Milwaukee Foot Model

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Shriners Hospitals
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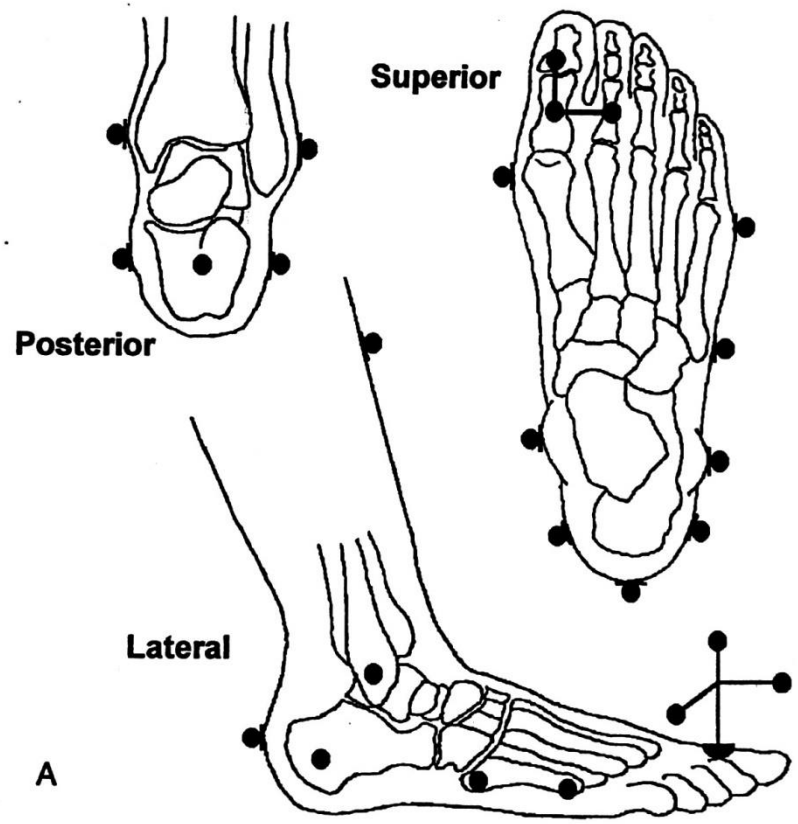
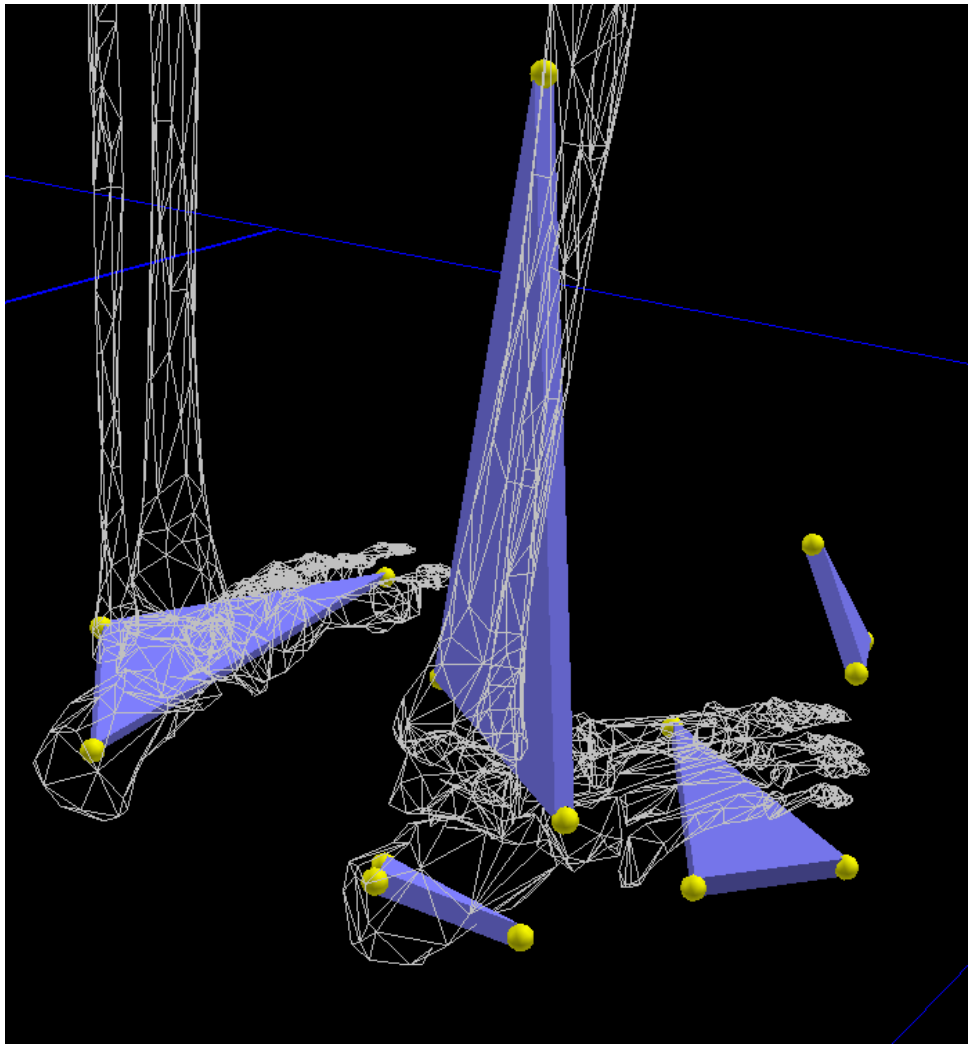
Milwaukee Foot Model Marker Set



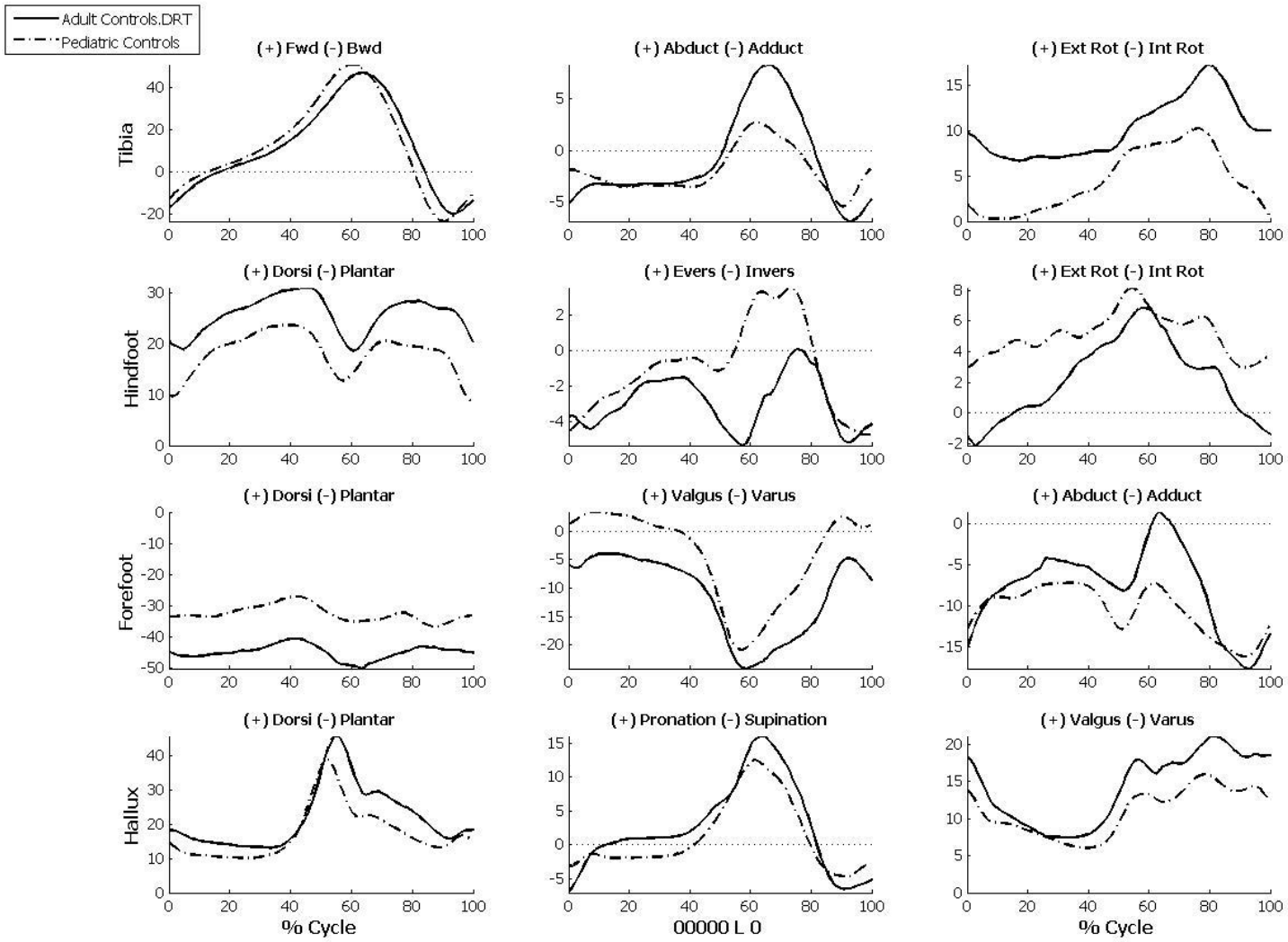
Marker Number	Marker Name	Description
1	MSAT	Medial superior anterior tibia
2	MMAL	Medial malleolus
3	LMAL	Lateral malleolus
4	TCAL	Calcaneal tuberosity
5	MCAL	Medial calcaneus
6	LCAL	Lateral calcaneus
7	T5ML	Tuberosity of the 5th metatarsal laterally
8	MH1M	Medial Head of the 1st metatarsal
9	LH5M	Lateral head of the 5th metatarsal
10	XHAL	Hallux triad x-axis
11	YHAL	Hallux triad y-axis
12	ZHAL	Hallux triad z-axis

