A Biomechanical Analysis of Ankle Instability in Supination External Rotation Ankle Fractures

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Introduction/Purpose: Supination external rotation (SER) 2 and SER3 ankle injuries are thought to be stable whereas SER4 injuries are thought to be unstable. In other words, deltoid rupture is thought to be a necessary component of instability in SER injuries. However, biomechanical evidence has shown that as little as 1mm talar shift results in 40% loss in contact area leading to increased contact forces. Additionally, the external rotation stress exam which is the typical test used to detect instability is poorly standardized in the literature limiting its ability to detect subtle instability. Therefore the purpose of this study is to analyze talar rotation and translation with external rotation stress specifically in SER2 and SER3 patterns in an effort to better define which injury patterns are unstable.

Methods: 19 legs disarticulated below the knee were obtained. Optotrak optoelectronic 3D motion measurement system was used to determine positioning of the talus compared to the tibia. Specimens were first tested intact using a jig capable of exerting known axial and rotational forces through the hindfoot in line with the weightbearing axis of the tibia. Specimens were loaded with 150N to simulate physiologic load and sequentially stressed with 0, 1, 2, 3, and 4Nm of external rotation. SER2 injury was then created by creating a Weber B distal fibula fracture and AITFL rupture. The above testing was then repeated. Next the injury was converted to SER3 by rupturing the PITFL, and the above testing was repeated. In all conditions coronal and sagittal translation as well as axial and coronal angulation from the uninjured/unstressed state were recorded. The SER2 and SER3 conditions were compared to the intact condition using a paired t-test.

Results: When compared to the uninjured state, the SER2 injury pattern demonstrated statistically significant differences in the following parameters:
- axial rotation at 1Nm (11.0±4.2°,$p<0.0005$), 2Nm (12.8±4.4°,$p<0.0005$), 3Nm (14.4±4.9°,$p<0.0005$), and 4Nm (15.8±5.2°,$p<0.0005$)
- sagittal translation at 1Nm (5.2±3.6mm,$p=0.007$), and 2Nm (6.4±3.9mm,$p=0.02$)
- coronal translation at 3Nm(0.6±3.2mm,$p=0.004$), and 4Nm (0.7±3.5mm,$p=0.003$)

When compared to the uninjured state, the SER3 injury pattern demonstrated statistically significant differences in the following parameters:
- coronal rotation at 4Nm (-0.9±6.8°,$p=0.03$)
- axial rotation at 1Nm (12.3±4.4°,$p<0.0005$), 2Nm (16.0±4.7°,$p<0.0005$), 3Nm (18.2±5.1°,$p<0.0005$), and 4Nm (20.4±5.7°,$p<0.0005$)
- sagittal translation at 1Nm (5.0±3.9mm,$p=0.03$), and 2Nm (6.4±3.9mm,$p=0.01$)
- coronal translation at 1Nm (0.7±1.9mm,$p=0.05$), 2Nm (0.8±2.5 mm,$p=0.01$), 3Nm (1.1±3.0mm,$p<0.0005$), and 4Nm (1.5±3.6mm,$p<0.0005$)

Conclusion: Current literature describes ankle instability in SER injury patterns in terms of coronal translation, and suggests that SER2 and SER3 injury patterns are stable. However, our data demonstrates that even SER2 and SER3 injury patterns with an intact deltoid ligament show signs of instability in sagittal translation and axial rotation as well as subtle signs of instability in coronal translation, especially at higher torques. As previously stated, subtle instability has been shown to significantly decrease contact forces, and therefore this data supports further study of long term clinical outcomes and reconsideration of our treatment algorithms for SER2 and SER3 fractures.

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