The Function Axis of Rotation of the Ankle Joint during Simulated Gait  
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Introduction/Purpose: Implant component positioning is considered as an important factor in function and longevity in total ankle arthroplasty (TAA). However, accurate and repeatable positioning remains a limitation with current techniques and instrumentation. In addition, further investigation is needed to objectively define the optimum component positioning. Cadaveric gait simulation is a valuable tool for investigating foot and ankle joint mechanics during functional tasks such as the stance phase of gait. The objective of this study was to investigate the functional axis of rotation of the native ankle joint during simulated gait.

Methods: The stance phase of healthy gait was simulated with six mid-tibia cadaveric specimens using a previously validated device and methodology. A robotic platform reproduced tibial-ground kinematics by moving a force plate relative to the stationary specimen while physiologic loads were applied to the extrinsic tendons to actuate the foot. (Figure 1A). Ankle kinematics were measured from reflective markers attached to the tibia and talus via surgical pins. The helical axes of rotation of the talus with respect to the tibia was calculated during three portions of stance: initial plantarflexion during earlier-stance after heal strike, dorsiflexion during mid-stance, and final plantarflexion during late-stance. The position and orientation of these kinematic-defined axes of rotation were compared to the transmalleolar axis and reduced to its anteroposterior position and transverse plane angle (Figure 1B).

Results: Analyses revealed that ankle joint functional axis of rotation varied from the anatomic reference throughout stance. The kinematic center of rotation was located 16.4 ± 5.8 mm, 16.5 ± 6.6 mm, and 15.6 ± 6.5 mm anterior to the transmalleolar axis during early-, mid- and late-portions of stance, respectively.

Conclusion: This study revealed that the position of the flexion-extension axis varies greatly between specimens during simulated gait. While previous reports have suggested that the transmalleolar axis is an acceptable approximation for the ankle joint center, these findings suggest that further research is warranted to better describe the complex tibiotalar kinematics. This work may provide future insight to guide implant design and advance techniques, to better place articular constraints of a total ankle in the native center of rotation of the joint.

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