Arthroscopic Versus Open Rotator Interval Closure: Biomechanical Evaluation of Stability and Motion

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Purpose: The purposes of this study were to investigate the differences between open and arthroscopic closure of the rotator interval (RI) on glenohumeral translation and range of motion. We also sought to determine if the addition of either an open or arthroscopic RI closure increases stability of the shoulder. Methods: Fourteen fresh-frozen (10 paired) cadaveric shoulder specimens were mounted in a custom testing apparatus, and glenohumeral translation and rotation were obtained by using an optoelectric tracking system (Optotrak Certus; Northern Digital, Ontario, Canada). Specimens were randomly allocated to either open (n = 7) or arthroscopic (n = 7) plication of the RI. The following were measured first with an intact and vented specimen and subsequently after an RI closure using either open or arthroscopic techniques: (1) range of motion in neutral and 90° abduction; (2) anterior and posterior translation at neutral rotation; (3) anterior translation at 90° abduction with external rotation; and (4) posterior translation at 90° flexion with internal rotation. Results: Posterior stability was not improved from the intact state by either open (1.0-mm change) or arthroscopic (0.1-mm change) repair. The sulcus stability was improved in the open group (5.7 mm to 2.9 mm, P = .028), but not arthroscopically (5.1 to 4.1 mm, P = .499). Neutral anterior stability was improved after open repair (7.2 to 2.6 mm, P = .018), but not arthroscopically (2.3 to 2.4 mm, P = .5). However, anterior stability in external rotation (ER) at 90° abduction was improved in the arthroscopic repair group (5.5 to 3.1 mm, P = .006). The mean loss of ER in neutral was greater in the open group (40.8°) versus the arthroscopic group (24.4°, P = .0038). The arthroscopic group showed an 11.7° loss of ER in 90° abduction (P = .018) versus the open group loss of 4.8°. There were no significant differences in loss of IR in either neutral or 90° abduction. Conclusions: Posterior stability was not improved by either open or arthroscopic rotator interval repair, and sulcus stability only improved with the open technique. Anterior stability in neutral was improved after open repair and in the arthroscopic repair group with the arm abducted. There was a large loss of external rotation with both techniques. Clinical Relevance: This study suggests that arthroscopic RI closure adds little to the overall posterior and inferior stability of the shoulder joint, although anterior stability may be improved. There is a potentially large loss of external rotation after either repair method. Key Words: Rotator interval—Plication—Shoulder—Shoulder instability—Anterior instability—Posterior instability—Multidirectional instability.
The function of the rotator interval (RI) in the stability of the shoulder joint has long been disputed. Defined as the tissue between the supraspinatus and subscapularis tendons, the RI contains several anatomic structures, including the coracohumeral ligament (CHL), the superior glenohumeral ligament (SGHL), and the joint capsule. The RI has been shown to play a role in the stability of the glenohumeral joint. Many studies have assessed the influence of the RI and have shown decreased translation and rotation in various planes with open imbrication of this area. However, the majority of these studies has only investigated what happens to shoulder stability after open plication of the RI. The open rotator interval plication study performed by Harryman et al. is frequently quoted to justify the plication of tissue in this area in certain shoulder stabilization cases, including arthroscopic. In this study, Harryman et al. showed that imbrication of the CHL resulted in decreased inferior and posterior translation. It is important to point out that Harryman et al. performed an imbrication of the CHL in line with its fibers, in a medial-lateral direction.

With the advancement of arthroscopic shoulder surgery for the treatment of anterior, posterior, and multidirectional instability, many authors have advocated arthroscopic plication of the RI capsule as an adjunct to the stabilization procedure. Techniques differ, but most authors describe a closure of the RI by a cephalad shift of the middle glenohumeral ligament (MGHL) or subscapularis tendon to the SGHL. Some have even advocated a shift of the more robust tissue of the subscapularis to the supraspinatus. Although the arthroscopic RI closure may have similarities to the open RI imbrication as described by Harryman et al., one has to keep in mind that there are noteworthy differences. The fundamental difference is the direction of the plication. Open RI closure is generally in a medial-lateral shift, whereas arthroscopic closure is in an inferior-superior shift. In addition, arthroscopic RI closure involves a shift of the MGHL and, possibly, may not have any effect on the length or tension of the CHL. It may, therefore, not be appropriate to apply the results of biomechanical studies of open RI closure to an arthroscopic setting.

