New Radiographic Parameter Assessing Hindfoot Alignment in Stage II Adult Acquired Flatfoot Deformity

Emilie Williamson, BS; Jeremy Chan, MD; Jayme C Burket, PhD; Jonathan T Deland, MD; Scott Ellis, MD

Department of Foot and Ankle Surgery, Hospital for Special Surgery, New York, NY, USA
New Radiographic Parameter Assessing Hindfoot Alignment in Stage II Adult Acquired Flatfoot Deformity

Emilie Williamson

My disclosure is in the Final AOFAS Mobile App. I have no potential conflicts with this presentation.
Introduction and Objectives

- **Adult acquired flatfoot deformity (AAFD)**
- Plain radiograph is implemented to assess AAFD
  - Difficulty remains in quantifying in a clinically relevant way
- Hindfoot alignment moment: reliable but less applicable clinically
- We sought to develop a new hindfoot angle measured on the hindfoot alignment view which can reliably quantify hindfoot valgus in patients with AAFD, and to establish the relationship of this angle with the hindfoot moment arm.
Methods

- Flatfoot Cohort, Ten stage II AAFD patients.
- Normal Cohort: Ten healthy patients
- **Traditional Flatfoot Parameters** Measured
  - Anteroposterior (AP) talonavicular coverage angle
  - AP talonavicular uncoverage percent
  - Lateral talo-1st metatarsal angle
  - Calcaneal Pitch
- **Statistical Analysis**
  - Intra- and Inter-rater reliability
  - Difference in angle between normal and flatfoot
  - Relationship between hindfoot moment arm and the new hindfoot alignment angle
  - Differences in patient demographic features (age, gender, BMI) and flatfoot parameters between flatfoot and normal cohorts
Methods

Measurements of Interest

• Hindfoot Moment Arm

• **New Hindfoot Alignment Angle**: The intersection of the tibial shaft longitudinal axis and the calcaneal tuberosity axis
  
  – Tibial axis: defined by Saltzman and el-Khoury
  
  – Calcaneal axis: bisector of the medial and lateral osseous contours

• The bisector of two transversals between the two lines adapted to the medial and lateral osseous contours of the calcaneus

• Transversals drawn with equal consecutive interior angles
Demographics variables and Flatfoot radiographic parameters

There was no significant difference between flatfoot and normal patients in terms of BMI ($p=0.054$) or gender ($p=0.385$). Compared to normal patients, however, flatfoot patients were older ($p<0.001$).

The average values for the calcaneal pitch, talonavicular coverage angle, talonavicular uncoverage percent, and lateral talo-1st metatarsal angle fell within those ranges previously identified for control and flatfoot groups.

### Table 1: Demographic Variables and Flatfoot Radiographic Parameters

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Normal (n=10)</th>
<th>Flatfoot (n=10)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)$^a$</td>
<td>29.1 ± 8.3</td>
<td>53.4 ± 8.0</td>
<td>0.0003*</td>
</tr>
<tr>
<td>BMI$^a$</td>
<td>22.0 ± 2.4</td>
<td>25.9 ± 5.1</td>
<td>0.0539</td>
</tr>
<tr>
<td>Gender$^a$</td>
<td>40%</td>
<td>70%</td>
<td>0.389</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flatfoot Parameter</th>
<th>Normal (n=10)</th>
<th>Flatfoot (n=10)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP TN Coverage</td>
<td>12.1 ± 6.1</td>
<td>29.5 ± 6.5</td>
<td>0.0002*</td>
</tr>
<tr>
<td>AP TN Uncoverage %</td>
<td>26.3 ± 3.4</td>
<td>39.5 ± 7.0</td>
<td>0.0003*</td>
</tr>
<tr>
<td>L talo-1st MA (Deg)</td>
<td>0.2 ± 4.9</td>
<td>-22.5 ± 6.9</td>
<td>0.0002*</td>
</tr>
<tr>
<td>Calcaneal Pitch$^a$</td>
<td>20.0 ± 3.1</td>
<td>15.8 ± 2.9</td>
<td>0.0113*</td>
</tr>
</tbody>
</table>
New hindfoot alignment angle had excellent reliability

- Intra-rater ICC = 0.979 (95% CI 0.948 – 0.922)
- Inter-rater ICC = 0.965 (95% CI 0.913 – 0.986)

Flatfoot patients had greater mean angles than normal patients

- 22.5±4.9 vs. 5.6±5.4 degrees, \( p < 0.001 \)
Linear correlation between hindfoot alignment angle and moment arm

- The hindfoot moment arm was found to be correlated significantly with the hindfoot alignment angle (p<0.001), increasing by 0.81mm for every degree increase in angle (Adj. R-squared=0.9046).

Moment Arm (mm) = 0.805 × Hindfoot Alignment Angle (degrees) – 4.12
Summary

• Intra- and inter-rater reliability for the hindfoot alignment angle was excellent.
• Flatfoot patients had greater mean angles than normal patients.
• The hindfoot moment arm was found to be correlated significantly with the hindfoot alignment angle, increasing by 0.81mm for every degree increase in angle.
Conclusions and Discussion

• The new hindfoot alignment angle is a reliable measure of hindfoot valgus and can differentiate between flatfoot versus normal patients.

• Limitations
  – Mean age and BMI differ between normal and flatfoot patients
  – Small cohort sizes

• Based on previous studies the amount of medializing calcaneal osteotomy (MCO) needed intraoperatively can be estimated by the equation:

  \[
  \text{Change in Hindfoot Alignment angle (degrees)} = 1.88 \times \text{Amount of MCO (mm)} - 1.42
  \]

  – Future investigations: prospective assessment of validity
2. Chan, JY; Williams, BR; Nair, P; Young, E; Sofka, C; Deland, JT; Ellis, SJ: The contribution of medializing calcaneal osteotomy on hindfoot alignment in the reconstruction of the stage II adult acquired flatfoot deformity. Foot Ankle Int. 34:159-166, 2013.
4. Ellis, SJ; Yu, JC; Williams, BR; Lee, C; Chiu, YL; Deland, JT: New radiographic parameters assessing forefoot abduction in the adult acquired flatfoot deformity. Foot Ankle Int. 30:1168-1176, 2009.
5. Lee, MS; Vanore, JV; Thomas, JL; Catanzariti, AR; Kogler, G; Kravitz, SR; Miller, SJ; Gassen, SC; Clinical Practice Guideline Adult Flatfoot Panel: Diagnosis and treatment of adult flatfoot. J. Foot Ankle Surg. 44:78-113, 2005.
8. Williamson, ERC; Chan, JY; Burket, JC; Deland, JT; Ellis, SJ: New Radiographic Parameter Assessing Hindfoot Alignment in Stage II Adult-Acquired Flatfoot Deformity. Foot Ankle Int. #1071100714558846, first published online November 7, 2014. To appear on paper.