Functional Axis of Rotation of the Ankle Joint during Simulated Gait

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AOFAS 2017 Annual Meeting
Complete disclosures of myself and my co-authors are listed in the final AOFAS mobile app.

The authors report the following disclosures:

Jonathan Deland, MD: Arthrex, Inc: IP royalties, Paid consultant; Zimmer; Paid consultant

Constantine Demetracopoulos, MD: Integra LifeSciences: Paid consultant; RTI Surgical: Paid consultant; Stryker: Paid consultant; Wright Medical Technology, Inc.: Paid consultant
Native ankle joint anatomy and biomechanics

- Bicondylar joint
  - Semi-constrained hinge joint
  - Concave tibia
  - Convex talus
- 3-dimensional motion
  - Primary motion in sagittal plane
  - Secondary motion in axial & coronal planes
Total ankle replacements aim to replicate native ankle motion

- Implant design considerations
  - Anatomic geometry
  - Articular constraint
  - Component position
- Malposition affects TAA function
  - Altered ligament balance
  - Increase contact stresses
  - Altered motion
Difficult to determine ideal TAA component position with limited understanding of the functional joint axis

• Ankle motion previously investigate through:
  – Kinematics
  – Geometry
  – Ligament linkage

• Limitations
  – Passive motion (loaded/unloaded)
  – Simplified models (2D/3D)
  – Fixed axis of motion
Objective: Investigate the functional axis of the ankle joint during simulated gait

In vivo
Gait inputs

In vitro
Simulations

Output
Kinematics

Stance phase simulated in 6 cadaver specimens

3-dimensional ankle joint kinematics
Axis of rotation identified during early-, mid- and late-portions of stance

Axes of Rotation
- Early-Stance
- Mid-Stance
- Late-Stance

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Variation in Axis Anterior-Posterior Position

Anterior position*

- Early-stance: 16.4±5.8 mm
- Mid-stance: 16.5±6.6 mm
- Late-stance: 15.6±6.5 mm

*Mean ± SD

Functional axes in axial plane
Variation in Axis Internal-External Rotation

Internal Rotation*

- Early-stance: -1.2±8.0 degrees
- Mid-stance: 12.2±7.2 degrees
- Late-stance: 11.5±14.9 degrees

*Mean ± SD
Conclusions and Discussion

• Functional axis varied greatly during gait
  – Between specimen
  – Across stance portion
• Future interest to investigate anatomic features that describe these variations
• Consideration required in next generation implant design and surgical technique
Thanks to our funding support and my co-authors

Funding source: American Iron & Metal (USA)

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