Multiple Foot Segments

- Marker-based segmental definition of foot
  - Tibia
  - Hindfoot
  - Forefoot
  - Hallux
- Compare to traditional SLEM model of foot



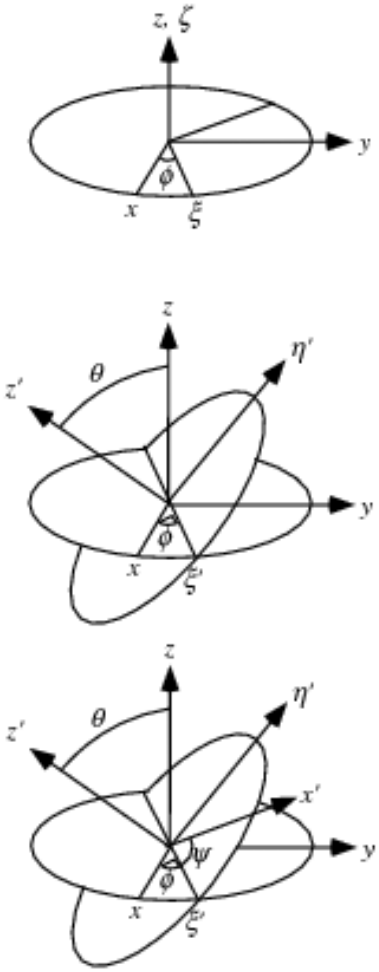
Definition of Joints



Euler Angles

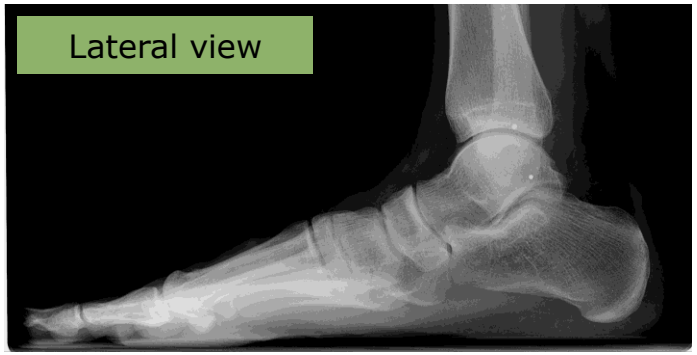
- Euler's Rotation Theorem
  - Any rotation can be described by three angles
- Distal segment D is "transformed" from alignment with a proximal segment P via a sequence of three order-specific rotations about local axes
  - 1: Sagittal (R_y)
  - 2: Coronal (R_x)
  - 3: Transverse (R_z)