The purposes of our study were to investigate the changes in the glenohumeral restraint, translation, and rotation after arthroscopic rotator interval plication in a cadaveric model and to compare this with the open RI closure that has been previously described. The null hypotheses were as follows: (1) there is no difference in anterior, posterior, or inferior translation after RI repair; (2) there is no difference in glenohumeral external or internal rotation after RI repair; and (3) there are no differences in glenohumeral mechanics between the open RI closure versus the arthroscopic RI closure. We sought to replicate the original study by Harryman et al. and compare the results of the open RI closure with arthroscopic RI closure techniques to determine if stability of the glenohumeral joint could be improved with either approach.

METHODS

General Approach

Fourteen fresh-frozen (10 paired) cadaveric shoulders with an average age of 71.2 years (range, 40 to 98 years) were obtained from the anatomic bequest program (Mayo Foundation, Rochester, MN). The specimens were randomly assigned to either the open (7 total) or arthroscopic (7 total) RI repair group; the paired specimens were randomly allocated to either open or arthroscopic groups.

Specimen Preparation

Once thawed for 24 hours, the skin and superficial muscles around the midshaft of the humerus were removed to facilitate the attachment of the sutures to the rotator cuff for loading. The clavicle was cut at the distal one third of the shaft. The rotator cuff muscles were elevated from the bone and resected at the midportion of the muscle, and nylon strings were sutured in a Krakow configuration for even loading. Care was taken to keep the rotator cuff tendon and capsule intact for execution of the arthroscopic and open procedures and to ensure loading of the cuff musculature during the kinematic testing.

The shaft of the humerus was potted into a cylindrical aluminum vessel with polymethylmethacrylate. The orientation of the humeral shaft was determined on the basis of the location of the bicipital groove, which is directly anterior with the arm in 10° of external rotation. The scapula was rigidly mounted to a 4-mm-thickness Plexiglas sheet in such a manner that the medial margin of the scapula was in line with the vertical axis of the device.

At this point, each specimen underwent an arthroscopic evaluation via a 4-mm posterior portal to assess for presence of osteoarthritis and for any soft-tissue abnormalities (large rotator cuff tears), prior surgical scars, and full range of glenohumeral motion. Two specimens with medium-to-large rotator cuff tears were excluded. This process was repeated until 14
cadaveric specimens were available for testing. The posterior portal also served as a vent of the glenohumeral joint before mechanical testing.

All specimens that met inclusion criteria underwent a manual/maximum stretch to 40 N in the anterior and posterior directions after venting to ensure no plastic deformation of the capsular structures provided sufficient subluxation of the humeral head over the glenoid in all specimens.

**Shoulder-Testing Apparatus**

A custom shoulder-testing apparatus constructed of stainless steel and aluminum was used to assess glenohumeral kinematics (Fig 1). This apparatus allowed 6° of freedom of the glenohumeral joint. Fluoroscopy was then used to place the scapula so that the glenoid was in a neutral version position, using the adjustment of the apparatus for scapula rotation during the specimen setup. The apparatus allowed for positioning the humerus in flexion, abduction, and adduction around a static scapula and glenoid.

The scapular plane was defined as a vertical plane perpendicular to the glenoid surface, which was identified with a fluoroscope. Abduction was defined as motion in the scapula plane, and flexion was defined in the anatomic sagittal plane at an angle of 60° to the scapular plane. The angle for glenohumeral abduction and flexion was chosen at 60°, which corresponded to 90° global abduction and flexion. To load the glenohumeral joint, a total of 22-N glenohumeral joint compression force was applied through the rotator cuff muscles through a pulley system with weights attached via Krakow stitches to each of the cuff muscles (supraspinatus = 3.5 N, infraspinatus/teres minor = 9.1 N, and subscapularis = 9.4 N) on the basis of the muscle volume data.

