A Biomechanical Analysis of Shoulder Stabilization: Anterior Bankart Repair using Suture Anchors

INTRODUCTION
In most episodes of traumatic glenohumeral instability, tearing of the labrum occurs, requiring repair of the torn tissue to the glenoid rim. Throughout the last decade, all-arthroscopic techniques have become an accepted method of performing shoulder stabilization procedures. Arthroscopic repairs of anterior Bankart lesions are typically performed with single loaded suture anchors tied with a simple stitch configuration. While there are several biomechanical studies describing properties of repair constructs for anterior shoulder instability repair, this is the first study to directly compare 4 specific techniques in terms of both ultimate load to failure and cyclical loading. The purposes of this cadaveric study were 1) to compare the biomechanical properties of single loaded suture anchor with simple stitch (SSA) and knotless suture anchors (KSA) without cyclic loading (Part 1 of study), and 2) to compare the biomechanical properties of an anterior Bankart repair with capsular plication performed with glenoid bone suture anchors utilizing several different suture plication techniques with cyclic loading (Part 2 of study).

METHODS
A total of 30 fresh-frozen human cadaveric shoulders were dissected to the glenohumeral capsule and the humeral head was disarticulated from the glenoid. To assess the potential influence of bone density, each specimen also underwent dual-energy x-ray absorptiometry (DEXA) bone density testing with a bone densitometer.

For all specimens, the glenoid capsulolabral complex was divided into quadrants, with a focus on the anteroinferior quadrant. The anteroinferior (AI) quadrant was defined as the inferior half of the glenoid from 3 o’clock to 6 o’clock (right shoulder). Prior to repair, a Bankart tear of the AI quadrant was simulated using a #15 scalpel (Figure 1).

For Part 1, a total of 10 specimens with a mean age of 55 ± 5 years (range, 48 to 63) were randomized into either SSA or KSA. Each shoulder was mounted onto a materials testing system (MTS Insight 5) and the construct was preloaded to 5 N for 1 minute and then loaded to failure at 25 mm/min. For Part 2, additional specimens with a mean age of 64 ± 15 years (range, 45 to 91) were randomized into one of the following four repair techniques: 1) SSA, 2) suture anchor with horizontal mattress configuration (HSA), 3) double loaded suture anchor with simple stitch configuration (DSA), or 4) KSA. Each shoulder was preloaded to 5N for 2 minutes, cycled from 5N to 25N for 100 cycles (1 Hz), and then loaded to failure at 15 mm/min.

Data recorded included mode of failure, ultimate load to failure, load at 2 mm of displacement, as well as displacement during cyclical loading (Part 2 only, during the entire 100 cycles and during the final cycle only). Unpaired t-tests for Part 1 and one-way analysis of variance (ANOVA) for Part 2 were used to analyze the different groups utilizing SPSS software (Chicago, IL), with statistical significance at p < 0.05.

RESULTS
Part 1: There was no statistical difference in ultimate load to failure between SSA (173.1 ± 45.3 N) and KSA (167.9 ± 42.3 N, p=0.30). The load required to achieve 2mm of actuator displacement was significantly greater in SSA (66.5 ± 21.7 N) compared to KSA (35.0 ± 12.5 N, p=0.02).

Part 2: There was a statistically significant difference in ultimate load to failure among the 4 groups, with both the single loaded suture anchor with simple stitch (184.0 ± 64.5 N), horizontal mattress stitch (189.0 ± 65.3 N) and double loaded suture anchor with simple stitch (216.7 ± 61.7 N) groups having significantly (p<0.05) higher loads than the knotless group (103.9 ± 52.8 N). There was no statistically significant difference (P>0.05) among the four groups in displacement after cyclical loading or load at 2mm of displacement.

Figure 2 – Effect of cycling on ultimate load to failure, showing a significantly higher (P<0.05) load to failure after cycling in the SSA group compared to the KSA.

DISCUSSION
In the present study, we observed that the SSA required greater loads to reach 2mm gapping compared to KSA without cyclic loading. We also determined that there was a significant difference between suture anchor repair with simple stitch (SSA and DSA) and horizontal mattress (HAS) compared to KSA in terms of ultimate load to failure with cyclic loading. The findings may suggest that with cyclical loading up to 25N there is no difference in gapping greater than 2mm, but a macrotraumatic event may demonstrate a difference in fixation during the initial post-operative period (Figure 2). If KSA are used, the authors recommend that surgeons consider altering the post-operative rehabilitation protocol. Additional in vivo studies are needed to determine whether these differences affect the integrity of the repair construct, and ultimately, the clinical outcome.

REFERENCES