$$D = P \cdot R_y \cdot R_x \cdot R_z$$



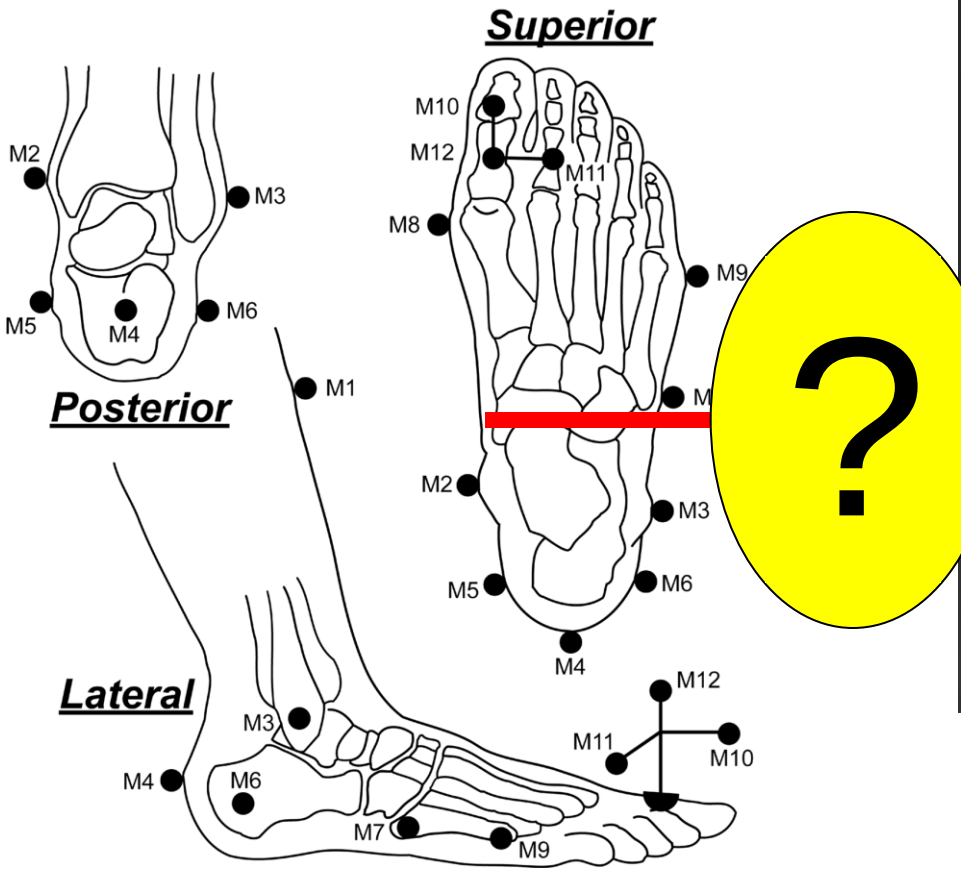
Bone-Based Axes

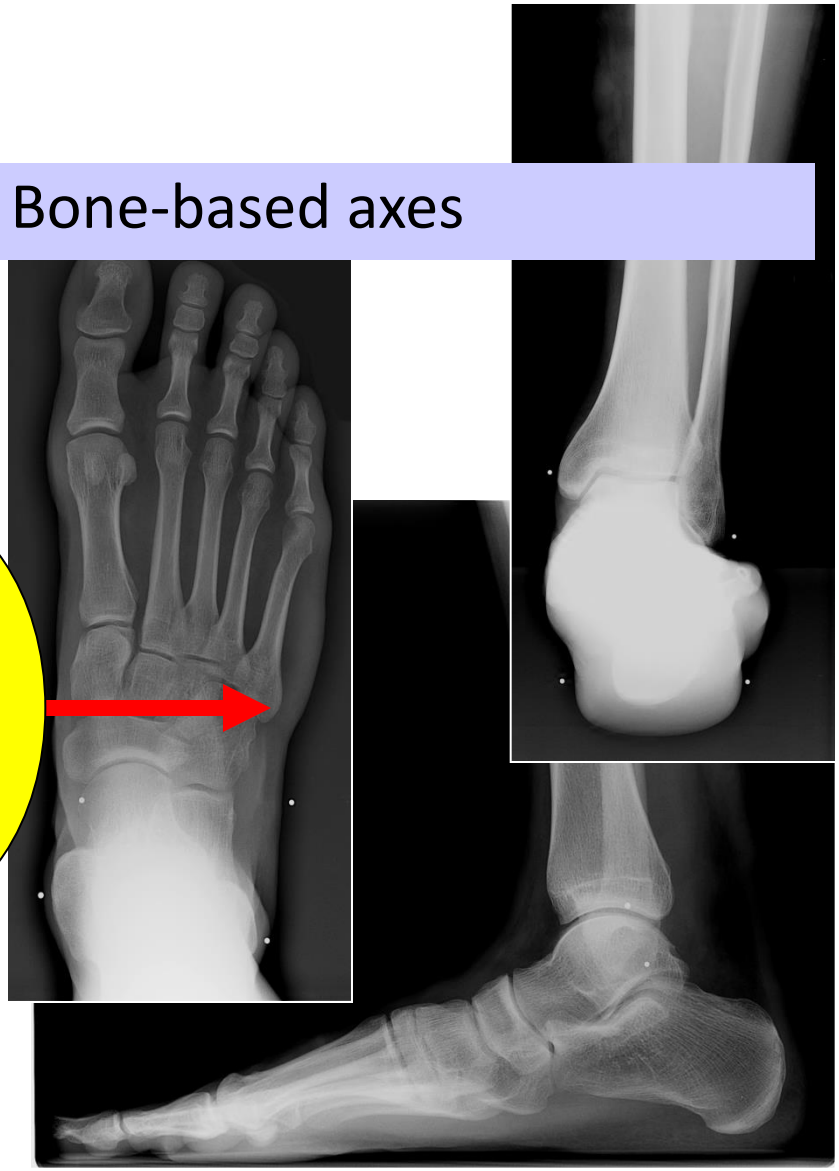
- Hindfoot, Forefoot, Hallux
  - A/P view
    - local x vs global X (transverse angle α)
  - Lateral view
    - local x vs global Z (sagittal angle β)
  - Milwaukee view
    - rotation about long axis ϕ (HF only)



So Now We Have…

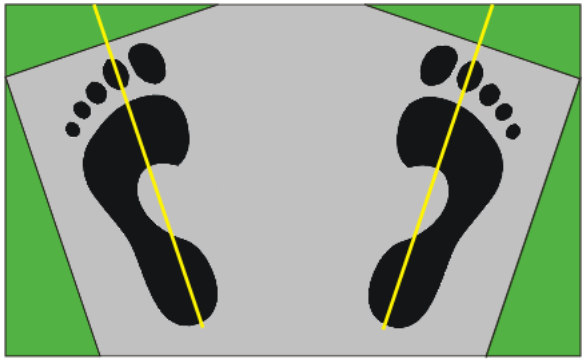
- Marker-based axes
- Bone-based axes





Key Assumption #1

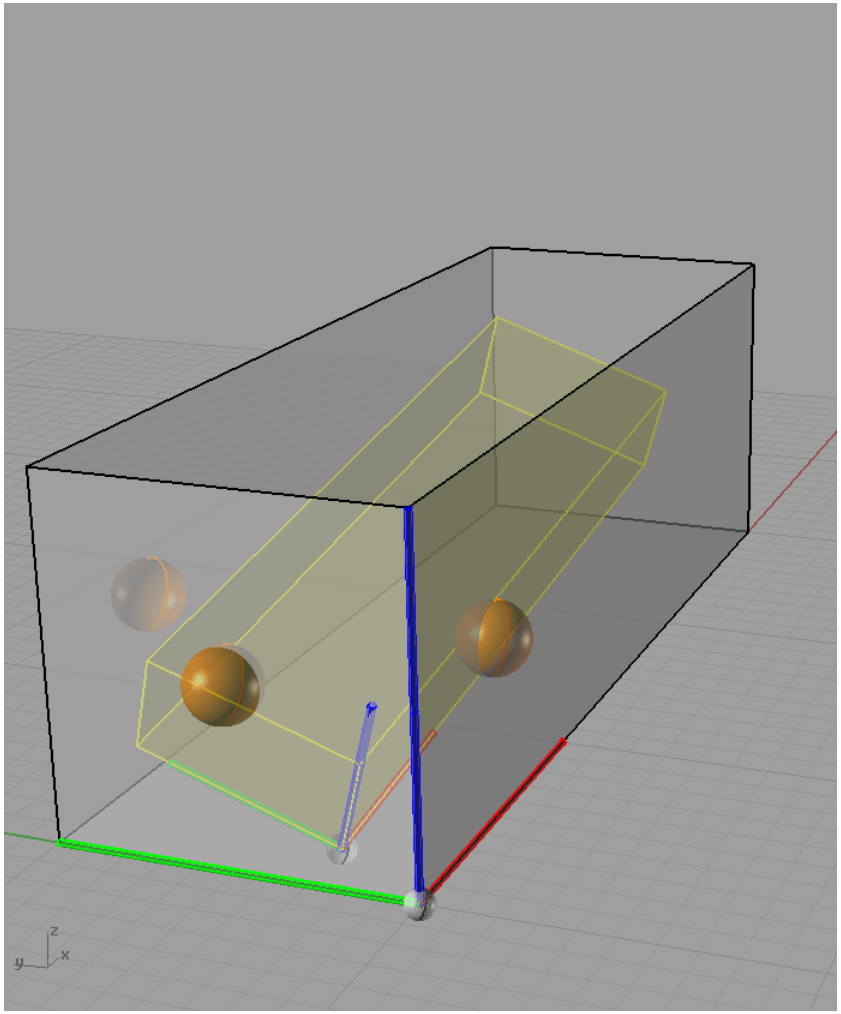
- Assume that the weightbearing posture is repeatable if foot position is repeatable



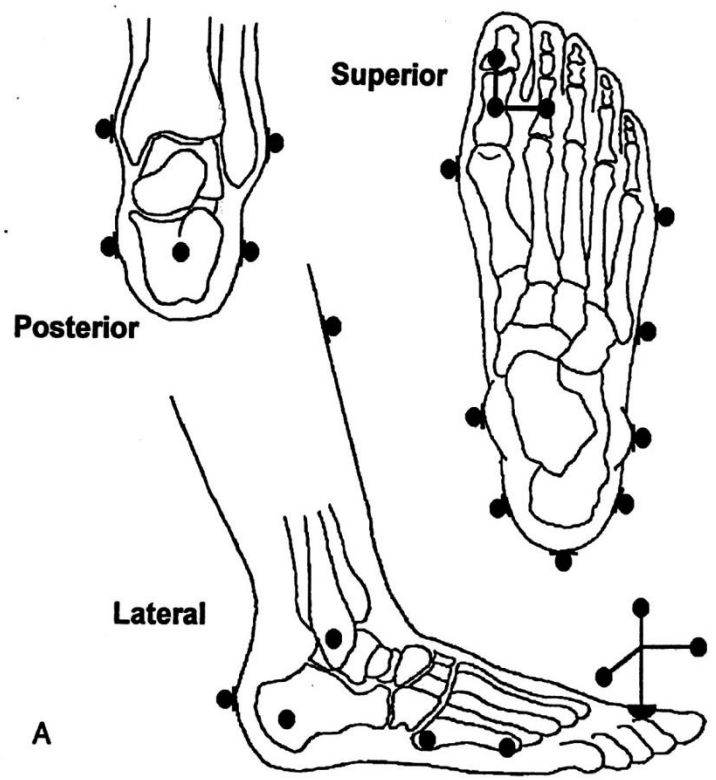
- Footprint template
  - Trace feet during comfortable standing
  - Reference line (foot axis) from calcaneal tuberosity through head of MT2
- Use to position feet for marker- and bone-based axis calibrations
  - Marker-based: motion analysis capture
  - Bone based: weightbearing radiographs

