Foot Modeling Symposium

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Multisegment FM History

- ## 1996 Milwaukee Model
  - S.M. Kidder, A. Abuzzahab, G.F. Harris, J.E. Johnson A system for the analysis of foot and ankle kinematics during gait IEEE Transactions on Rehabilitation Engineering., 4 (1996), pp. 25–32

- ## 1999 Leardini I
  - A. Leardini, M.G. Benedetti, F. Catani, L. Simoncini, S. Giannini An anatomically based protocol for the description of foot segment kinematics during gait Clinical Biomechanics, 14 (1999), pp. 528–536

- ## 2001 Oxford Model
  - M.C. Carson, M.E. Harrington, N. Thompson, J.J. O'Connor, T.N. Theologis Kinematic analysis of a multi-segment foot model for research and clinical applications: a repeatability analysis J. Biomech., 34 (2001), pp. 1299–1307

- ## 2003 SHC Greenville Model
  - Pediatric and Adult Foot and Ankle: New Horizons in Clinical Treatment and Innovative Technology (NIH)
  - R.B. Davis, J.R. Davids, G.G. Jameson, J.P. Anderson, F.R. Murphy, L.M. Christopher: A Multi-Segment Foot Model for Whole Body Clinical Gait Analysis

- ## 2007 Leardini II
  - Leardini, A., Benedetti, M. G., Berti, L., Bettinelli, D., Nativo, R., & Giannini, S. Rear-foot, mid-foot and fore-foot motion during the stance phase of gait. Gait and Posture, 25(3) (2007) pp. 453–462

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Motivation

- 25 - 30% of all surgeries on ambulatory children with CP are foot procedures*

- Ultimately better outcomes
  - Through research
  - Through patient specific treatment decisions

- Not reimbursement

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*Andreacchio A et al. J.Pediatr.Orthop. 2000.

SLC Clinical Experience

- Over 100 subjects
- Still struggle with utility of data
  – Confirms problems, severity
  – Excellent outcomes data
  – No surgical indications
- My interest: how are others using foot models to make clinical decisions?
  – Milwaukee model: Dwyer +/- SplATT

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Differences

- Additional static markers or virtual points?

- Are technical (motion tracking) markers located on specific anatomic landmarks?

- Is the ground used as a neutral reference

  - for hindfoot?
  - for forefoot?

- Is plantargrade standing/sitting required? Is other positioning required?

- Are radiographs used? Are they required?

- How much additional time is required?

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Features

Feature	Milwaukee	Leardini	Oxford	mSHCG
Static/virtual markers	No	Yes	Yes	Yes
Separate technical marker sets	No	No	No	FF
Neutral ground reference	No	No	Optional	Optional
Plantigrade static	Required	No (STJN)	No	Required
Radiographs	Required	No	Optional	Optional
Additional Time	90 min	20-30 min	15-20 min	10-15 min

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Similarities

- Segments

- Many marker locations
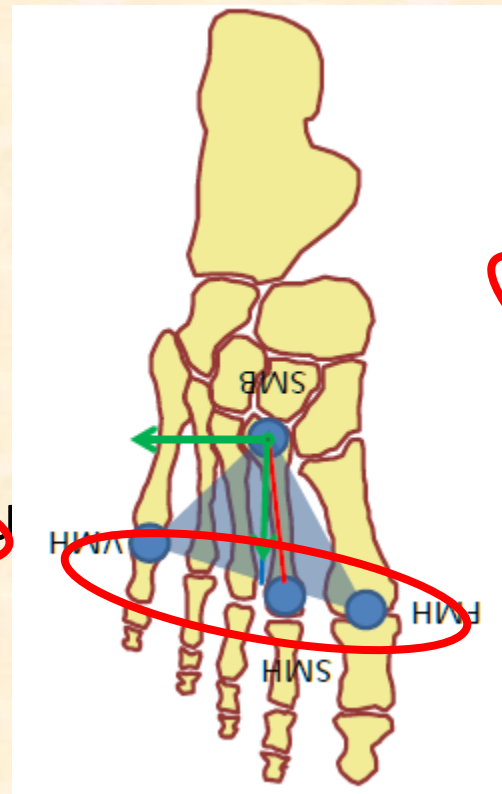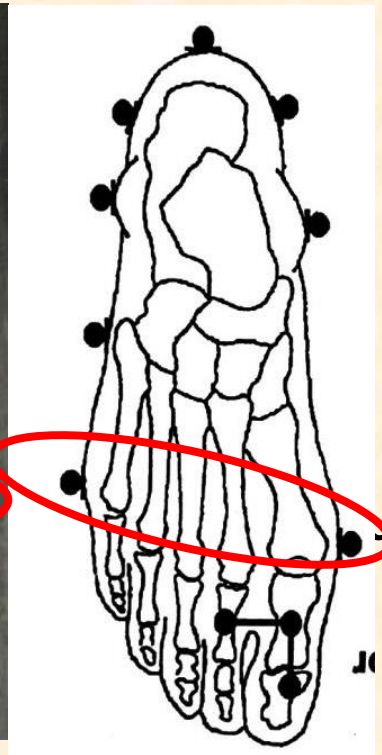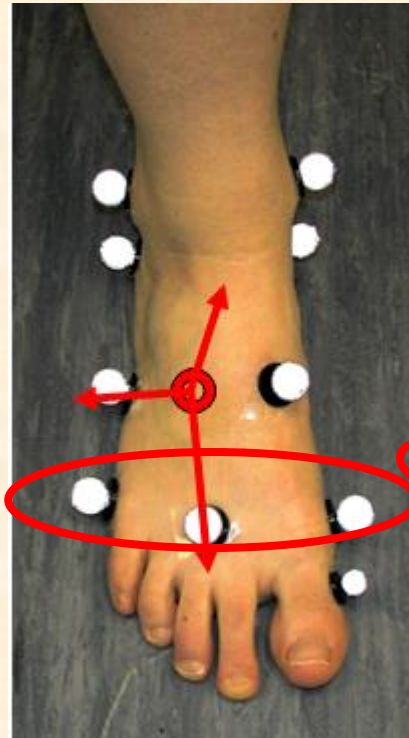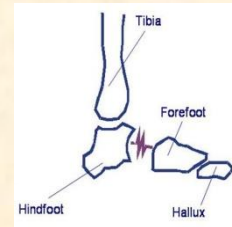
Going Forward

