Syndesmotic Malreduction Assessment using Three-Dimensional Distance Mapping: A Cadaveric WBCT Study

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Introduction/Purpose: Diagnosing syndesmotic injuries is challenging. Avoiding intra-operative syndesmotic malreduction is even more challenging. Malreduction can be devastating to the long-term health of the ankle joint and has been shown to be more frequent and unforgiving with rigid screw fixation when compared to flexible implants. Syndesmotic position assessment postoperatively is usually performed using bilateral CT. Evaluation is frequently subjective or based on conventional distance, angular, area, and volumetric measurements. Diagnostic accuracy of these measurements is still questionable. The goal of this study was to utilize a 3D Weightbearing CT distance mapping algorithm to objectively assess syndesmotic position in a cadaveric model simulating different patterns of syndesmotic malreduction. We also aimed to evaluate the relative changes in syndesmotic position when fixation was converted from rigid to flexible.

Methods: In this cadaveric experimentation, four below-knee specimens were utilized. Specimens were mounted in an external frame simulated weightbearing condition (350N of axial load). Specimens underwent sequential WBCT imaging in four different conditions: native normal ankle, syndesmotic instability, malreduced, and released conditions. In the instability condition, syndesmotic ligaments were surgically released using a conventional limited lateral approach. The malreduced position consisted of controlled 5mm anterior displacement, 5mm posterior displacement, 15° of internal rotation, and over-compressed (160N) states. Fixation was performed with a single implant 20mm proximal to the ankle joint. Implant utilized allowed initial rigid screw-type fixation, followed by implant flexibilization similar to a suture-type fixation (released position). Tibia, fibula, and talus WBCT images were segmented, and syndesmotic incisura and gutter distances were assessed using a 3D distance map algorithm. The syndesmotic position was compared between normal, unstable, malreduced, and released positions. Color-coded representations of the observed differences were presented (Figure).

Results: When comparing normal to unstable condition, we observed significant widening of the syndesmotic posterior aspect (average, 13.9%; p=0.004). Overall, all four malreduced positions lead to significantly decreased tibiofibular distances when compared to the unstable state, consistent with syndesmotic over-compression (average, 19.8%; p=0.01), particularly in the posterior aspect of the joint (average, 26.9%; p=0.04). This over-compression was also more pronounced in the anterior displacement (31.5%) and internal rotation malreductions (23.1%). In the released flexible position we found a non-significant trend towards widening of the tibiofibular distances (average, 12%; p=0.08) when compared to the malreduced conditions, indicating partial restoration the syndesmotic relationship. The syndesmotic distances in the released position were also not significantly different from the normal condition. When compared to normal, the lateral gutter demonstrated significant widening in the unstable condition (average 16.7%; p=0.02), narrowing in the malreduced state (average 6.6%; p=0.04), and widening in the released position (average 3.7%; p=0.002).

Conclusion: In this study we used 3D WBCT distance mapping to assess syndesmotic position in a cadaveric model simulating syndesmotic instability and multiple syndesmotic malreduction conditions (anterior and posterior displacement, internal rotation and over-compression). We observed significant widening when the syndesmotic ligaments were sectioned, followed by significant tibiofibular narrowing in the malreduced and fixed rigid states. When the implant fixation was released, we observed a trend towards restoration of normal syndesmotic alignment, with relative widening that was however not significantly different from the malreduced rigidly fixed state. Increased sample size cadaveric assessment and clinical studies are necessary to validate our results.

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Unstable Widening → Malreduced → Released

Syndesmotic Distances

- Overcompression
- Anterior Translation
- Posterior Translation
- Internal Rotation

Improvement from Malreduced to Released

Screw Release