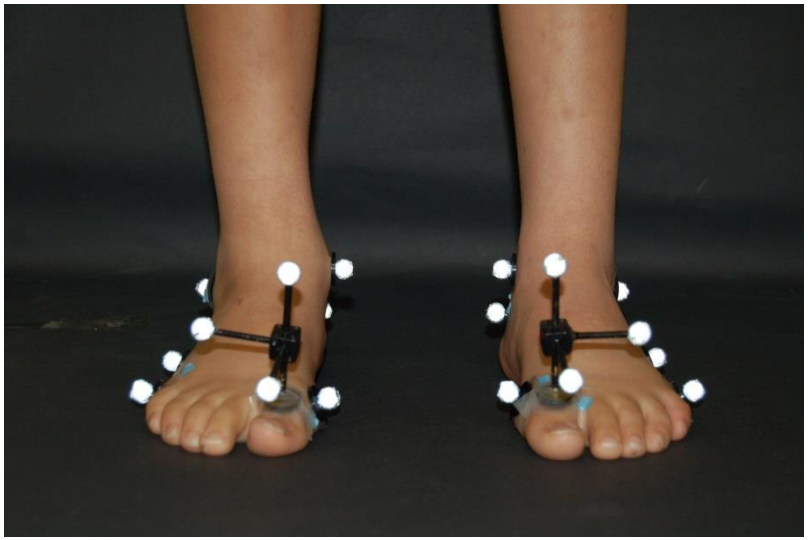
Key Assumption #2

- For each segment, assume a constant relationship between marker-based axes and bone-based axes
- This relationship can be used to transform between axis systems



Segmental Foot and Ankle Analysis



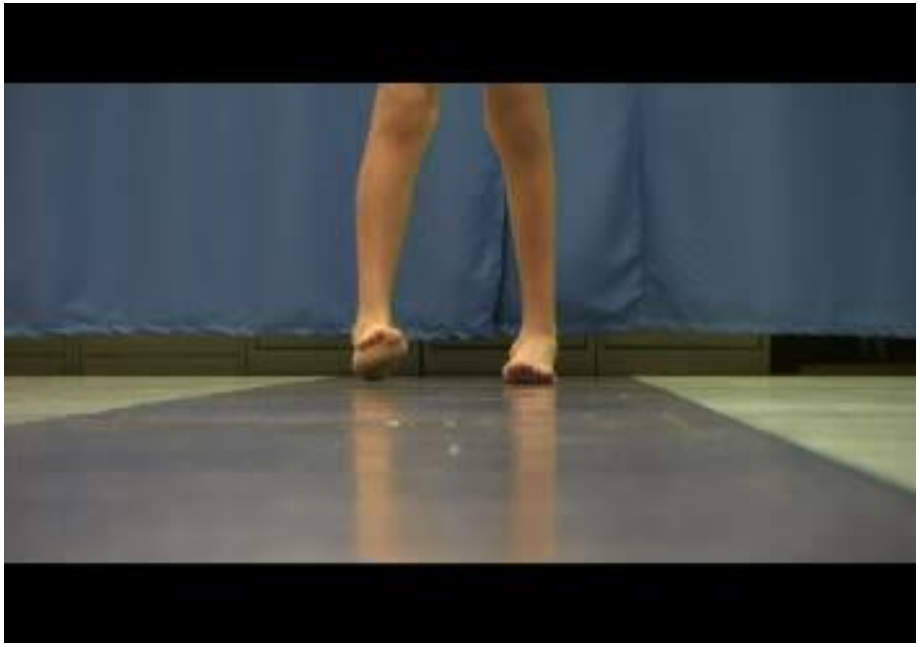


Clinical Applications of the Milwaukee Foot Model

- Identify atypical segmental foot motion during ambulation
- Measure the effectiveness of intervention(s) on improving foot and ankle motion (i.e. play Monday morning quarterback)
- Plan single event multi-segment surgery

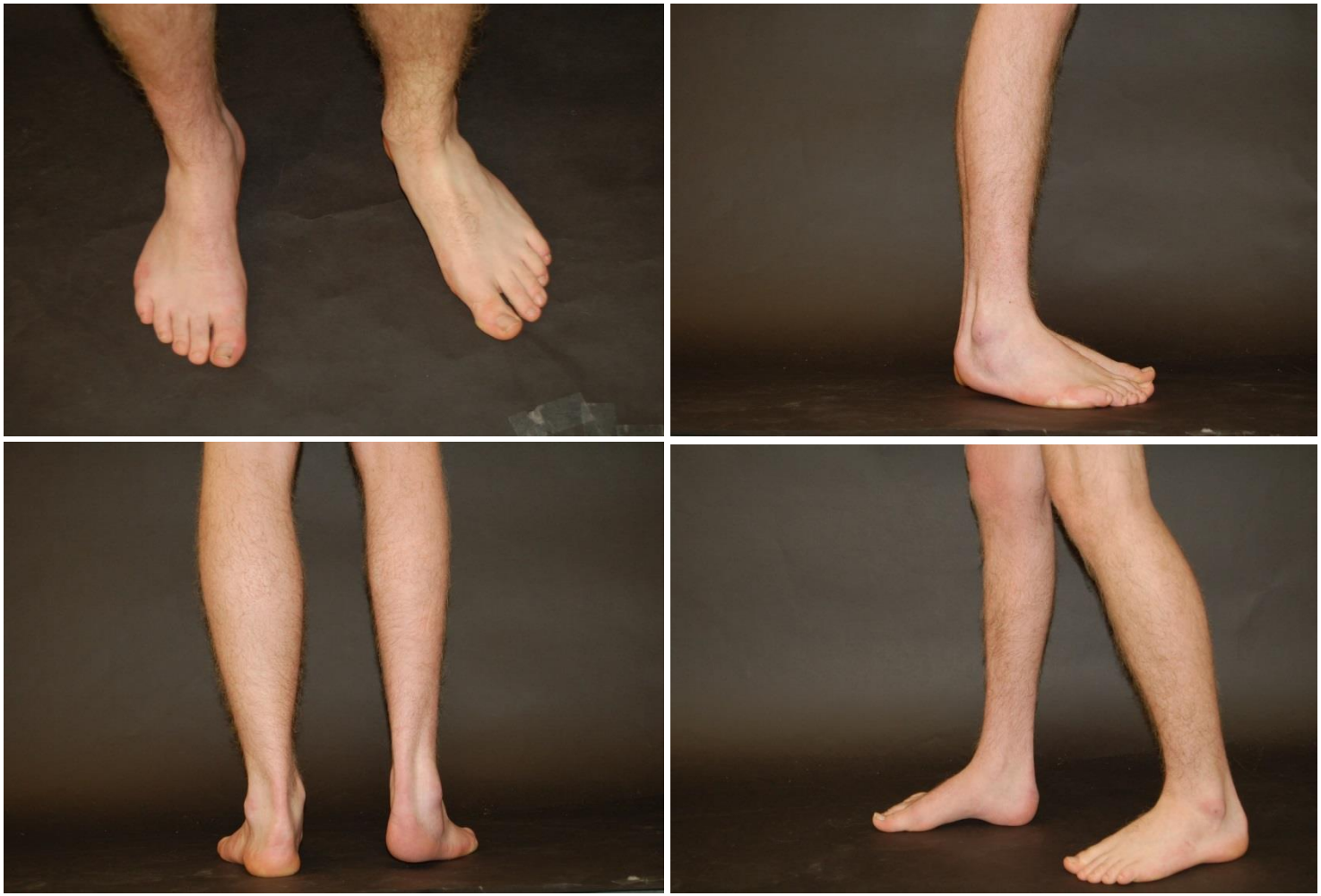
Case Examples
Hemiplegia with Equinovarus

