4DCT Evaluation of Scapholunate Ligament and Dorsal Capsular Scapholunate Septum after Sectioning in Cadaveric Models

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Summary

Dynamic instability of the scapholunate joint poses diagnostic challenges in wrist injuries. Using four-dimensional computed tomography (4DCT), this cadaveric study evaluated the impact of selective ligament sectioning on joint stability. Five fresh-frozen specimens were imaged in a custom wooden frame during wrist flexion, extension, and radial–ulnar deviation. Arthroscopic sectioning was performed on the volar scapholunate ligament (VSL), dorsal scapholunate ligament (DSL), scapholunate interosseous ligament (SLIL), and combinations including partial or complete dorsal capsular scapholunate septum (DCSS). Dynamic imaging with semi-automated segmentation enabled quantitative analysis of scapholunate diastasis and bone tilting. Isolated VSL sectioning maintained joint congruency, whereas DSL sectioning produced diastasis during flexion and extension. Increasing ligament disruption, especially with DCSS involvement, correlated with greater instability. These results support 4DCT as a promising tool for diagnosing wrist instability.

Introduction

Scapholunate instability is a common yet often under-recognized pathology in wrist trauma. Conventional imaging may not capture the dynamic changes during motion, leading to potential misdiagnosis. Recent advances in 4DCT offer enhanced, multi-planar visualization of wrist kinematics, thereby providing new insights into the contributions of intrinsic and extrinsic stabilizers.

Methods

In this cadaveric study, five fresh-frozen upper extremities were secured in a custom wooden frame that simulated wrist flexion, extension, and radial–ulnar deviation. Arthroscopic sectioning was sequentially performed on the VSL, DSL, and SLIL, as well as in combinations with partial and complete DCSS sectioning. Dynamic 4DCT acquisitions and semi-automated segmentation techniques were used to quantify scapholunate diastasis and tilting.

Results and Discussion

Isolated VSL sectioning resulted in no significant diastasis during any movement. In contrast, DSL sectioning induced diastasis during flexion and extension but not during radial–ulnar deviation. Combined sectioning—including the DCSS—resulted in progressive increases in scapholunate separation and altered bone tilting. These findings underscore the complex interplay of intrinsic and extrinsic stabilizers in wrist kinematics and highlight the diagnostic potential of 4DCT in detecting subtle dynamic instability.

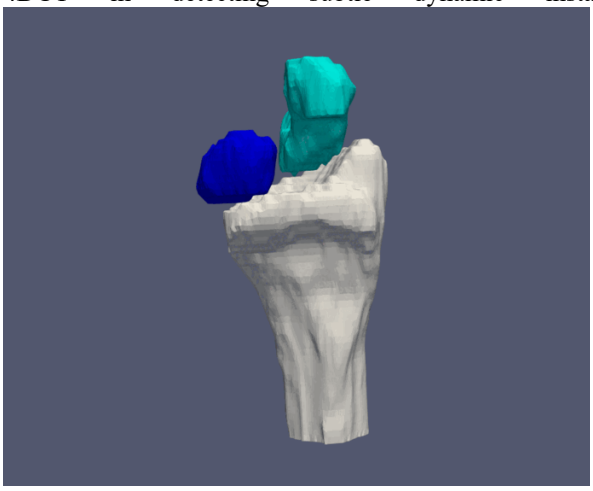

Figure 1: 3D reconstruction of segmented radius, scaphoid and lunate.

Conclusions

4DCT offers a multi-planar assessment of wrist kinematics, demonstrating that integrity of the DSL and DCSS is crucial for maintaining scapholunate stability. The study supports incorporating 4DCT into the diagnostic algorithm for suspected scapholunate injuries, which may ultimately improve clinical management and patient outcomes.

References

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