Significant increases in sagittal translation and transverse movement of the fibula occur with sequential disruption of the syndesmosis

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INTRODUCTION: An injured syndesmosis is the most predictive measure of residual symptoms in ankle sprains [1] and doubles recovery time [2]. Lack of knowledge regarding the kinematics of the tibiofibular joint often results in missed diagnoses, subsequent lack of therapeutic intervention, and malreduction during surgical repair for injuries to the Anterior inferior tibiofibular ligament (AITFL), Posterior inferior tibiofibular ligament (PITFL) and Interosseus membrane (IOM). Studies have shown that the AITFL is the first ligament of the syndesmosis to fail during injury [3]. Operative management is dictated by stability of the tibiofibular joint. This stability is assessed with AP and mortise X-rays, external rotation stress test, and intraoperative Cotton test which are all designed to assess lateral fibular displacement as the primary indicator of syndesmotic disruption. However, previous biomechanical studies have demonstrated that fibular motion exists in several planes after injury [4]. The objective of this study is to determine increases in fibular motion with sequential syndesmotic injury. It was hypothesized that the most significant increase in fibular motion will occur after disruption of the AITFL with only minimal increases in further fibular motion after progressive syndesmotic disruption.

METHODS: Five fresh-frozen human cadaveric tibial plateaus-to-toe specimens with a mean age of 58 years (range 38-73 years) were tested using a 6-degree-of-freedom robotic testing system (MTJ Model FRS2010, Chino, Japan). The tibia was rigidly fixed to the lower plate of the robotic testing system. The calcaneus was rigidly fixed to the upper end plate of the robotic manipulator through a universal force/moment sensor (UFS, ATI Delta IP60 (SI-660-60), Apex, NC). The subtalar joint was fused with wood screws under fluoroscopic guidance. In this construct, the full length of the fibula was maintained and fibular motion was unconstrained. A reference position for the ankle was defined at 0° plantarflexion with no external applied moment from the robotic testing system. A 5Nm external rotation moment and 5Nm inversion moment were applied to the ankle at 0°, 15°, and 30° plantarflexion and 10° dorsiflexion. The motion of the fibula with respect to the tibia was tracked by a 3D optical tracking system (Video Tracking/Motion Capture Systems Optitrack Motive) and six 1280x1024 240 Hz Motion Capture Cameras (Optitrack Flex 13). Outcome variables included fibular medial-lateral (ML), anterior-posterior (AP), and external rotation (ER) translation, and external rotation (ER) during each applied moment and flexion angle in the following conditions: 1) intact ankle, 2) AITFL transected, 3) PITFL and IOM transected. The placement of the fibular optical markers relative to the tibial optical markers determined the three-dimensional movement of the fibula. Outcome variables were reported relative to the reference position of the ankle. Multiple ANOVA with a post-hoc Tukey analysis were performed to compare the changes in fibular motion between the intact and injury models at each loading condition and flexion angle (*p<0.05).

RESULTS: The only significant differences in fibular motion at any measured flexion angle were during the 5Nm inversion moment. The posterior translation of the fibula was significantly greater in the AITFL injury compared to the intact ankle at 15° and 30° plantarflexion. Furthermore, significant increases were observed between the intact ankle and combined AITFL, PITFL, and IOM injury at 0°, 15°, and 30° plantarflexion. No significant differences were observed between the AITFL transection alone and the combined injury at any flexion angle or applied moment. When comparing the intact ankle and combined injury, significant increases in ER exist at 0° and 30° plantarflexion and 10° dorsiflexion. The only significant difference in ER between the intact ankle and AITFL transection exists at 0° plantarflexion.

DISCUSSION: The data from this study showed that transecting the AITFL resulted in the largest increases fibular motion with only minimal further displacement of the fibula with subsequent transection of the PITFL and IOM, confirming the hypothesis under study. Although combined AITFL, PITFL, IOM disruption does create significant fibular motion when compared to the intact ankle, a significant portion of the displacement of the fibula already occurs after isolated AITFL injury. Some studies have not demonstrated any measurable ML displacement of the fibula during syndesmosis injury [4]. This result was not supported by our findings nor is it observed clinically. This study utilized a novel setup to measure unconstrained motion in a full length, intact fibula. Clinical decision making is based mainly on fibular ML translation. According to these findings this could underestimate the grade of instability in AITFL injuries regarding rotational and sagittal motion. Evaluating these increases in AP translation and ER are not part of current standard diagnostic protocols and may go undiagnosed or untreated leading to diminished clinical outcomes. Physicians may consider more aggressive treatment in the setting of isolated AITFL injuries.

SIGNIFICANCE: This study demonstrates that significant fibular motion occurs with isolated AITFL disruption and only minimally increases with sequential PITFL and IOM transection. Clinical diagnostic protocol should be expanded to evaluate beyond ML translation of the fibula and account for sagittal and rotational displacements as well.

REFERENCES:

![FIGURE 1: Medial-lateral fibular translation at various flexion angles with 5Nm inversion moment. (Mean +/- SD)](image1)

![FIGURE 2: Anterior-posterior translation at various flexion angles with 5Nm inversion moment. *p<0.05 (Mean +/- SD)](image2)

AITFL = anterior inferior tibiofibular ligament. PITFL = posterior inferior tibiofibular ligament. IOM = interosseus membrane.