**Range-of-Motion Testing**

Range of motion was recorded directly off a 360° protractor, which was mounted at the base of the freely rotating humeral-apparatus interface, calibrated in 1° increments. The neutral position was predetermined based on the transepicondylar axis, and the protractor was adjusted to where the zero position was in neutral. Range-of-motion data were recorded for the intact specimen. The range of motion of the humerus represented the maximum angle to which the humerus was rotated before meeting a resistance of 0.4 Nm, which was shown to provide maximal end range of motion without permanent deformation in pilot data. Each specimen was preconditioned before the measurements by moving the humerus through 3 full motions of the shoulder in the plane of interest. Two repeated rotation measurements were recorded, and the mean value was maintained as the final range of motion data point.

**Stability Testing**

Three custom optoelectric sensors, 48 mm in diameter and containing 3 infrared markers, were attached to the humerus via metal bone screws. A fourth sensor was mounted for static reference data on the scapular spine. Sensor data were acquired during dynamic loading of the specimen by using the Optotak Certus position sensor (Northern Digital, Ontario, Canada) and commercial software (MotionMonitor, Innovative Sports Training, Chicago, IL). The center of the shoul-
The glenohumeral joint was defined by using 3-dimensional sensor data while rotating the humerus centered in the glenoid by compression forces of the rotator cuff.Translations (in millimeters) of the humerus relative to the scapula at the joint center were obtained dynamically for each testing condition.

The translation of the glenohumeral joint was first obtained in the intact and vented specimen. An anterior, posterior, or inferior (sulcus) force was applied to displace the humerus relative to the rigidly mounted scapula. This force was administered through a consistent pull on a spring scale mounted through a direct in-line pulley system and loaded from 0 to 3.5 kg, which was precisely measured by using a custom force transducer, accurate to 0.01 kg after calibration.

The overall stability testing sequence was as follows: (1) sulcus at neutral rotation; (2) anterior and posterior translation at neutral rotation; (3) anterior translation at 60° glenohumeral abduction with 90° external rotation; and (4) posterior translation at 60° flexion with internal rotation. Measurements were repeated 2 times, and the mean value maintained as the final data point. Translation between the scapula and humerus at 15 N and 30 N of load was analyzed by using the load-displacement relationships.

A rotator interval repair was then performed by either open or arthroscopic techniques (see later) with the arm placed in 30° of external rotation, and both the rotation and translation testing sequences were repeated to determine the effect on glenohumeral kinematics after RI repair.

### RI Closures

**Open Closure:** An open RI closure was performed with the glenohumeral joint in 30° of external rotation and neutral abduction. The CHL was identified and fully outlined by using a permanent marker (Fig 2A) at a point approximately 1 cm lateral from the base of the coracoid (as determined by Harryman et al.). The CHL was sutured transversely, and the 2 ends were sutured together in a pants-over-vest fashion by using two No. 2 Ethibond sutures (Ethicon, Somerville, NJ) (Figs 2B and C).

**Arthroscopic Closure:** In neutral abduction and 30° external rotation, an arthroscopic RI closure was performed in a similar fashion to Gartsman et al. and Taverna et al. The RI repair was performed with a Spectrum crescent hook (Linvatec, Largo, FL), which plicated tissue directly adjacent to the supraspinatus tendon (SGHL) and a Bird-beak device (Arthrex, Naples, FL) through the MGHL. The SGHL and MGHL were imbricated with two No. 2 Ethibond sutures, one placed approximately 3 to 4 mm lateral to the glenoid edge (the medial-most rotator interval suture) and the lateral suture 12 to 15 mm lateral to the glenoid (Fig 2D). In all cases, the CHL was ensured to be included in the repair because it offered the most robust tissue in the RI, as well as consistency between the open and arthroscopic techniques.

### Statistical Analysis

With 7 specimens, the study had an 80% power to detect a difference in means between the open and arthroscopic groups with the given number of paired specimens and an 85% power to detect a difference in means within each group (eg, difference before and after RI repair in the arthroscopic group). The pre-RI versus post-RI closure data were compared by using a signed-rank test, and differences between the open and arthroscopic groups were compared with rank-sum tests, with the level of significance set at \( P < .05 \).

