



Double-loaded suture anchors in the treatment of anteroinferior glenohumeral instability

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Hypothesis: The purpose of this study was to determine the clinical outcomes of arthroscopic labral repair for anteroinferior glenohumeral instability with the use of double-loaded suture anchors.

Methods: This study evaluated a series of consecutive patients treated after the senior author changed from single- to double-loaded suture anchors for the treatment of anteroinferior glenohumeral instability with a minimum follow-up period of 2 years. We collected the following outcomes at final follow-up: visual analog scale pain score, Simple Shoulder Test score, American Shoulder and Elbow Surgeons score, and instability recurrence data.

Results: A total of 41 consecutive patients underwent arthroscopic labral repair with double-loaded anchors, of whom 30 (71%) were able to be contacted at a minimum of 2 years postoperatively. These patients included 4 contact or collision athletes (13%). The patients had an average of 12 ± 13 prior dislocations over an average period of 56 ± 57 months preoperatively. Mean glenoid bone loss measured $16\% \pm 10\%$, and 67% (18 of 27 patients) had glenoid bone loss $\geq 13.5\%$. Intraoperatively, 3.2 ± 0.4 anchors were used. No posterior repairs or remplissage procedures were performed. At an average of 6.7 ± 2.7 years' follow-up, the visual analog scale pain score was 0.8 ± 1.4 ; Simple Shoulder Test score, 11 ± 2 ; and American Shoulder and Elbow Surgeons score, 90 ± 14 . Patients with bone loss $< 13.5\%$ had a 0% redislocation rate and 11% subluxation rate, whereas those with bone loss $\geq 13.5\%$ had a 6% reoperation rate, 22% redislocation rate, and 22% subluxation rate.

Conclusion: Arthroscopic labral repair with double-loaded anchors provides satisfactory clinical results at early to mid-term outcome assessment when glenoid bone loss is $< 13.5\%$.

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Surgical techniques and implants for arthroscopic labral repair have advanced, and as a result, recurrence rates for anterior glenohumeral instability may also have improved.^{6,9,21} One advancement in the field has been the availability of double-loaded anchors. Conceptually, the use of double-loaded anchors allows surgeons to increase the number of suture strands crossing the repair for each anchor placed, which could be especially helpful when limited osseous volume is available. In a glenoid labral repair, double-loaded anchors allow reinforcement of the labral repair²⁹ and have been shown to improve ultimate tensile load in a

cadaveric study.¹⁰ However, there is limited clinical evidence regarding recurrence and patient-reported outcomes after arthroscopic labral repair for anteroinferior glenohumeral instability using double-loaded anchors.¹¹

Thus, the purpose of this study was to report the clinical outcomes of arthroscopic labral repair for anteroinferior glenohumeral instability with the use of double-loaded suture anchors. We hypothesized that arthroscopic labral repair with double-loaded suture anchors would provide a low risk of postoperative instability recurrence.

Methods

Patient selection

This was a retrospective case series. The operative logs of the University of Utah were searched for all patients who underwent a surgical procedure between June 27, 2007, and December 30, 2016, with the use of Current Procedural Terminology code 29806 to capture all patients who underwent surgical treatment of glenohumeral

This study was performed with the approval of the University of Utah Institutional Review Board (protocol no. 46622). Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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instability by a single surgeon (R.Z.T.). The start date of the study period was selected as it was the date the surgeon (R.Z.T.) first began using double-loaded anchors. The end date of the study period was selected based on when patients would be eligible for 2-year follow-up at the commencement of our study. Patients were excluded if they had multidirectional or posterior instability or underwent prior ipsilateral shoulder surgery, concomitant posterior labral repair or remplissage, and/or repair with only single-loaded anchors.

Data collection

For patients who met the inclusion and exclusion criteria, we collected the following information via chart review: age, sex, body mass index, whether the patient had any preoperative advanced imaging, whether the patient was a contact or collision athlete, length of time from the initial dislocation to the surgical procedure, whether any concomitant biceps tenodesis or superior labral repair was performed, and number of anchors implanted.

