World Academy of Science, Engineering and Technology
International Journal of Health and Medical Engineering
Vol:18, No:04, 2024

Comparing Radiographic Detection of Simulated Syndesmosis Instability Using Standard 2D Fluoroscopy Versus 3D Cone-Beam Computed Tomography

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Abstract : Introduction: Ankle sprains and fractures often result in syndesmosis injuries. Unstable syndesmotic injuries result from relative motion between the distal ends of the tibia and fibula, anatomic juncture which should otherwise be rigid, and warrant operative management. Clinical and radiological evaluations of intraoperative syndesmosis stability remain a challenging task as traditional 2D fluoroscopy is limited to a uniplanar translational displacement. The purpose of this pilot cadaveric study is to compare the 2D fluoroscopy and 3D cone beam computed tomography (CBCT) stress-induced syndesmosis displacements. Methods: Three fresh-frozen lower legs underwent 2D fluoroscopy and 3D CIOS CBCT to measure syndesmosis position before dissection. Syndesmotic injury was simulated by resecting the (1) anterior inferior tibiofibular ligament (AITFL), the (2) posterior inferior tibiofibular ligament (PITFL) and the inferior transverse ligament (ITL) simultaneously, followed by the (3) interosseous membrane (IOM). Manual external rotation and Cotton stress test were performed after each of the three resections and 2D and 3D images were acquired. Relevant 2D and 3D parameters included the tibiofibular overlap (TFO), tibiofibular clear space (TCS), relative rotation of the fibula, and anterior-posterior (AP) and medial-lateral (ML) translations of the fibula relative to the tibia. Parameters were measured by two independent observers. Inter-rater reliability was assessed by intraclass correlation coefficient (ICC) to determine measurement precision. Results: Significant mismatches were found in the trends between the 2D and 3D measurements when assessing for TFO, TCS and AP translation across the different resection states. Using 3D CBCT, TFO was inversely proportional to the number of resected ligaments while TCS was directly proportional to the latter across all cadavers and ‘resection + stress’ states. Using 2D fluoroscopy, this trend was not respected under the Cotton stress test. 3D AP translation did not show a reliable trend whereas 2D AP translation of the fibula was positive under the Cotton stress test and negative under the external rotation. 3D relative rotation of the fibula, assessed using the Tang et al. ratio method and Beisemann et al. angular method, suggested slight overall internal rotation with complete resection of the ligaments, with a change < 2mm - threshold which corresponds to the commonly used buffer to account for physiologic laxity as per clinical judgment of the surgeon. Excellent agreement (>0.90) was found between the two independent observers for each of the parameters in both 2D and 3D (overall ICC 0.9968, 95% CI 0.995 - 0.999). Conclusions: The 3D CIOS CBCT appears to reliably depict the trend in TFO and TCS. This might be due to the additional detection of relevant rotational malpositions of the fibula in comparison to the standard 2D fluoroscopy which is limited to a single plane translation. A better understanding of 3D imaging may help surgeons identify the precise measurements planes needed to achieve better syndesmosis repair.

Keywords : 2D fluoroscopy, 3D computed tomography, image processing, syndesmosis injury
Conference Title : ICOTSR 2024 : International Conference on Orthopaedics and Traumatology: Surgery and Research
Conference Location : New York, United States
Conference Dates : April 22-23, 2024