### RESULTS

Posterior glenohumeral translation was not improved by either open or arthroscopic RI closure, with less than a 1.0-mm decrease in neutral posterior translation after open RI closure and only a 0.4-mm decrease in neutral posterior translation after arthroscopic RI closure (Table 1). Additionally, there was no improvement in posterior translation with the arm flexed and internally rotated in either the open or arthroscopic group (Figs 3 and 4).

However, anterior stability was significantly improved in the neutral glenohumeral position after open RI closure (7.2 to 2.6 mm, \( P = .018 \) at 15 N; 12.4 to 4.5 mm, \( P = .001 \) at 30 N) but not in the abducted ER position (1.2 to 1.3 mm, \( P = .3105 \) at 15 N). In addition, RI closure significantly improved anterior stability in the abducted ER position (5.5 to 3.1 mm, \( P = .0425 \) at 15 N) and neutral positions (11.6 to 8.9 mm, \( P = .029 \) at 30 N). The mean sulcus stability was improved in both groups, but the open RI closure showed the most notable decrease (2.8 mm change after open RI closure vs 1.0 mm after arthroscopic, \( P = .028 \)).

The open RI closure improved anterior stability preferentially in the neutral position (12.4 to 4.5 mm, 30-N data) to a larger extent than arthroscopic closure (11.6 to 8.9 mm, 30-N data; \( P = .0021 \) between groups). Arthroscopic RI closure improved anterior stability to a larger extent in the abducted and ER
FIGURE 2. (A) The CHL is shown, originating at the base of the coracoid and inserting laterally on the humerus, outlined in ink (arrows). The CHL is made more visible with sulcus translation of the glenohumeral joint, placing the CHL under tension and isolating the structure as a consistent cord-like band of tissue. (B) Open RI closure as described by Harryman et al. An open repair of the RI is performed, and the CHL is imbricated by 1 cm (C) in the medial-to-lateral direction, with the arm in 30° of external rotation. (D) Arthroscopic RI repair is performed using two No. 2 nonabsorbable sutures (one medial and one lateral), with the arm in 30° of external rotation.
position (5.5 to 3.1 mm, \( P = .0163 \)) versus the open RI group in a similar position.

A large amount of external rotation loss occurred after both arthroscopic (mean 24.4° loss, \( P = .0116 \)) and open (mean 40.8° loss, \( P = .0118 \)) RI closure in the neutral glenohumeral position (Table 2). In addition, the open RI closure group showed a statistically larger loss of ER than the arthroscopic group in the neutral position (40.8° open vs 24.4° arthroscopic, \( P = .050 \)). The ROM data were also analyzed for percent change from the intact state, which showed similar statistical results. Abducted ER losses were less but still notable in the arthroscopic RI closure group (mean loss of 11.7°, \( P = .018 \)). The RI was not