On preoperative 3-dimensional imaging, an attending orthopedic surgeon with fellowship training in shoulder and elbow surgery measured the percentage of glenoid bone loss and determined whether the shoulder was considered on or off track. The percentage of glenoid bone loss was measured using linear measurements based on the best-fit circle method. Specifically, on the sagittal en face glenoid image, the glenoid width was measured as the diameter of the center of the best-fit circle.²³ On this same image, the glenoid defect width was measured as the distance from the anterior glenoid rim to the best-fit circle. The percentage of glenoid bone loss was defined as the glenoid defect width divided by the glenoid width multiplied by 100. We measured the width of the Hill-Sachs lesion as the distance from the posterior humeral articular surface to the rotator cuff attachment on the axial image where this distance was the greatest. If the glenoid width multiplied by 0.83 minus the glenoid defect width was greater than the Hill-Sachs lesion width, then the shoulder was considered on track. If not, it was considered off track. Glenoid and humeral measurements were made on computed tomography (CT) scans if available. Otherwise, they were made on magnetic resonance imaging (MRI) scans.^{7,14,17,25} All MRI scans were performed on a 1.5-T magnet, and all CT scans were performed at a 1-mm slice thickness. Regarding preoperative imaging, 90% of patients (27 of 30) had a preoperative advanced imaging study, with 37% (10 of 27) having both CT and MRI scans and 57% (17 of 27) having an MRI scan but not a CT scan. In the remaining 3 patients, preoperative scans were obtained but this imaging was performed outside of our institution and was not uploaded into the electronic medical record.

All patients were contacted via telephone for the purpose of this study to collect follow-up data. For each patient, the following outcome data were collected: visual analog scale (VAS) score for pain, Simple Shoulder Test (SST) score, and American Shoulder and Elbow Surgeons (ASES) score. We also asked the following instability-recurrence questions: (1) Since your instability repair surgery, have you had a full shoulder dislocation? If so, how many times? If so, was it self-reduced or reduced in an emergency department? (2) Since your instability repair surgery, do you ever feel your shoulder slips out of place? If so, how often? (This is used as the definition of subluxation in this article.) (3) Since your instability repair surgery, have you had any trauma associated with your shoulder? If yes, did the trauma contribute to any of the above symptoms? (4) Since your instability repair surgery, have you had any additional surgeries on your affected shoulder? If so, what procedure was performed?

Surgical technique

All procedures were performed with the patient in the lateral decubitus position with the arm in axial and abduction traction. All

surgical procedures were performed with 4 portals: high anterior (just anterior to the supraspinatus in the rotator cuff interval), low anterior (just superior to the subscapularis in the rotator cuff interval), 5-o'clock portal (through the subscapularis 1 cm inferior to the superior border), and posterior (2 cm medial and 2 cm inferior to the posterolateral corner of the acromion). The labrum was evaluated and confirmed not to have injury posterior to the 6-o'clock inferior position in any patient. If a concomitant superior labral tear was present, it was either repaired or left unrepaired, and an open subpectoral biceps tenodesis was performed. No superior labral tears extended beyond the 10-o'clock position (or 2-o'clock position for the opposite shoulder).

The scope was positioned in the high anterior portal, and the labrum was elevated off the anterior-medial glenoid neck inferior to the 6-o'clock position where the labral tear ended. Elevation was performed until the subscapularis muscle was visualized and the labrum "floated" up into a repair position adjacent to its original attachment (Fig. 1). An arthroscopic shaver and curette were used to remove all soft tissue off the anterior-medial neck of the glenoid. The curette was also used to remove 2 mm of cartilage along the anterior-medial rim of the glenoid, which would be the location for the anchors. A drill guide was placed percutaneously through the 5-o'clock portal. A double-loaded 3.0-mm Biocomposite SutureTak anchor (Arthrex, Naples, FL, USA) was placed at the 5:30 clock-face position anteriorly. A retrograde suture-shuttling device (Spectrum; ConMed, Utica, NY, USA) was used to shuttle both stitches through the capsule and around the labrum. Approximately 1-cm bites were taken adjacent to the labrum, and the stitches were passed at the 6-o'clock and 5:30 clock-face positions. Each suture was tied with a Duncan loop knot backed up with 3 half-hitches reversing directions and posts. A second anchor was placed at the 4:30 clock-face position with stitches passed at the 5-o'clock and 4:30 clock-face positions, and the last anchor was placed at the 3-o'clock position with stitches passed at the 4-o'clock and 3:30 clock-face positions (Fig. 2).

