Radiographic Evaluation of Flatfoot

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The American College of Foot & Ankle Orthopedics & Medicine
CONFLICT OF INTEREST

• I have no conflicts of interest pertaining to the material presented in this lecture.
Objectives

1. Consider the use of planal dominance and an alternative approach.
2. Understand the use of radiographs as part of a larger paradigm to choose nonsurgical and surgical treatments for flatfoot pathology.
3. Appreciate the limitations of radiographs for flatfoot deformities.
4. Discuss alternative radiographic methods to assist with clinical decision making.

Disclaimer: This lecture will focus on flexible flatfoot and exclude tarsal coalitions and Charcot.
11 y/o w/painful flatfoot – how would you evaluate?
<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cheap</td>
<td>• Radiographs aren’t patients.</td>
</tr>
<tr>
<td>• Quick</td>
<td>• Technique variations</td>
</tr>
<tr>
<td></td>
<td>• Minimal soft tissue considerations</td>
</tr>
</tbody>
</table>
Biomechanics Reminder

Kinematics vs Kinetics

Radiographs mostly kinematic
Currently, a major podiatric concept in choosing flatfoot surgical procedures using PE and radiographs.

Examined Motion | Axis located
--- | ---
Frontal (inv/ev) | Horiz, sagittal planes
Transverse (ab/adduction) | Vertical, sagittal planes.
Sagittal (DF, PF) | Frontal, horiz

Green, Carol. JAPA, Feb 1984; 74(2): 98-103
Surgical Considerations in the Treatment of Pes Planus

ANTHONY H. BORRELLI, DPM
STEPHEN D. SMITH, DPM

Table 1. Primary Repair Is Directed Toward the Primary Deforming Force

<table>
<thead>
<tr>
<th>Primary Deformity</th>
<th>Primary Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1, frontal plane, subluxed subtalar joint</td>
<td>Subtalar arthroereisis</td>
</tr>
<tr>
<td>Type 2, transverse plane, lateral column abduction</td>
<td>Lateral column lengthening</td>
</tr>
<tr>
<td>Type 3, sagittal plane, medial column subluxation</td>
<td>Medial column fusion</td>
</tr>
</tbody>
</table>

- Classified deformity
- Listed procedures to address

Borrelli & Smith. JAPMA, June 1988; 78(6): 305-309
The Algorithmic Approach to Pediatric Flexible Pes Planovalgus

Jonathan M. Labovitz, DPM\textsuperscript{a,b,c,*}

Determining planal dominance on radiographs

<table>
<thead>
<tr>
<th>Sagittal plane</th>
<th>Frontal plane</th>
<th>Transverse plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ Talar declination angle</td>
<td>↓ First metatarsal declination angle</td>
<td>↑ Talocalcaneal angle (AP)</td>
</tr>
<tr>
<td>↑ Talo-calcaneal angle (lateral)</td>
<td>↓ Height sustentaculum tali</td>
<td>↑ Calcaneocuboid angle</td>
</tr>
<tr>
<td>↓ Calcaneal inclination angle</td>
<td>↑ Superimposition lesser tarsus (lateral)</td>
<td>↓ Talonavicular congruency</td>
</tr>
<tr>
<td>Naviculocuneiform breach</td>
<td>Widening lesser tarsus (AP)</td>
<td>↓ FF to RF adduction</td>
</tr>
</tbody>
</table>

Procedures based on planal dominance

<table>
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<tr>
<th>Sagittal plane</th>
<th>Frontal plane</th>
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</thead>
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<tr>
<td>Kidner procedure</td>
<td>L-shaped osteotomy</td>
<td>Evans osteotomy</td>
</tr>
<tr>
<td>Young’s tenosuspension</td>
<td>Medial displacement</td>
<td>Calcaneo-cuboid distraction</td>
</tr>
<tr>
<td>TAL/Gastrocnemius recession</td>
<td>Calcaneal osteotomy</td>
<td>arthrodesis</td>
</tr>
<tr>
<td>Spring ligament desmoplasty</td>
<td>Koutsogiannis</td>
<td>Cuboid osteotomy</td>
</tr>
<tr>
<td>Cotton osteotomy</td>
<td>Reverse Dwyer</td>
<td>Medial cuneiform osteotomy</td>
</tr>
<tr>
<td>Lowman arthrodesis</td>
<td>Gleich</td>
<td></td>
</tr>
<tr>
<td>Miller arthrodesis</td>
<td>Silver</td>
<td></td>
</tr>
<tr>
<td>Hoke arthrodesis</td>
<td>Lord</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STJ arthroereisis</td>
<td></td>
</tr>
</tbody>
</table>

Deformity Location

Based off of the hinge axis concept (proven untrue).

Focuses primarily on the STJ.

Has never been validated.

Impossible to truly determine the dominant plane.
“Transverse” Plane Dominant Algorithm

What about the “dominant” plane?