### Table 1. Anterior, Posterior, and Sulcus Translations Before and After RI Closure

<table>
<thead>
<tr>
<th>Testing Condition</th>
<th>Glenohumeral Position</th>
<th>Type of RI Closure</th>
<th>Pre-RI Closure</th>
<th>Post-RI Closure</th>
<th>Total Change‡</th>
<th>( P ) Value*</th>
<th>Pre-RI Closure</th>
<th>Post-RI Closure</th>
<th>Total Change‡</th>
<th>( P ) Value*</th>
</tr>
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<td><strong>Posterior</strong></td>
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<tr>
<td>Translation</td>
<td>Neutral</td>
<td>Open</td>
<td>4.8 ± 1.9</td>
<td>3.8 ± 2.2</td>
<td>-1.0</td>
<td>0.8658</td>
<td>6.0 ± 2.1</td>
<td>7.8 ± 5.3</td>
<td>1.8</td>
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<td>Arthroscopic</td>
<td>4.4 ± 2.4</td>
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<td>0.7353</td>
<td>5.7 ± 2.1</td>
<td>5.8 ± 2.1</td>
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<td></td>
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<td>( P ) value§</td>
<td>.6547</td>
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<tr>
<td>Flexion and IR</td>
<td>Open</td>
<td>1.8 ± 0.9</td>
<td>1.9 ± 0.7</td>
<td>0.1</td>
<td>0.6002</td>
<td>2.5 ± 1.0</td>
<td>3.3 ± 1.3</td>
<td>0.8</td>
<td>.223</td>
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<td></td>
<td>Arthroscopic</td>
<td>2.0 ± 0.8</td>
<td>2.0 ± 0.5</td>
<td>0.0</td>
<td>0.499</td>
<td>3.1 ± 1.3</td>
<td>3.1 ± 1.5</td>
<td>0.0</td>
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<td>( P ) value§</td>
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<td>.661</td>
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<td><strong>Anterior</strong></td>
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<tr>
<td>Translation</td>
<td>Neutral</td>
<td>Open</td>
<td>7.2 ± 3.1</td>
<td>2.6 ± 2.1</td>
<td>-4.6</td>
<td>0.018†</td>
<td>12.4 ± 3.3</td>
<td>4.5 ± 3.7</td>
<td>-7.9</td>
<td>.001†</td>
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<td>Arthroscopic</td>
<td>2.3 ± 0.6</td>
<td>2.4 ± 0.5</td>
<td>0.1</td>
<td>0.233</td>
<td>11.6 ± 3.8</td>
<td>8.9 ± 3.1</td>
<td>-2.7</td>
<td>.029†</td>
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<td>( P ) value§</td>
<td>.0060†</td>
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<td>.0021†</td>
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<td>Abducted and ER</td>
<td>Open</td>
<td>1.2 ± 0.6</td>
<td>1.3 ± 0.7</td>
<td>0.1</td>
<td>0.3105</td>
<td>3.9 ± 2.8</td>
<td>4.4 ± 3.2</td>
<td>0.5</td>
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<tr>
<td></td>
<td>Arthroscopic</td>
<td>5.5 ± 2.0</td>
<td>3.1 ± 1.8</td>
<td>-2.4</td>
<td>0.0425†</td>
<td>6.5 ± 2.2</td>
<td>5.5 ± 2.4</td>
<td>-1.0</td>
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<td>( P ) value§</td>
<td>.0163†</td>
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<td><strong>Sulcus</strong></td>
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<tr>
<td>Translation</td>
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<td>5.7 ± 2.2</td>
<td>2.9 ± 2.1</td>
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<td>0.028†</td>
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<td>Arthroscopic</td>
<td>5.1 ± 2.8</td>
<td>4.1 ± 2.6</td>
<td>-1.0</td>
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</table>

NA, not applicable.

*\( P \) value signifying mean differences between pre-RI closure and post-RI closure translations (signed rank test).

†A significant result with \( P < .05 \).

‡Change is (pre-RI closure) – (post-RI closure) in millimeters. A negative result indicates decreased glenohumeral translation after RI closure, and a positive result indicates increased translation after RI closure.

§\( P \) value signifying mean differences between open and arthroscopic RI closure groups (rank-sum test).

![Figure 3](image-url) The magnitude of change in anterior (A) and posterior (B) translation after open RI repair. *\( P < .05 \).
affected in either group in both neutral and abducted shoulder positions (Fig 5).

**DISCUSSION**

The role of the RI in stability of the glenohumeral joint remains debatable. Although deficiency in the RI has been associated with multidirectional, anterior-inferior, and posterior instability, we sought to better define the role of RI closure in an arthroscopic setting.\(^7,8,16,17,19,24,28-32\) The elegant work by Harryman et al.\(^8\) showed that with a medial-to-lateral open imbrication of the RI, the glenohumeral joint showed a decreased inferior translation in the adducted shoulder and decreased posterior translation in flexion. Harryman et al. recommended an imbrication of the RI in shoulders unstable inferiorly in adduction or posteriorly in flexion. However, these findings are frequently quoted and applied to what should be performed in an arthroscopic setting. The problem with this extrapolation is the fact that Harryman et al. closed the RI in a medial-to-lateral direction that involves tissues that are distinct from an arthroscopic closure, which is generally in a superior-inferior direction.

