Acromioclavicular Reconstruction with Human Dermal Allograft and Interlinked Knotless All-Suture Anchor Hybrid Construct Restores Translational and Rotational Stability: A Biomechanical Study

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INTRODUCTION:

Acromioclavicular joint (ACJ) injuries can disrupt the acromioclavicular capsuloligamentous complex (ACLC) and the coracoclavicular ligaments (CCL), leading to ACJ instability and shoulder dysfunction. **Current surgical techniques commonly stabilize the CCL, without directly treating the ACJ injury**. Despite reports of 150-plus surgical techniques in literature to date, no ideal treatment consensus has emerged, and outcomes remain unpredictable, with instability recurrence up to 25%. Rotational instability also commonly persists with reported techniques and may contribute to the high failure rate.

The purpose of this study was to biomechanically evaluate a **new human dermal allograft (HDA) and interlinked knotless all-suture anchor (IKASA) hybrid construct for ACLC reconstruction (Fig 1)**. We hypothesized the construct will restore time-zero intact-ACLC translational and rotational stability.

METHODS:

Eight cadaveric shoulders (66 ± 11 yo, 6M/2F) with intact ACLC and CCL were set in a custom testing system allowing superior-inferior (SI) and anterior-posterior (AP) distal clavicle translations and sagittal clavicle rotation (Fig 2). ACJ positions under 2.5/5.0/7.5 N AP and SI loads and 0.08/0.16 Nm torques were captured with 3-D coordinate measurement.

The following conditions were tested (Fig 3): **1) intact**; **2) complete ACLC transection**; **3) ACLC reconstruction with hybrid HDA and 4 x 2.6 mm IKASA construct** providing multidirectional stabilization and multiplanar recreation of key ACLC components (Fig 1, 3); **4) complete CCL transection**; and **5) CCL re-stabilization** with a standard tape/button construct. After kinematic testing, the CCL stabilization was released, and the clavicle was loaded to translate superiorly until ACJ failure.

Data were analyzed with a linear mixed-effect model and Tukey's HSD tests. Significance was $< .05$. Sample size of 8 was sufficient with $\alpha = 0.05$ and $\beta = 0.8$ based on 7.5 N load SI translation pilot results.

RESULTS:

Complete ACLC transection with CCL intact (Condition 2) resulted in significant increases in AP translation and rotation at all load and torque levels (Fig 4A, 4C), and trends toward SI translation increase (Fig 4B).

ACLC reconstruction with HDA/IKASA hybrid construct significantly reduced AP and SI translations and rotations to intact-equivalent or below at all load and torque levels, whether the CCL was intact (Condition 3), transected (Condition 4), or re-stabilized (Condition 5), with Condition 5 demonstrating the lowest translations and rotations throughout (Fig 4)**.**

Ultimate failure load of the hybrid construct was 225.5 ± 119.1 N. Failure modes: 4 acromial fractures, 2 clavicular fractures, and 2 suture/graft failures. Given the novel nature of this construct, post hoc power analysis was also performed, confirming $n = 8$ was sufficient to achieve $\alpha = 0.5$ and $\beta > 0.8$ for all parameters.

DISCUSSION AND CONCLUSION:

In summary, the HDA/IKASA hybrid ACLC reconstruction demonstrated **intact or greater SI, AP, and rotatory stabilization of the ACJ, notably even with the CCL completely transected (Condition 4),** highlighting the stabilizing

potential of direct ACJ reconstruction absent with current CCL-only surgical techniques. Rotatory stability restoration has not been previously reported with CCL or ACLC constructs.

The present study also found that **complete transection of the ACJ with intact CCL (Condition 2), analogous to the prevalent CCL-only treatment approach, led to significant AP translation and rotation increases plus a trend toward higher SI translation**, all of which may contribute to loosening of CCL-only constructs and eventual instability in all directions.

In this hybrid construct, the IKASA sutures and HDA are positioned to provide **acromion up/clavicle down mechanical stabilization** similar to a metal hook plate, but without the added morbidity of the plate removal surgery. The HDA is specifically shaped to provide three-sided distal clavicular coverage and superior/inferior acromial coverage, for a **biologic reconstruction** of the essential components of the native ACLC, and soft tissue interposition at the bone/suture interface throughout to reduce potential bone erosion. The use of KASA eliminates knots as the primary source of fixation strength, and permits retensioning to maximize final construct security. The failure incidence via fractures (75%) suggests the construct strength may be higher in-vivo.

Relevant to the ongoing challenges with recurrent ACJ instability despite extensive effort to improve surgical outcomes, present findings demonstrate the **translational and rotatory stabilizing capability of the novel hybrid ACLC reconstruction construct**, and support **concurrent ACLC and CCL treatment** for high-severity ACJ injuries.

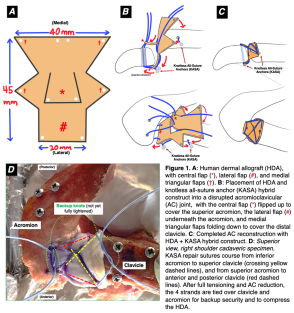

Figure 1. A: Human dermal allograft (HDA), with central flap (*), lateral flap (#), and medial triangular flaps (†). **B:** Placement of HDA and knotless all-suture anchor (KASA) hybrid construct into a disrupted acromioclavicular (AC) joint, with the central flap (*) flipped up to cover the superior acromion, the lateral flap (#) underneath the acromion, and medial triangular flaps folding down to cover the distal clavicle. **C:** Completed AC reconstruction with HDA + KASA hybrid construct. **D:** Superior view, right shoulder cadaveric specimen. KASA repair sutures course from inferior acromion to superior clavicle (crossing yellow dashed lines), and from superior acromion to anterior and posterior clavicle (red dashed lines). After full tensioning and AC reduction, the 4 strands are tied over clavicle and acromion for backup security and to compress the HDA.

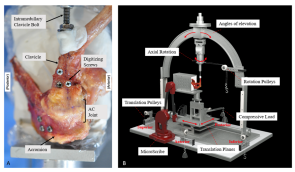

Figure 2. A: *Superior view, right shoulder cadaveric specimen.* The scapula is potted in the custom box and a bolt is inserted into the clavicle. B: Schematic of the acromioclavicular (AC) joint custom testing system with six degrees of freedom.

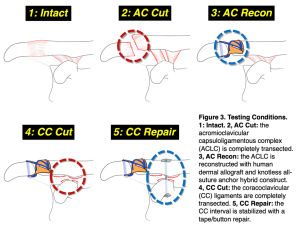

Figure 3. Testing Conditions. 1: Intact, 2, AC Cut: the acromioclavicular capsuloligamentous complex (ACLC) is completely transected. **3, AC Recon:** the ACLC is reconstructed with human dermal allograft and knotless all-suture anchor hybrid construct. **4, CC Cut:** the coracoclavicular (CC) ligaments are completely transected. **5, CC Repair:** the CC interval is stabilized with a tape/button repair.

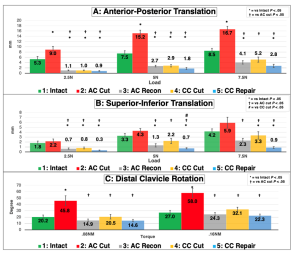

Figure 4. Translations (mm) and rotation (deg) in the five testing conditions: 1) Intact; 2) AC Cut; 3) AC Recon; 4) CC Cut; 5) CC Repair. A: Anterior-posterior translation. **B:** Superior-inferior translation. **C:** Distal clavicle rotation.