Case #1



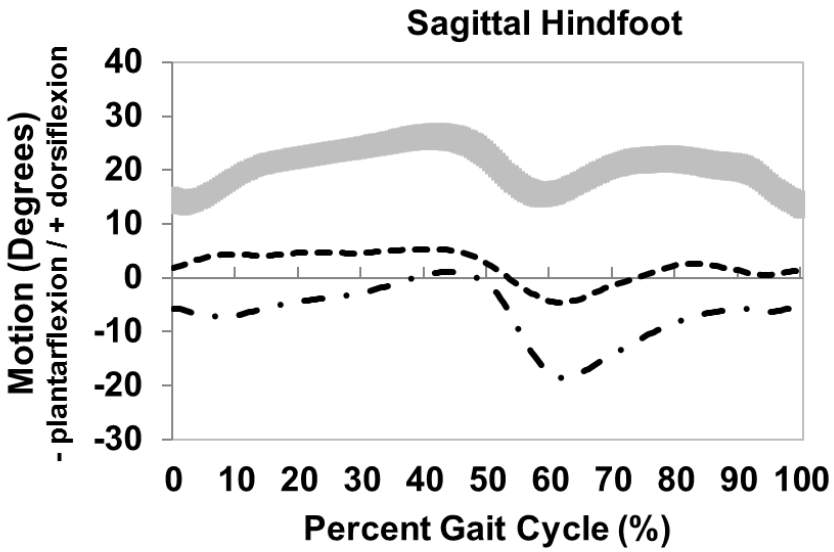
Case #2

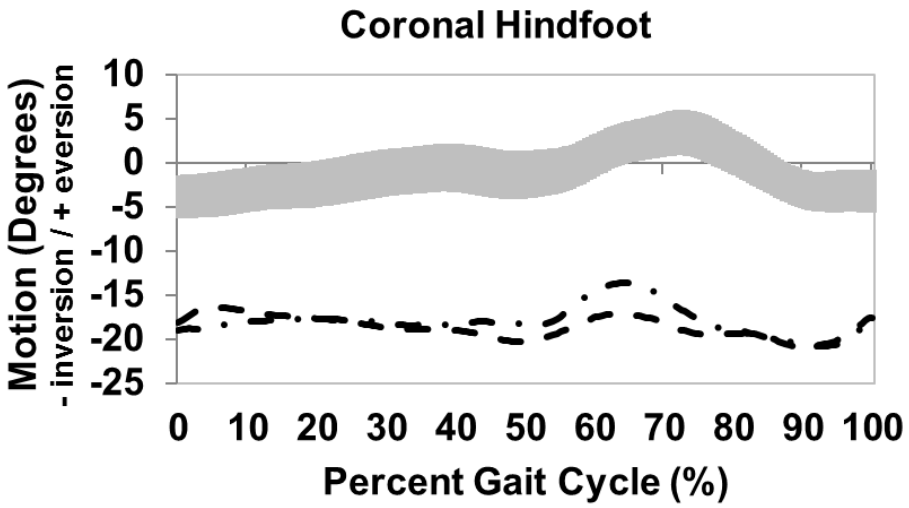
Case #1



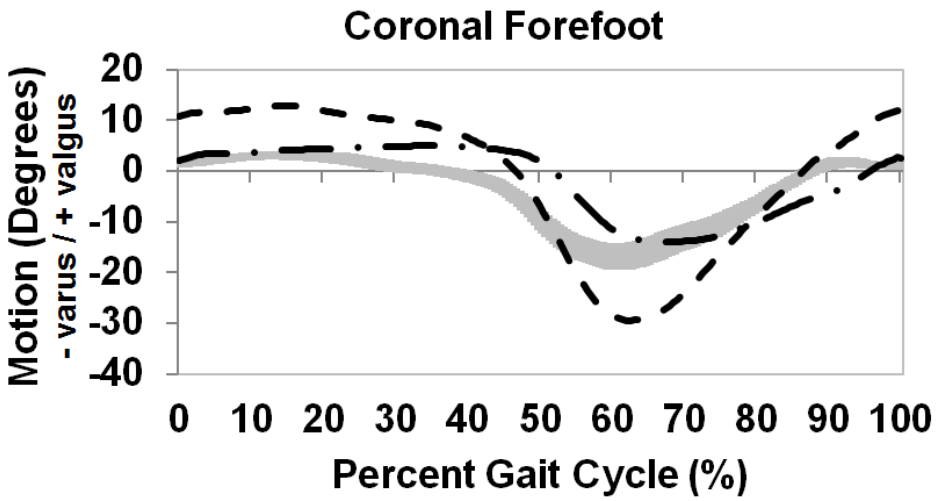
Case #2

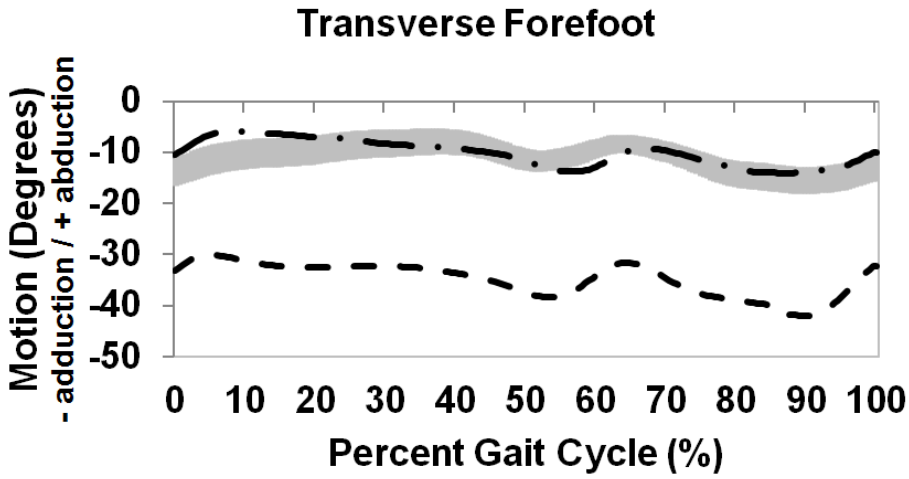
Hindfoot Kinematics





Forefoot Kinematics





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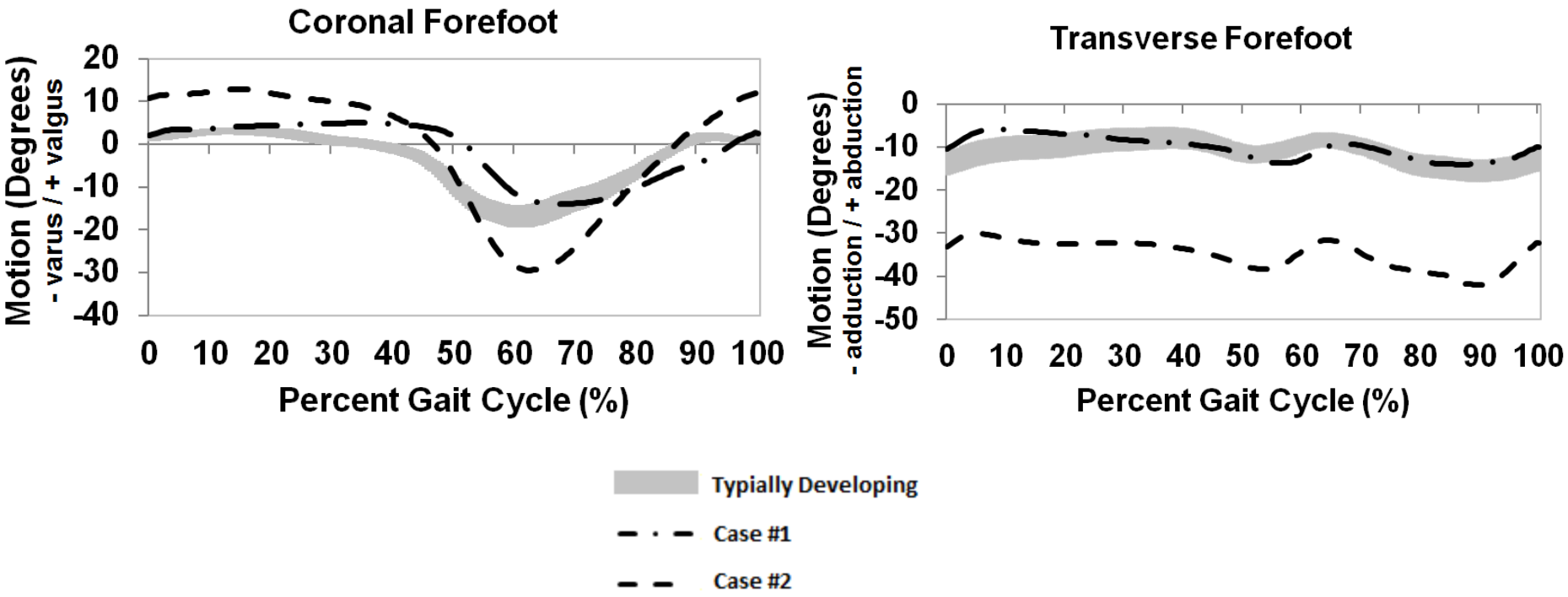
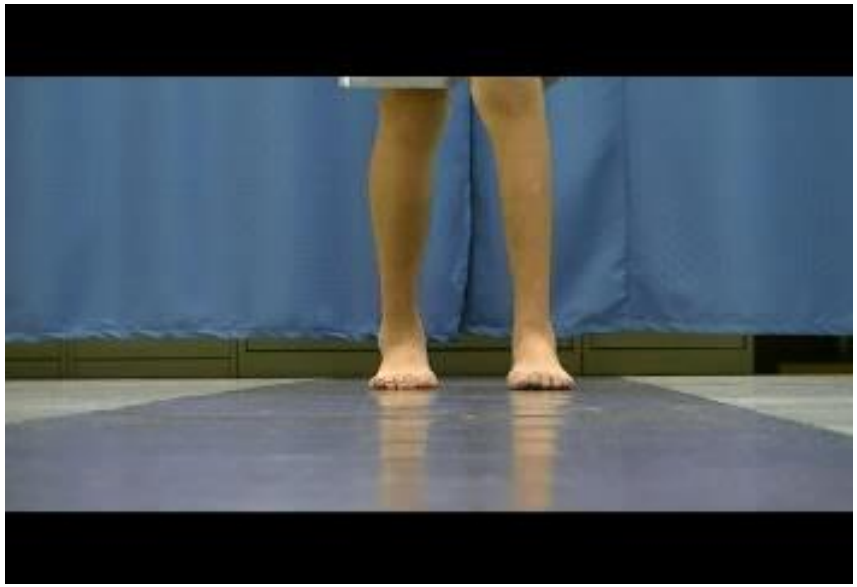
Remember This????



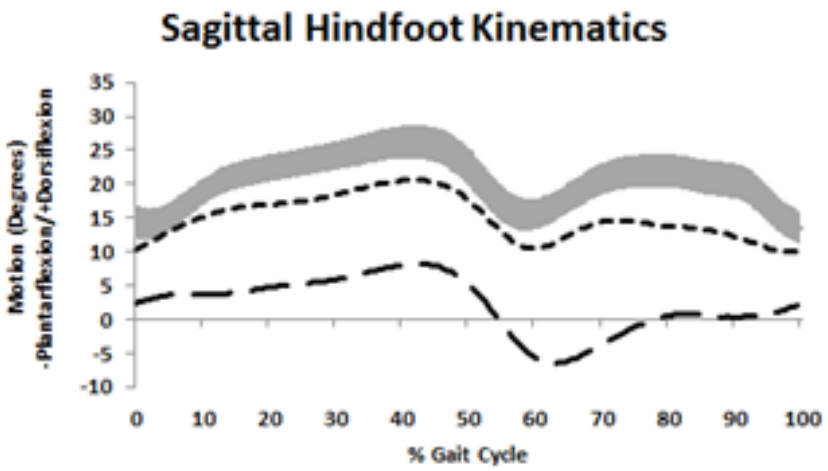
- Both patients had a lengthening of the plantar flexors and a split transfer of the posterior tibilais