In contrast to the findings of Harryman et al.,\(^8\) we found no significant difference in posterior stability.

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**TABLE 2. Range of Motion Data Before and After RI Closure**

<table>
<thead>
<tr>
<th>Testing Condition</th>
<th>Type of RI Closure</th>
<th>Pre-RI Closure</th>
<th>Mean Absolute Change (°)‡</th>
<th>Mean Percent Change§</th>
<th>P Value*</th>
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<td></td>
<td></td>
<td>SD</td>
<td>SD</td>
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<tr>
<td>Neutral ER</td>
<td>Open</td>
<td>68.1 17.7</td>
<td>27.3 12.6</td>
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<td>.0116†</td>
</tr>
<tr>
<td></td>
<td>Arthroscopic</td>
<td>77.0 15.7</td>
<td>52.6 13.7</td>
<td>-24.4 -31.1</td>
<td>.0180†</td>
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<tr>
<td></td>
<td></td>
<td>30.7 14.4</td>
<td>28.8 13.1</td>
<td>-1.9 -6.3</td>
<td>.1768</td>
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<tr>
<td></td>
<td>Arthroscopic</td>
<td>18.6 5.7</td>
<td>18.2 6.7</td>
<td>-0.4 -0.5</td>
<td>.9324</td>
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<tr>
<td>Abducted ER</td>
<td>Open</td>
<td>18.6 5.7</td>
<td>18.2 6.7</td>
<td>-0.4 -0.5</td>
<td>.9324</td>
</tr>
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<td>Arthroscopic</td>
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<td>91.4 10.8</td>
<td>-11.7 -10.1</td>
<td>.0180†</td>
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<td>14.9 9.9</td>
<td>12.9 7.5</td>
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<tr>
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<td>12.6 2.8</td>
<td>9.2 5.9</td>
<td>-3.4 -27.6</td>
<td>.1755</td>
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</tbody>
</table>

\(^1\) SD, standard deviation.

\(^2\) P value represents mean differences between post-RI closure and pre-RI closure within the group, either open or arthroscopic (signed rank test).

\(^3\) A significant result, with P < .05.

\(^4\) Mean absolute change: absolute mean difference in degrees (post-pre). A negative change is less ROM after RI closure.

\(^5\) Mean percent change: (post-pre)/pre × 100. A negative percent change is less ROM after RI closure.

\(^6\) P value represents mean differences between open and arthroscopic closure (rank-sum test).
after addition of the open RI closure. By using a similar technique, the RI was imbricated 1 cm in a medial-to-lateral direction, and we found that posterior stability was not improved with the arm in either a neutral or flexed internally rotated position. Additionally, the arthroscopic RI closure did not improve posterior translation in either arm position. Although not identical to the work by Harryman et al., we used a custom apparatus that was highly reproducible and did show some significant changes between the 2 groups. We used vectors and glenohumeral axes similar to those used by Harryman et al. to reproduce the study; however, our apparatus included an infrared tracking system that has been shown to be highly accurate, as well as the utilization of force transducers to better model the characteristics of glenohumeral translation over time. The only finding consistent between our study and that of Harryman et al. was a decrease in sulcus translation after open RI repair. Arthroscopic RI closure did not have a significant effect on the sulcus translation.

Of interest in our study was that anterior translation was statistically reduced in the neutral position after open RI repair. Anterior translation was also improved in the abducted and externally rotated position. Several authors have shown a decrease in anterior translation after cadaveric studies on RI repair or imbrication. The increase in anterior stability seen in the open RI closure group may be caused by the tensioning of the tissue in this area (CHL), which possesses greater stiffness and ultimate load than the SGHL. Also, the CHL imbrication effectively closes down the space of the RI, which may allow for an improved soft-tissue barrier for which the shoulder is prevented from subluxating anteriorly. The findings of improved anterior stability may have several explanations: (1) the position of the arm during the RI closure is in 30° of external rotation, and the RI structures (SGHL for example) are already taut in this position, allowing for the imbrication to have maximal effect in this position; (2) the MGHL and SGHL are able to function at an advantage in the ER and abducted position, allowing for an increase in anterior translation in this position, where the MGHL functions as an anterior stabilizer predominantly in the midrange of abduction and external rotation; and (3) the direction (inferior to superior) of RI tissue imbrication may play a role in the improved translation in the abducted externally rotated position, allowing for the MGHL and SGHL to be tensioned more efficiently nearly perpendicular to their vector of normal ligament function.

