Kinematic effect of MGHL incorporation into Bankart repair

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Kinematic Effect of MGHL Incorporation into Bankart Repair

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abstract

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Surgical treatment for traumatic shoulder instability has progressed in tandem with the evolution of the current understanding of the anatomy and biomechanics of the shoulder. Proponents of incorporating the middle glenohumeral ligament (MGHL) in Bankart repair believe this technique could increase repair strength. The purpose of this biomechanical study was to compare the range of motion and humeral head kinematic changes that result from including the MGHL in a Bankart repair in an effort to identify possible changes in shoulder biomechanics as a result of this addition in surgical repair.

Six cadaveric shoulders were tested in 4 conditions: intact, Bankart lesion, repair excluding the MGHL, and repair including the MGHL. Each condition was tested for range of motion, glenohumeral translation, and humeral head apex position. Standard Bankart repair and repair with MGHL inclusion resulted in decreased range of motion, but no statistically significant difference was found between the 2 repair types \( (P = .846) \). Anterior translation was significantly reduced with both the Bankart repair \( (4.8 \pm 0.9; P = .049) \) and included MGHL repair \( (4.6 \pm 0.9; P = .029) \). No statistically significant difference was found between both repairs \( (P = .993) \). Although both repairs showed posterior displacement of the humeral head apex when in external rotation, this trend only reached statistical significance when compared with the Bankart lesion in 90° of external rotation \( (P = .0456) \); however, no significant difference was found between the 2 repairs \( (P = .999) \).

Inclusion or exclusion of the MGHL in a Bankart repair does not significantly affect the range of motion, translation, or kinematics of the glenohumeral joint.

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Figure 1: Arthroscopic photograph showing the middle glenohumeral ligament.

Figure 2: Photograph showing a custom testing apparatus that permits 6° of freedom for positioning the glenohumeral joint.
Surgical treatment of traumatic shoulder instability has progressed in tandem with the evolution of the current understanding of the anatomy and biomechanics of the shoulder. Early nonanatomic procedures, such as the Putti-Platt or Magnuson-Stack, excessively tightened the anterior portion of the shoulder. These procedures were successful in increasing stability; however, they resulted in loss of external rotation. These abnormal kinematics shifted the humeral head posteriorly, resulting in higher rates of glenohumeral arthritis.\(^6,^7\)

Open and arthroscopic capsulorrhaphy was developed in an effort to create a surgical labral repair that optimized stability without compromising normal shoulder kinematics.\(^7\) These more anatomic repair types have been highly successful in the treatment of anterior instability in the setting of a traumatic Bankart lesion.\(^6,^7\)

Unfortunately, despite improved clinical results, these procedures are not completely protective of the development of arthritis. In 1 study at 10-year follow-up, 39\% of patients undergoing arthroscopic Bankart repair demonstrated evidence of radiographic arthritis.\(^8\)

The inferior glenohumeral ligament is recognized as the primary stabilizer to anterior translation in a shoulder in the position most at risk for dislocation: 90° of abduction and external rotation. The repair of the inferior portion of the inferior glenohumeral ligament is critical to reduce anterior translation in a repaired Bankart lesion.\(^9\) The middle glenohumeral ligament (MGHL) is also important in resisting anterior translation of the humeral head. Although the MGHL has its greatest contribution to stability in lesser degrees of abduction, it still shows significant strain in 90° of abduction.\(^10\)

The MGHL is easily identifiable arthroscopically. The MGHL is often substantial, measuring up to 2 cm wide and 4 mm thick. Interestingly, several anatomic variants exist and are present between 13\% and 35\% of the time.\(^11,^12\) Most commonly, the MGHL originates from the labrum either separately or at the origin of the superior glenohumeral ligament.\(^13\)

In rarer cases, the MGHL can appear cord-like (9\%-17\%), with or without the presence of anterior-superior labral tissue present (Buford complex, 1\%-5.6\%).\(^14,^15\)

Proponents of incorporating the MGHL in Bankart repair believe this technique could increase repair strength. However, critics believe that MGHL inclusion could result in motion loss and altered shoulder kinematics.\(^8\) Both of these theories are currently unsubstantiated. Therefore, the objective of the current biomechanical study was to compare the range of motion (ROM), stability, and humeral head kinematic changes that result from including the MGHL in a Bankart repair in an effort to identify possible changes in shoulder biomechanics as a result of this modification in surgical repair.

**MATERIALS AND METHODS**

Six fresh cadaveric shoulder specimens were tested on a customized shoulder translation testing system. Average donor age was 61.0±6.6 years. Each glenohumeral joint was vented through the rotator interval and examined arthroscopically through the rotator interval portal to confirm the presence of an MGHL (Figure 1) and to ensure that the specimens had no significant arthritis or abnormal glenolabral anatomy. Specifically, any specimens that demonstrated a cord-like MGHL or Buford complex structural variant were excluded from the investigation.