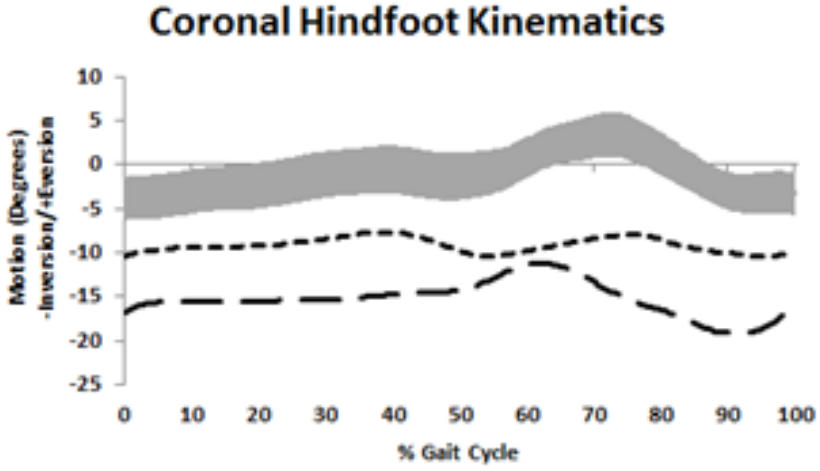
Case #1 Pre-Post

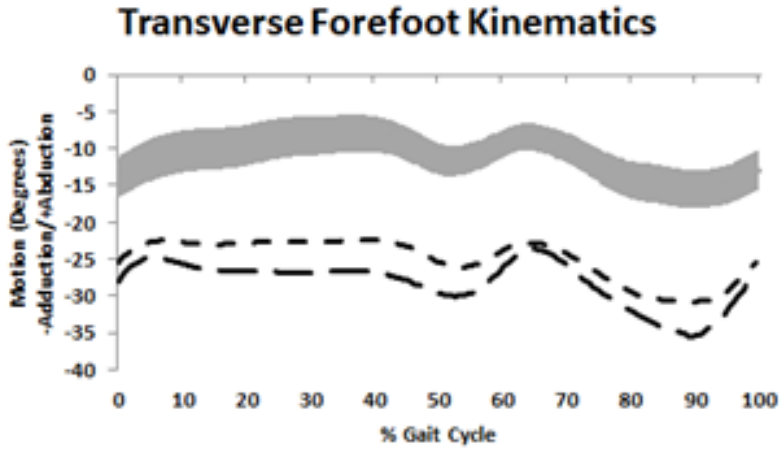
Case #2 Pre-Post



Case #2 Pre-Post







Clinical Applications of the Milwaukee Foot Model

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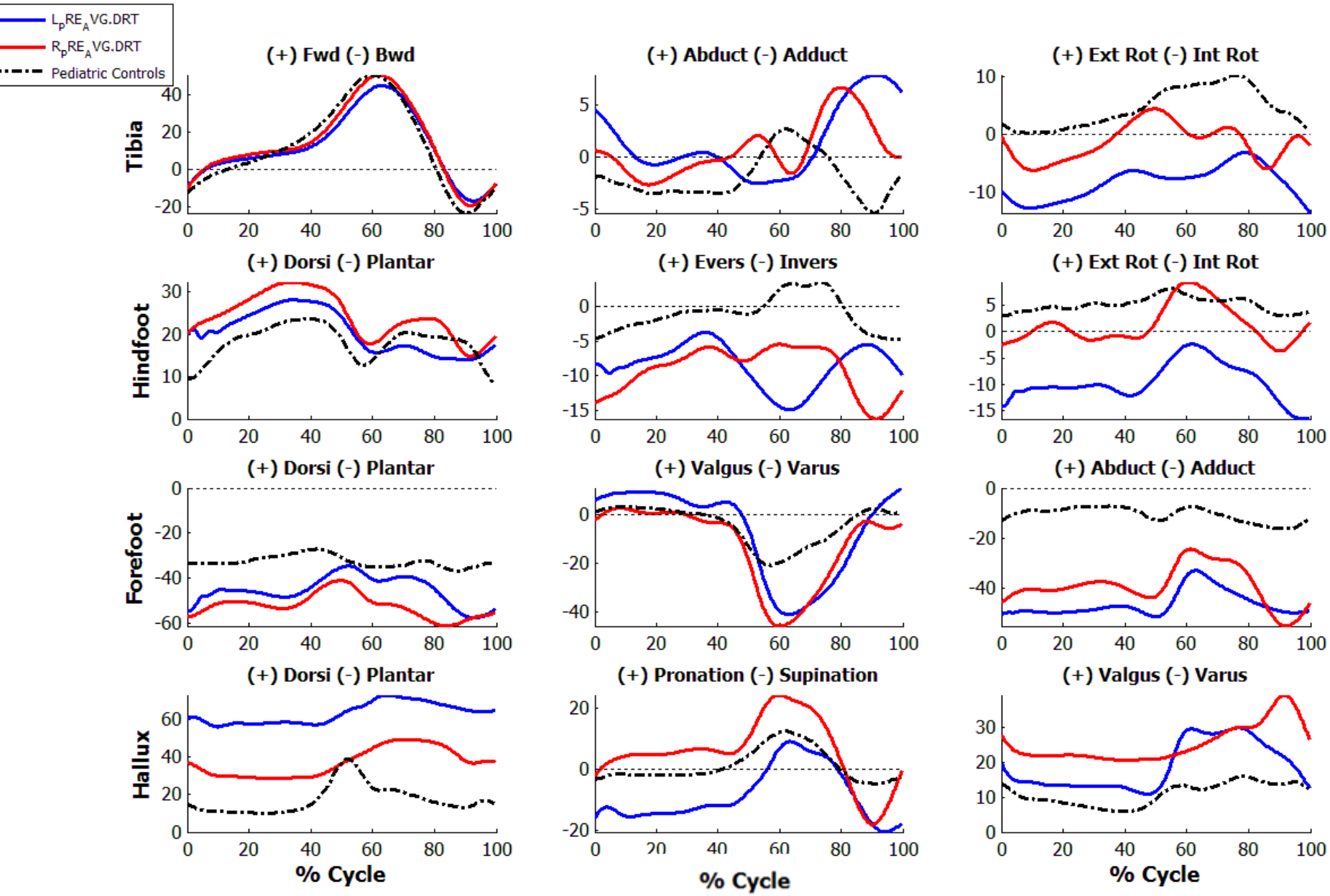
Case Examples
Charcot Marie Tooth with Cavovarus

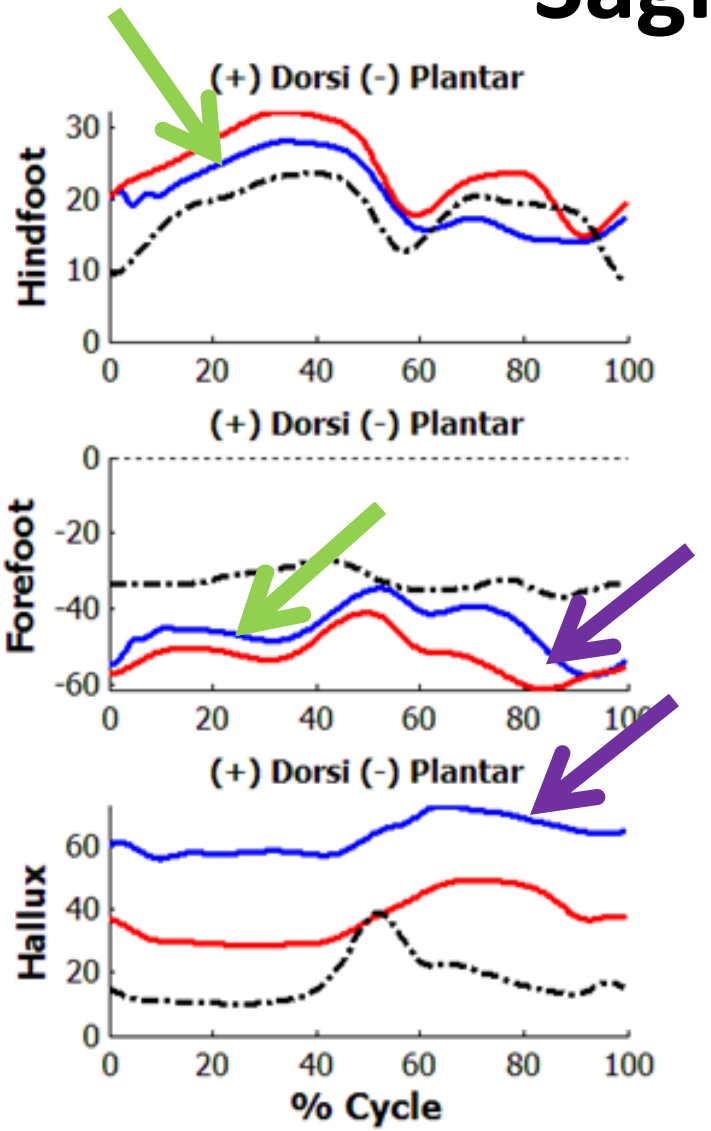
Case #3

Pre Op Pictures


LpREAVG.DRT
RpREAVG.DRT
Pediatric Controls
Tibia
Hindfoot
Forefoot
Hallux
(+) Fwd (-) Bwd