The Problem With Planal Dominance

What is the dominant plane?
IF NOT PLANAL DOMINANCE THEN WHAT?
The Kineticokinematic (KK) Approach

1. Determine The Damaged/Strained Anatomy
2. Clarify the Underlying Biomechanical Cause
3. Fix It By Adjusting Forces and/or Correcting Deformity
Radiographs become important for what they tell us about function, not just position.
Reminder: Radiographic Pronation

- TN Uncovering
- CC Abduction
- Talar 1\textsuperscript{st} metatarsal
- Kite's angle
Reminder: Radiographic Pronation

- Talar declination
- Calc inclination
- Midfoot breach
- Meary’s
- Metatarsal overlap
Reminder: Radiographic Pronation

1️⃣ Tibio-calcaneo angle
2️⃣ Lateral calcaneal translation

Long leg calcaneal axial view
Hindfoot alignment view
Calcaneal Axial Vs Hindfoot Alignment Views

<table>
<thead>
<tr>
<th></th>
<th>Intraclass correlation</th>
<th>Interclass correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hindfoot alignment</td>
<td>0.72</td>
<td>0.58</td>
</tr>
<tr>
<td>Calc axial</td>
<td>0.93</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Calcaneal axial more reliable

Caution With The Long Leg Calcaneal Axial Clinical Appearance

Camera angled between feet

LT Direct Posterior

RT Direct Posterior
Same Issue With Long Leg Calcaneal Axial Radiographs

Angle & Base

Tibia, 2nd met aligned + foot aligned w/ plate

Boffeli & Waverly. JFAS, 2016; 55: 1043-1051
**Standardized LLCA**

- Angle and base of gait.
- RCSP
- Tibia upright, heels at back of cassette.
- Tube head angled 45°, angled to superimpose tibia and 2nd met.
- Rotate entire patient to position lateral foot parallel with edge of plate.

Boffeli & Waverly. JFAS, 2016; 55: 1043-1051
Intraop Standardized LLCA
Let’s Talk Medial Column

- Find the motion with radiographs?
- What radiographic concerns arise?
- Using radiographs more dynamically.
Hallux limitus does not have to arise from motion at the 1\textsuperscript{st} TMTJ
Hallux limitus does not have to arise from motion at the 1st TMTJ.
Biomechanics of the First Ray. Part IV: The Effect of Selected Medial Column Arthrodeses. A Three-Dimensional Kinematic Analysis in a Cadaver Model

Brian A. Roling, DPM,¹ Jeffrey C. Christensen, DPM,² and Cherie H. Johnson, DPM³

But standard lateral doesn’t always show dynamic motion.

Where is the arch motion here?
Using The Modified Coleman Block

- Estimate amount PF of medial column to establish perpendicular FF: RF.
- Determine which medial column joint(s) contribute to deformity.

Using the Coleman Block Radiograph

“Atavistic” Cuneiform - NOT
Elevatus Is An Artifact?
Bone appearance depends on angle.
Navicular Appearance Depends On Angle

Pronated

Supinated
False Elevatus?

Radiographic Analysis of Metatarsus Primus Elevatus
A Preliminary Study

Robert A. Christman, DPM*
K. Paul Flanigan, DPM†
Dean L. Sorrento, DPM†
Christopher C. Stanich, DPM‡

Increased apparent elevatus w/ decreased tube head angle & elevation.

A Test Anecdote

90°

5mm elevation

20° dorsal angulation
Is this real or artifact?
The Influence of X-Ray Orientation on the First Metatarsocuneiform Joint Angle

Michael E. Brage, M.D.,* James R. Holmes, M.D.,† and Bruce J. Sangeorzan, M.D.‡
Seattle, Washington

7 loaded cadaver feet on plexiglas apparatus.

1st MCJ angle lessens significantly as beam orientation changes from 10 - 30 deg tilt.

<table>
<thead>
<tr>
<th>Mean Angular Measurements of the Feet at 10°, 20°, and 30°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>First MC angle</td>
<td>18.0 (5.4)</td>
<td>10.8 (7.1)</td>
<td>7.6 (5.5)</td>
<td>0.0001</td>
</tr>
<tr>
<td>First IM angle</td>
<td>9.2 (2.3)</td>
<td>9.6 (1.8)</td>
<td>9.2 (1.6)</td>
<td>NS</td>
</tr>
</tbody>
</table>

• Looked at 1st TMTJ angle at various central beam angulations in 515 random bone specimens.

→ More apparent when 1st met in increased declination and when inverted.

All Specimens Rectus

Real Life Example

Red lines in 10, 15, 20 degree DP views are compared with 0 degree measurement.
• Recommend obtaining lateral radiograph, measuring 1st met declination angle, then obtain DP radiograph with tube head angled at value equal to 1st met declination.
Using Corrected Radiograph Views To Plan Care
Postop radiographs
Conclusions

1. Planal dominance is too unidimensional to be used for clinical practice.

2. Consider the kineticokinematic approach for decision-making.

3. Caution with details when reading radiographs.

4. Use methods like the Coleman block radiograph to obtain dynamic images.
Thank You!