Automatic 3D Volumetric Analysis of the Distal Tibiofibular Syndesmotic Incisura: A Case-Control Study of Subtle Chronic Syndesmotic Instability

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Introduction/Purpose: Chronic subtle distal tibiofibular syndesmotic instability (DTFSI) is relatively common, and consequences of undiagnosed injuries can be devastating. Diagnosing acute and chronic injuries is challenging, and the most commonly used diagnostic tools are physical exams, conventional radiographs and bilateral CT, and MRI. Arthroscopic assessment, an invasive method, is currently considered the gold standard. Weightbearing CT has just emerged as an excellent dynamic non-invasive diagnostic test. Recent literature highlighted the accuracy of syndesmotic incisura area measurements in diagnosing subtle DTFSI. The aim of our study was to develop and validate the use of a novel automatic 3D volumetric assessment of the incisura, and to compare the measurements between patients with surgically confirmed DTFSI and controls.

Methods: In this IRB-approved case-control study, patients with suspected unilateral chronic subtle DTFSI underwent bilateral standing weightbearing CT (WBCT) examination before surgical treatment. DTFSI was confirmed by arthroscopic assessment. We also included control patients that underwent WBCT tests for forefoot related problems and no history of syndesmotic injuries. The syndesmotic incisura volume (mm3) was measured starting at the level of the ankle joint to two proximal points, 10 and 15mm proximally to the joint. A 3D automatic measurement algorithm composed of automated segmentation of the distal tibia and fibula and recognition of the incisura volume based on Hounsfield units (HU) assessment was performed. Measurements were compared between DTFSI patients and controls. A partition prediction model, ROC curves and area under the curve (AUC) were performed to assess the diagnostic accuracy of the automatic volumetric analysis to detect DTFSI. P-values of less than 0.05 were considered significant.

Results: In this preliminary report, four patients with DTFSI and seven controls were included. Mean value and 95% CI for 3D Syndesmotic Incisura volumetric measurements at 10 and 15mm points: 1457 mm3 (1233 to 1680)/2241 mm3 (1951 to 2531) for controls, and 1679 mm3 (910 to 2447)/2425 mm3 (1408 to 3443) for patients with DTFSI (p-values of respectively 0.35 and 0.55). When comparing injured and uninjured DTFSI ankles, volume measurements at 10 and 15mm points were increased on injured ankles, with a Hodges-Lehmann difference of respectively 287 mm3 (p=0.19), and 186 mm3 (p=0.31). The partition model demonstrated that the volume of the first 10mm was the best predictor of DTFSI, with only 3% chances of DTFSI when the incisura volume was below 1291 mm3 (AUC=0.71).

Conclusion: Our study aimed to describe and validate the use of a novel automatic 3D volumetric measurement of the distal tibiofibular incisura in patients with chronic subtle ankle syndesmotic instability and controls. Our preliminary results demonstrated increased volumes on injured ankles when compared to contralateral uninjured ankles and controls. Measurements performed within the first 10mm length of the syndesmosis were found to predict better the presence of syndesmotic instability, with a volume of 1291 mm3 representing an important diagnostic threshold. Automatic 3D WBCT volumetric measurements may represent a useful non-invasive diagnostic tool for subtle and chronic syndesmotic instability.
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- Measurement starting at the level of the ankle joint (Cross-Section of Blue Line and Distal Red Line)
- Syndesmatic Incisura Volume Measured 10mm proximally to that point (Red area)
- Example of Cross-Sectional Axial Image of the Incisura Volume being Measured Bilaterally
- Example of 3D Incisura Volume Measurement (Blue): Injured (Left) and Uninjured (Right) ankle.

| STATUS INJURED VS NON-INJURED | Area Under the Curve (AUC) |
|------------------------------|----------------------------|
| CONTROL                      | 0.7143                     |
| INJURED                      | 0.7143                     |

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