(+) Abduct (-) Adduct
(+) Ext Rot (-) Int Rot
(+) Dorsi (-) Plantar
(+) Evers (-) Invers
(+) Ext Rot (-) Int Rot
(+) Dorsi (-) Plantar
(+) Valgus (-) Varus
(+) Abduct (-) Adduct
(+) Dorsi (-) Plantar
(+) Pronation (-) Supination
(+) Valgus (-) Varus
% Cycle
% Cycle
% Cycle

Problem List – Left Side (Blue)

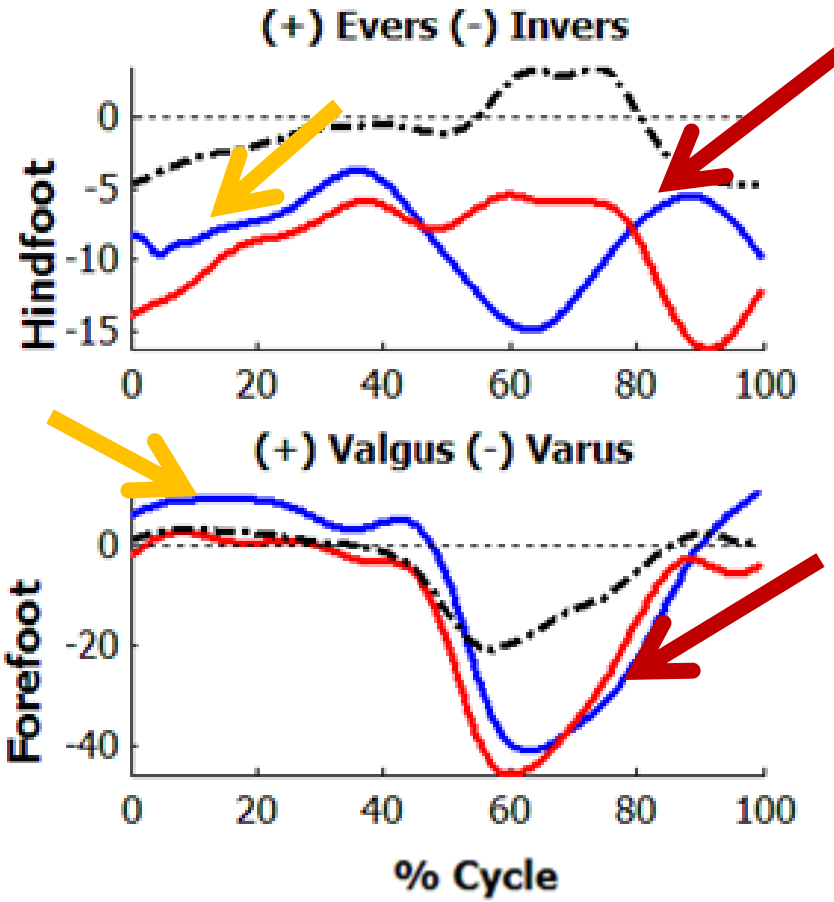
Sagittal Plane



1. **Hindfoot dorsiflexion + forefoot plantar flexion = Cavus**

2. **Decreased forefoot dorsiflexion in swing with compensatory hallux dorsiflexion**