Figure 5. The magnitude of change in range of motion after open (A) and arthroscopic (B) RI repair.

Posterior stability was not improved by either method. Although in contrast to the method of Harryman et al., our open repair model, nonetheless, sought to replicate this experimental setup, definition of anatomic axes, and kinematic characteristics. Our apparatus included several improvements over Harryman’s initial setup including infrared sensors for sensitive translational measurements, a global axis coordinate system (to ensure joint centering in each testing condition), and a load-displacement transducer linked to the translation data. We also tested the shoulder in a position of forward flexion and internal rotation, in which posterior instability is most often clinically symptomatic, and we failed to find an improvement in stability after imbrication of the RI structures. This may be explained by the relative lack of tension in these structures in this position, and we are unable to
surgically impart enough tension in the RI area to make an improvement in posterior stability. The sulcus or inferior translation of the glenohumeral joint was improved after open RI closure but not arthroscopically. Our open RI closure findings are similar to what Harryman et al. found after shortening the CHL, with a decrease in inferior translation. We found approximately a 3-mm improvement in sulcus stability at 15 N in neutral rotation, consistent with the findings of Harryman et al. These findings are also consistent with Ovesen and Nielsen and Itoi et al. who showed that the anterosuperior capsule and CHL are important structures to prevent downward subluxation. In contrast, Warner et al. found that the SGHL was the primary restraint to inferior translation, and, in some cases, the MGHL also acts to prevent inferior subluxation. We do not believe that an arthroscopic RI closure reliably improves sulcus translation in our cadaveric model.

When contemplating closure of the RI, it should be kept in mind that plications of the shoulder capsule are not without consequence. Gerber et al. showed a significant decrease in external rotation in 0° abduction, with a mean ER loss of 30.1° after a 1-cm anterosuperior plication and a mean ER loss of 18.6° in 45° of abduction. We found a mean loss of 40.8° in neutral rotation but only a 4.8° loss in 60° of abduction, consistent with the results of Gerber et al. Our arthroscopic loss of ER in the neutral position was still 24.4° but decreased to 11.7° in 60° abduction. Van der Reis and Wolf found predictable but smaller ER losses after a similar arthroscopic plication of the RI (mean loss of 10° of ER). In addition, we found that the open RI closure showed more ER loss than the arthroscopic closure group. The anatomic orientation of the structures in the RI probably explains this finding because the contribution and strain of the CHL and SGHL are more pronounced in neutral rotation and exhibit greater restraint to rotation in this position.

Our study has several limitations. All of the findings were derived from a time-zero determination of glenohumeral kinematics and may not represent the actual clinical scenario of vascularized tissue that is generally more compliant. Nonetheless, we could show no improvement in posterior stabilization with either technique, under optimal testing and surgical conditions, which, historically, has not proven to incrementally improve on a temporal basis in the clinical setting. The mean cadaveric age was 71, and age-related changes to the capsule and glenohumeral stabilizing structures may be different versus younger specimens. In addition, it was unclear if these cadavers possessed any findings of clinical instability. We measured pure inferior, posterior, and anterior translation in a biomechanical setting; however, in a clinical setting, there is probably some overlap of these vectors.

CONCLUSIONS

Posterior stability of the shoulder was not improved after either open or arthroscopic repair of the RI. Anterior stability in neutral was improved primarily by open RI repair and in the abducted externally rotated position by arthroscopic RI repair. Both open and arthroscopic RI closure showed large losses of external rotation, especially in the neutral position. This study suggests that arthroscopic RI closure adds little to the overall posterior and inferior stability of the shoulder joint; however, anterior stability may be improved.

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