Simulated Radioscapholunate Fusion Alters Carpal Kinematics While Preserving Dart Thrower's Motion
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Introduction: Radioscapholunate (RSL) fusion is a common surgical treatment for degeneration of the radiocarpal joints caused by traumatic, inflammatory, and metabolic processes. The goals of this limited wrist arthrodesis are twofold: pain relief and the preservation some wrist motion. While these goals are generally achieved, midcarpal degeneration is not an uncommon complication [1,2,3,4]. Likely multifactorial in nature, the etiology of this midcarpal degeneration has not been established, though it is commonly thought to be due, in part, to altered kinematics, which changes the bony articulations and cartilage contact. To date, however, kinematics of the midcarpal and lunotriquetral articulations following RSL fusion have not been quantified. Accordingly, in this study we evaluated carpal bone motion in cadaver wrists before and after simulated RSL fusion. We hypothesized that RSL fusion would alter the kinematics in the remaining carpal joints. As recent investigations have found that the scaphoid and lunate are very stable during the dart thrower’s motion, suggesting that this motion might be selectively preserved after RSL fusion, we focused specifically on the dart thrower’s path.[5,6]

Materials and Methods: Simulated radioscapholunate fusions were performed on 6 unembalmed cadaveric wrists in the anatomic neutral posture. Two 0.060 in. carbon fiber pins were placed from proximal to distal across the radiolunate joint and two more across the radioscaphoid joint. The wrists were secured in a custom jig for CT imaging and passively positioned through the full range of motion along the anatomical axes (flexion/extension and ulnar/radial deviation), as well as combined motions, including additional intermediate positions along the dart thrower’s path (13 positions per subject). Utilizing a CT-based markerless bone registration technique [7], the 3-D rotation of each carpal bone as a function of wrist position was described with respect to the pinned neutral position. Hierarchical linear regression analysis and paired Student’s t-tests were used to compare the kinematic data from the fused wrists to data collected on the same wrist prior to pinning.

Results: Following simulated fusion, wrist range of motion was restricted to an average flexion-extension arc of 47.9°, reduced 38% from 77.2°, and an ulnar-radial deviation arc of 19.3°, down 41% from 32.6° (Figure 1). Residual motion was maximally preserved along the dart thrower’s path, from radial-extension toward ulnar-flexion.

The simulated fusion significantly increased rotation at the scaphotrapezial joint (p<0.01), scaphocapitate joint (p<0.01), triquetrohamate joint (p<0.01), and lunotriquetral joint (p<0.01). For example, in the pinned wrist, rotation of the hamate relative to the triquetrum increased 85%. (i.e. for every 10° of total wrist motion the hamate rotated an average of 7.6° relative to the triquetrum after pinning, versus 4.1° before pinning. Figure 2).

Discussion: Simulated radioscapholunate fusion alters the kinematics of the lunotriquetral and midcarpal joints. The increased rotations across these joints provides insight into one potential explanation for midcarpal degeneration following radioscapholunate fusion. Additionally, this fusion model confirms the hypothesis that the dart thrower’s wrist motion, from radial-extension toward ulnar-flexion, was largely preserved following simulated radioscapholunate fusion.


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Figure 1. Wrist motion following simulated radioscapholunate fusion was reduced at the extremes of flexion/extension and ulnar deviation, but was generally preserved along the arc of the dart thrower's path, from radial-extension to ulnar-flexion.

Figure 2. Regression lines illustrating the greater rotation of the hamate relative to the triquetrum following simulated fusion.