- Do we need a "universal" model?

- Advantages:
  - Ease of comparisons between studies
  - Often confounded by coordinate system issues

- Disadvantages:
  - No single model can likely incorporate all features desired by all investigators
  - Stifle development

Going Forward

- What we do need
  - Common underlying anatomic references
    - Maybe
    - Similar to current LE models
  - Due diligence of all models
    - Robust sets of normative data
    - Thorough studies of reliability
      - Inter and intra marker error
      - Analysis of errors in specific populations
      - Many models have no validation
   - Makes establishing a new model difficult

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Going Forward

- ## What we do need
  - Need to set a high bar to filter potentially misleading data
  - Dissemination
    - Better education
    - Better software and ease of protocols for implementation (OFM)

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Going Forward

Validation/error quantification of soft tissue artifact

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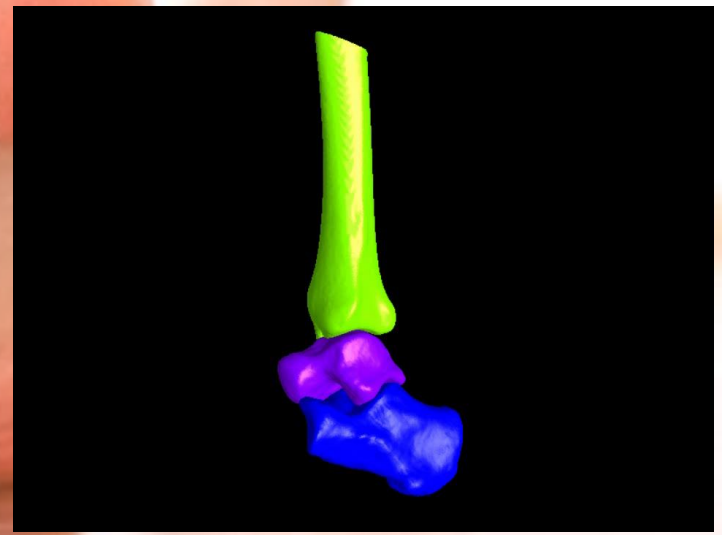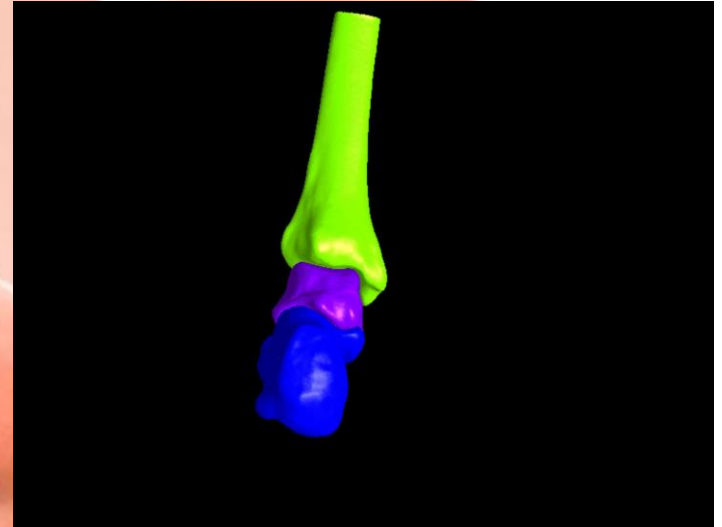
Going Forward

- Research to address clinical utility
  - Outcomes of disease based populations to retrospectively determine which characteristics benefited from a particular surgery and which did not
  - Same steps that over several decades have given us the same tools for lower extremity clinical decision making

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Questions/Opinions

- What motions are most clinically relevant in your work?

- How much time/effort are you willing to commit to something that is not reimbursable?

- Is there a simpler solution for your needs?

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