Storage, preparation, and dissection were completed in accordance with a previously described technique.\(^16\) Muscles were dissected from the shoulder, leaving only the shoulder capsuloligamentous structure. The base of the scapula was trimmed so that it could fit in a custom aluminum box. This was secured with plaster of Paris so that the anterior-posterior and superior-inferior axes of the scapula were aligned with the top of the box. The humerus was trimmed 20 cm from the shoulder joint. This was then centered in a polyvinyl chloride pipe, and similarly potted with plaster of Paris.

Once potted, each specimen was mounted on custom shoulder testing apparatus that permitted 6\° of freedom for positioning the glenohumeral joint.

**Figure 1:** Arthroscopic photograph showing the middle glenohumeral ligament.

**Figure 2:** Photograph showing a custom testing apparatus that permits 6\° of freedom for positioning the glenohumeral joint.
height of the humerus on the glenoid to a neutral position. Glenohumeral abduction was set at 60°, simulating 90° of shoulder abduction. Once mounted, a 22-N compressive load was applied perpendicular to the glenoid using a weight hanging from a lever arm attached to the linear bearing underneath the scapular box.

Six screws were placed and used as reference markers to define 2 coordinate systems on the humerus and scapula. The 3 scapular markers were placed on the coracoid, anterior acromion, and posterior acromion, and the 3 humeral screws were placed proximal and distal along the posterior ridge of the bicipital groove and at a third location at a point posterior and between these anatomical spots. A MicroScribe 3DLX (Revware Inc, Raleigh, North Carolina) was used to record the 3-dimensional position of the scapula with respect to the glenoid.

Range of Motion

Rotational ROM was evaluated by applying rotational torque using a torque wrench attached to the distal end of the humeral cylinder. Each specimen was preconditioned in both internal and external rotation to 2.2 Nm of torque for 3 seconds for 10 cycles. Ninety degrees of external rotation was defined as the point that the bicipital groove was lined up with the anterior acromion. This reference was used because the epicondylar axis was not present after the midhumerus transection during specimen preparation. Maximum internal and external rotation was then tested at 2.2 Nm.

Glenohumeral Translation

Anterior, posterior, superior, and inferior translation were measured with the humerus locked in 90° of external rotation. Translational loads were applied by hanging loads of 10 and 15 N from cables that were attached to the translational plates and routed by using a pulley. A MicroScribe 3DLX was used to record the 3-dimensional position of the scapula with respect to the glenoid. Translational preconditioning was performed before testing by applying 10-N loads in alternating directions for a total of 10 cycles each. Translations were quantified by first measuring the position of the scapula with the humerus centered in the glenoid and then with the load applied in the direction being tested. After all of the directions were completed, a second trial was performed in each direction, and the mean of these trials was used in data analysis.

Humeral Head Apex Measurements

Through tracking of the 6 reference screws placed on the scapula and humerus, a MicroScribe was used to measure the humeral head location in reference to the glenoid at maximum internal rotation, 0°, 30°, 60°, 90°, and maximum external rotation. Two trials were repeated, and the mean of these trials was used in data analysis.

Bankart Lesion and Repair

After the intact specimen was subjected to biomechanical testing, the Bankart lesion was created as previously described.20 The lesion was created under direct arthroscopic visualization using a scalpel and elevator to detach the anterior labrum from the glenoid neck. The lesion was initiated above the MGHL and extended to the 6-o’clock position. Care was taken to dissect the labrum directly from the bone, elevating both the labrum and the capsule from the glenoid. Biomechanical testing was then performed.

Using arthroscopic visualization, 2 titanium Fastak II anchors (Arthrex, Naples, Florida) were placed at the 5:30-o’clock and 3:30-o’clock positions. Because this model had not undergone capsular stretching, care was taken to include minimal capsule when the suture was passed with a suture shuttling device (Arthrex). These sutures were tied using a sliding knot backed up with 3 half hitches. This construct was tested and on completion, and using similar suturing technique, a third anchor was placed in the 2-o’clock position. This corresponded with the anatomic labral attachment of the MGHL. This construct was then biomechanically tested.

After testing, the specimens were disarticulated and examined to ensure that none of the repairs had failed during testing. The disarticulated specimens were digitized to acquire geometric data of the glenoid and humerus in relation to the 6 reference markers. These were used to determine kinematic data.21

Data Analysis

Two trials were recorded for each data point. The average of the 2 trials was used to compare the 4 tested conditions: intact labrum, Bankart lesion, repair excluding MGHL, and repair including MGHL. A multivariate repeated measures analysis of variance with a Tukey post hoc test for individual comparisons was used for statistical analysis. The significance level was set a P value of .05.

RESULTS

Range of Motion

All motion examined significantly increased after the creation of a Bankart lesion (Figure 3). Compared with the in-

*P<.05 vs intact.`
tact specimen, the creation of a Bankart lesion resulted in increased total ROM (122.5° ± 8.7° vs 135.7° ± 8.9°, respectively; \( P < .00196 \)) and increased external rotation (128.3° ± 6.1° vs 132.8° ± 5.7°, respectively; \( P < .00229 \)). Both the isolated Bankart repair and MGHL inclusion repair decreased total ROM (132.8° ± 8.2° and 134.3° ± 8.3°, respectively); however, this was not statistically significant (\( P = .846 \)). Repair reduced external rotation to 132.5° ± 5.6° (isolated Bankart repair) and 132.8° ± 5.2° (included MGHL repair) (\( P = .987 \)).