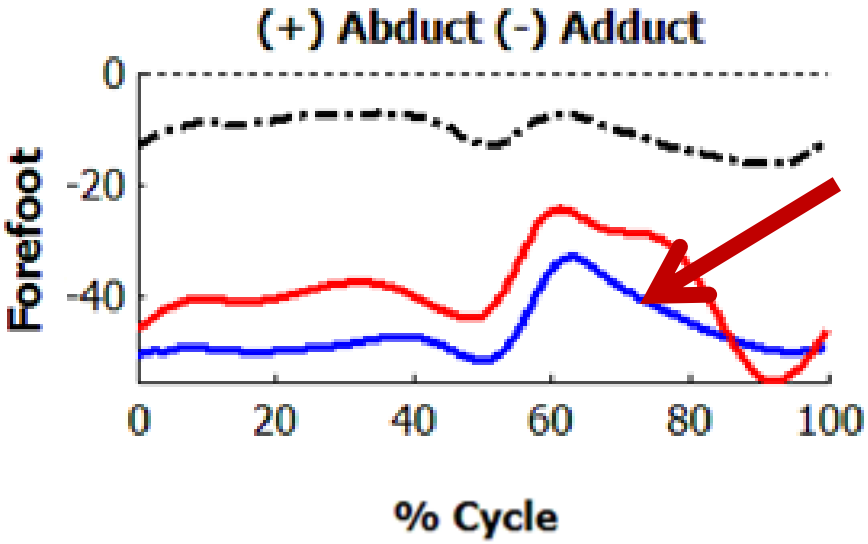
Problem List – Left Side (Blue)
Coronal Plane



3. Hindfoot inversion (varus) with compensatory forefoot valgus during stance

4. Hindfoot inversion and forefoot varus at toe-off and throughout swing (supination)

Problem List – Left Side (Blue)
Transverse Plane



- **Persistent forefoot adduction throughout the gait cycle**

Summary of Problems

1. **Hindfoot dorsiflexion + forefoot plantar flexion = Cavus**
2. **Decreased forefoot dorsiflexion in swing with compensatory hallux dorsiflexion**
3. **Hindfoot inversion (varus) with compensatory forefoot valgus during stance**
4. **Hindfoot inversion, forefoot varus at toe-off and throughout swing, and forefoot adduction**

Plan of Care

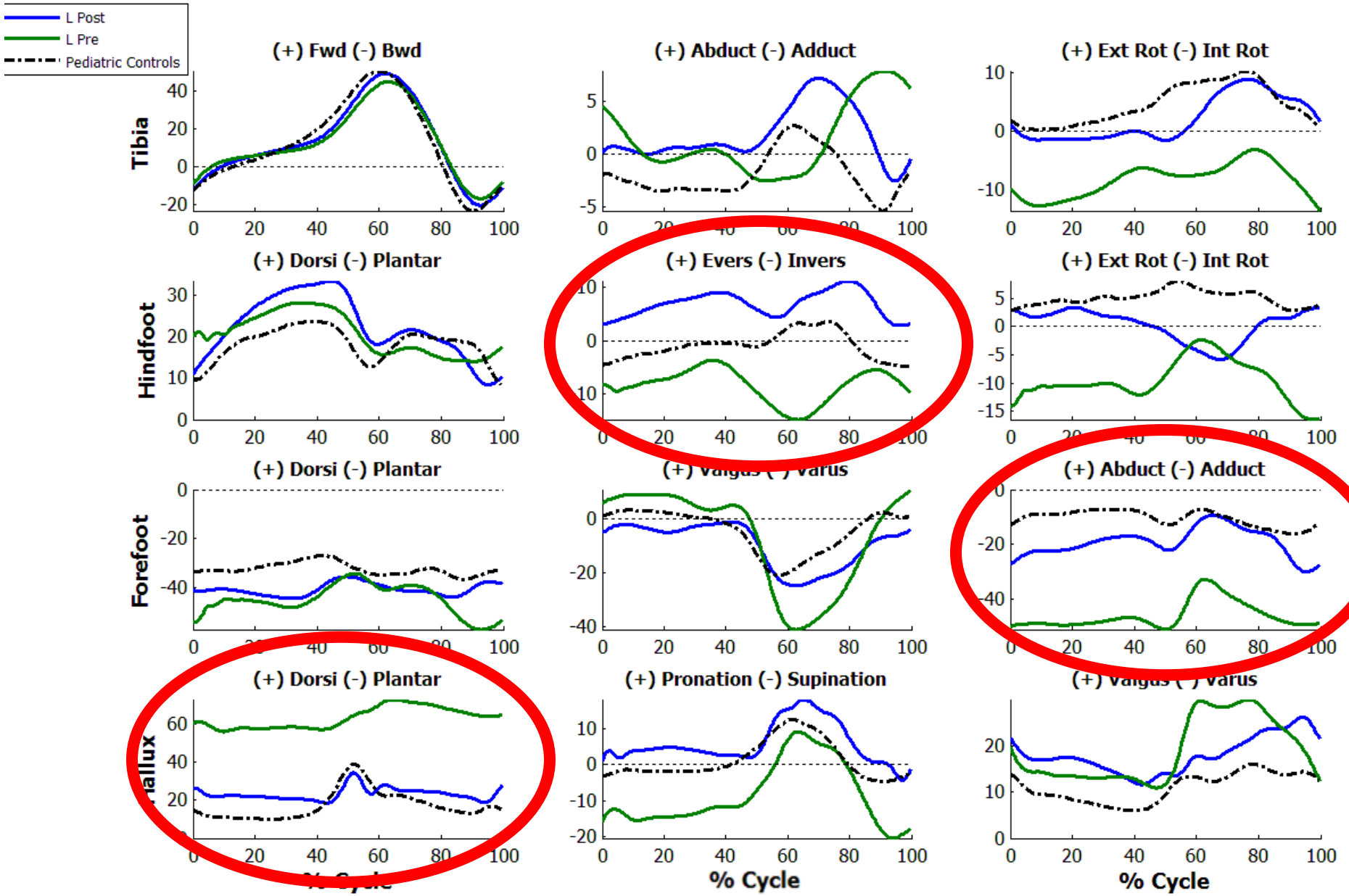
1. **Hindfoot dorsiflexion + forefoot plantar flexion = Cavus**
   - **Plantar fascia release**
2. **Decreased forefoot dorsiflexion in swing with compensatory hallux dorsiflexion**
   - **Jones Transfer**
3. **Hindfoot inversion (varus) with compensatory forefoot valgus during stance**
   - **Calcaneal (Dwyer) osteotomy**
4. **Hindfoot inversion, forefoot varus at toe-off and throughout swing, and forefoot adduction**
   - **Split transfer of the anterior tibialis to the cuboid (SPLATT)**

Post Op Video

Case #3

Pre vs. Post Op

Left Pre vs Post



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Thank you!