View Measurements

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<tr>
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<th>Pearson Correlation Coefficient (r)</th>
<th>P-value</th>
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<tr>
<td>Forefoot Arch Angle</td>
<td>0.983</td>
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<tr>
<td>Navicular to Floor Distance</td>
<td>0.984</td>
<td>&lt; 0.0001</td>
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<tr>
<td>Navicular to Skin Distance</td>
<td>0.977</td>
<td>&lt; 0.0001</td>
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<tr>
<td>Medial Cuneiform to Floor Distance</td>
<td>0.986</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Medial Cuneiform to Skin Distance</td>
<td>0.984</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Subtalar Horizontal Angle 25%</td>
<td>0.784</td>
<td>&lt; 0.0001</td>
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<tr>
<td>Subtalar Horizontal Angle 50%</td>
<td>0.891</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Subtalar Horizontal Angle 75%</td>
<td>0.809</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Calcaneal-Fibular Distance</td>
<td>0.808</td>
<td>&lt; 0.0001</td>
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</tbody>
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Results
Axial View Measurements

<table>
<thead>
<tr>
<th>Pearson Correlation Coefficient (r)</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Talar Uncoverage Angle</td>
<td>0.6235</td>
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<tr>
<td>Talar-1st Metatarsal Angle</td>
<td>0.4649</td>
</tr>
</tbody>
</table>

- Level of training did not statistically significantly influenced the mean value of the measurements, with two exceptions:
  - Medial Cuneiform-1st Metatarsal Angle in the sagittal view (specialist: 8.83°; student: 1.61°; p<0.01).
  - Talar Uncoverage Angle in the axial view (specialist: 27.94°; student: 39.97°; p< 0.0256).
Conclusions

• Literature describes a large variability for AAFD measurements from plain radiographs among readers of different medical experience.

• Followed by a training period, 3D WB CBCT images can yield similar measurements with high reliability and interobserver agreement, independently of reader experience.
References