### Glenohumeral Translation

Compared with the intact specimens, the Bankart lesion demonstrated significantly increased anterior translation, with a 15-N force (7.1° ± 1.2° vs 4.7° ± 0.8 mm, respectively; \( P = .043 \)) (Figure 4). Anterior translation was significantly reduced with isolated Bankart repair (4.8° ± 0.9 mm; \( P = .049 \)) and included MGHL repair (4.6° ± 0.9 mm; \( P = .029 \)). The reduction seen between both repair types was not statistically significant (\( P = .993 \)).

The 10 N force showed a similar trend with the intact specimen (3.2° ± 0.5°), and increased to 4.9° after the Bankart lesion was created. Superior, inferior, and posterior translation was not significantly affected by the creation of the Bankart lesion or either repair (Figures 4, 5).

### Humeral Head Apex Measurements

In 60° and 90° of external rotation, the specimens with Bankart lesions trended toward a more anterior shift of the humeral head apex. Both repairs showed a trend toward posterior displacement of the humeral head apex in external rotation (Figure 6) This was statistically significant compared with the Bankart lesion in 90° of external rotation (\( P = .0456 \)). No statistically significant difference was found between the 2 repairs (\( P = .999 \)). No significant difference was found in superior and inferior displacement of the humeral head apex (Figure 7).

### DISCUSSION

As expected, rotational ROM, glenohumeral translation, and humeral head position increased when the Bankart lesion was created. In this injury model, total ROM, external rotation, and anterior humeral translation increased, and the humeral head apex trended to a more anterior position.

All parameters decreased after isolated Bankart repair and with MGHL repair. Specifically, both repair techniques decreased ROM (Figure 2). No statistically significant difference was found between the amount of reduced motion between
either repair type \( (P=.993) \). Evaluation of the humeral head apex in reference to the glenoid throughout rotational ROM showed no difference between the repairs. This evidence suggests that the inclusion of the MGHL does not significantly restrict anterior translation, indicating that this type of repair may not overtighten the shoulder.

Shortening of the MGHL inherent with its inclusion into the Bankart repair did not affect shoulder ROM. This indicates that the MGHL ligament can tolerate a small amount of shortening without adversely affecting ROM. This appears to be unique to the MGHL because even 5 mm of shortening of the inferior glenohumeral ligament that occurs with capsular inclusion results in decreased ROM.\(^{4,22}\)

Prior biomechanical investigation has shown that, to recreate normal translation, an anchor must be placed in the anterior-inferior 5-o’clock position.\(^9\) Many studies have addressed how to maximize the strength of the Bankart repair. It is logical that the inclusion of additional, more robust tissue at this interface (the MGHL) may significantly strengthen surgical repairs.\(^{23,25}\)

Unfortunately, no research has explored the effect of this surgical technique.

The current study has several limitations. As with any cadaveric investigation, the age of the specimens may not reflect the age demographics of those who would undergo capsulorraphy surgery. The creation of a Bankart lesion might not actually reflect a true injury model. In addition, as is inherent with cadaveric studies, the effects of the healing remain unanswered, and the dynamic stabilizers for the shoulder could not be accounted for.

The position when testing translation was that of abduction-external rotation (90°/90°). This was chosen in an effort to recreate the position of clinical instability or apprehension. Although a position of less external rotation could be more useful for evaluating the MGHL in isolation, the authors’ goal was to evaluate the entire repair in the position of abduction external rotation because the inferior glenohumeral ligament was also included in the repair.

In addition, the technique used for Bankart repair used 2 or 3 anchors. This is likely biomechanically less strong than other repair techniques either using more anchors\(^{26}\) or additional rows of glenoid fixation.\(^{27}\) However, it is likely that constructs that incorporate higher numbers of anchors likely include the MGHL. Furthermore, the authors did not biomechanically test the failure strengths between both repair techniques. Although the authors presume that the inclusion of additional robust capsular material would improve construct strengths, they cannot confirm this assumption with their study.

The results from this study should only be applied to the model that was studied; conclusions should only be applied for normal MGHL anatomy in situations of traumatic instability. In an effort to exclude another possible variable, the authors did not include the capsule with the Bankart repairs. A simple labrum repair was performed, and the current results did not include capsular plication. Accordingly, the results should not be applied for multidirectional cases that rely on a component of capsular plication for more global capsular tightening.

**CONCLUSION**

The authors evaluated the kinematic effects of including the MGHL into a Bankart repair and found that including the MGHL had no significant effect on the ROM, anterior translation, or motion of the humeral head apex. The MGHL can be included during anterior instability repair with confidence, and without risk of negatively affecting shoulder biomechanics.

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