Evaluation of the Reduction and Association of the Scaphoid, Capitate, and Lunate (RASCL) Procedure: A Biomechanical Analysis

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INTRODUCTION: Disruption of the scapholunate (SL) ligament leads to progressive radiocarpal and midcarpal arthritis, pain, and instability. While the reduction and association of the scaphoid and lunate (RASL) procedure can restore anatomic alignment of the carpus, complications and reoperations are common, even with optimal screw placement proximal to the dorsal ridge of the scaphoid. Previous studies have shown up to a 33% complication rate, with SL joint widening being the most common complication. The purpose of this study is to evaluate the effect of the reduction and association of the scaphoid, capitate, and lunate (RASCL) procedure, whereby an additional screw is placed at the scaphocapitate (SC) interval. We hypothesize the addition of the SC screw unique to the RASCL procedure will decrease both diastasis and rotation at the SL interval under physiologic levels of loading, conferring greater stability and a lesser likelihood of implant failure compared to the RASL procedure.

METHODS: Twelve fresh-frozen cadaveric upper extremities (age range 33-64) without evidence of injury were harvested via transradial disarticulation. Prior to preparation and biomechanical testing, specimens were thawed for 18 hours at 4°C. Specimens were positioned grasping a custom bar attached to an Instron testing system to mimic clenched-fist loading and subjected to discrete loads of transcarpal axial force of 150 Newtons (N), 200 N, and 250 N for 20 cycles in SL ligament intact, SL ligament injury, RASL, and RASCL models. We defined the SL ligament *injury* model as complete obliteration of the SL ligament and the portion of the dorsal intercalated ligament (DIC) ulnar to the most ulnar aspect of the scaphoid. This created a Garcia-Elias stage IV SL instability injury which was confirmed with radiographs. RASL and RASCL procedures were performed using cannulated headless compression screws (Trimed, Inc. Santa Clarita, California) with entry point proximal to the lateral aspect of the dorsal scaphoid ridge. The primary outcome measured was diastasis in millimeters at the SL interval. Infrared (IR) 3D motion capture cameras viewed custom-made, spherical IR markers embedded into the scaphoid and lunate. Vicon motion capture software (Vicon Motion Systems Ltd, UK) was used to quantify cyclic motion diastasis. One way ANOVA, paired t-tests, and repeated measure ANOVA tests were used to analyze differences in means of each model at force levels tested.

RESULTS SECTION: All twelve specimens tested were included in analysis. At 200N, mean SL diastasis of the SL intact, SL injury, RASL, and RASCL models were 0.136 mm, 0.802 mm, 0.461 mm, and 0.211 mm, respectively. Paired t-test analysis showed a difference in SL diastasis means between RASL and RASCL procedures that was statistically significant at 150N (p=0.014), 200N (p=0.014) and approached significance at 250N (p=0.062). At 250N, repeated measures ANOVA showed a statistically significant difference between the SL diastasis means in the following groups: SL intact and SL injury model (p=.004), SL intact and RASL model (p=0.027), and SL injury and RASCL model (p=0.006). There was no significant difference on repeated measures ANOVA between the means of the following groups at 250N: SL intact and RASCL model (p=0.056), SL injury and RASL model (p=0.103), and RASL and RASCL model (p=0.317). This trend remained consistent at 200N and 150N.

DISCUSSION: Mean SL diastasis increased after creating an SL injury and decreased after internal fixation. Mean diastasis of 0.438 mm in the RASL group was equivalent to previously published diastasis values (Koehler 2018). Repeated measures ANOVA analysis showed a significant difference in SL diastasis between the intact model and the RASL model, however there was no significant difference in SL diastasis between the SL intact model and RASCL model.This indicates that the RASCL model achieves a postoperative construct more closely resembling the intact model than the RASL is able to achieve. In comparison to the injured state, we can conclude RASCL arrests movement about the SL interval to a greater degree than RASL. A limitation of the study is the use of cadaveric specimens which do not take into account the effects of healing bone and carpal vascularity. In conclusion, our study shows that the mean SL diastasis in the RASCL model was less than the mean SL diastasis RASL model which was statistically significant (p=0.014).

SIGNIFICANCE/CLINICAL RELEVANCE: The most common complication after the RASL procedure is SL widening. Our data shows the addition of the scaphocapitate screw confers additional stability to the SL interval and may help decrease the SL widening after injury and subsequent internal fixation.

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Table 1. Paired T-test results of Cyclic Motion Diastasis at 150, 200, and 250 N

Mean Diastasis (mm)	SL intact (mm)	SL Injury (mm)	RASL (mm)	RASCL (mm)
150 N	0.131	0.872	0.318	0.172
200 N	0.136	0.802	0.461	0.211
250 N	0.148	0.831	0.438	0.275