If an open biceps tenodesis was performed, the biceps tendon was cut and an open tenodesis was then performed as previously described.⁸ If a superior labral repair was performed, a port-of-Wilmington portal was created for the drill guide for the 3.0-mm Biocomposite SutureTak. The superior glenoid tubercle was débrided using a shaver through the high anterior portal. The drill guide placed through the port of Wilmington penetrated the

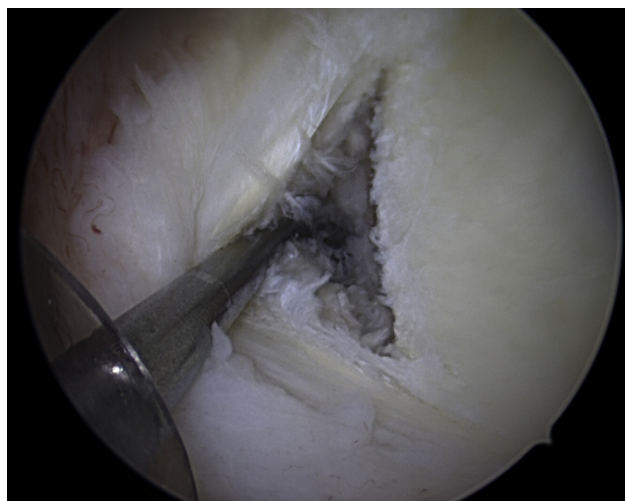


Figure 1 Arthroscopic image demonstrating an anteroinferior labral tear in a right shoulder during preparation using an elevator through the low anterior portal while viewing from the high anterior portal.

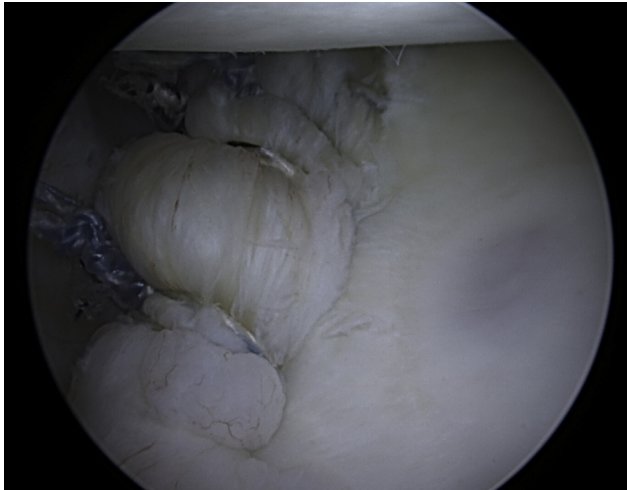


Figure 2 Arthroscopic image demonstrating the final repair with 3 double-loaded anchors between the 3- and 6-o'clock positions while viewing from the high anterior portal.

muscular portion of the rotator cuff. A single double-loaded anchor was positioned at the 11:30 clock-face position just posterior to the biceps insertion, and 2 stitches were shuttled using the suture-shuttling device, with the first stitch just posterior to the biceps anchor and a second stitch approximately 5 mm posterior to the first stitch. Both stitches were tied through the high anterior portal using a Duncan loop backed up with 3 half-hitches alternating directions and posts.

Postoperative rehabilitation

Postoperatively, patients were placed in a sling with an abduction pillow. At 2 weeks, patients started therapy including passive supine forward elevation in the scapular plane to 100° of elevation, pendulums, and active-assisted external rotation to neutral. At 4 weeks, patients were advanced to full passive supine forward elevation in the scapular plane. At 6 weeks, the sling was removed and patients were allowed to use the arm for daily activities, actively lifting up to 4.5 kg (10 lb) but avoiding abduction and external rotation. From 6 to 12 weeks postoperatively, stretching with therapy was allowed in all directions except abduction and external rotation. At 3 months postoperatively, patients were allowed full range of motion with active and passive stretching, and strengthening of the rotator cuff, deltoid, and scapular stabilizers was initiated. Patients were allowed to lift up to 11.5 kg (25 lb). At 4 months postoperatively, patients returned to all activities except contact sports and were allowed to lift up to 18 kg (40 lb). At 6 months postoperatively, patients were allowed unrestricted use and participation in contact sports.

Statistical analysis

We calculated and reported descriptive statistics. All analyses were conducted in Excel X (Microsoft, Redmond, WA, USA) and SPSS (version 25; IBM, Armonk, NY, USA). We performed a subgroup analysis of instability recurrence subdivided based on humeral- and glenoid-sided bone loss for the 27 of 30 patients with preoperative imaging. First, the cohort was divided into subgroups based on whether the shoulder was on track vs. off track. Second, the cohort was divided according to the amount of glenoid bone loss using the following groups: 0%-13.4%, 13.5%-20%, and >20%. These thresholds were selected a priori based on prior studies.^{5,24}

Results

Included patients

Through the application of our inclusion and exclusion criteria, we identified 41 patients, of whom 30 (73%) could be contacted at a minimum of 2 years postoperatively. Among the contacted patients, the mean follow-up period (± standard deviation) was 6.7 ± 2.7 years (range, 2-11.4 years). This group was composed of 63% male patients (19 of 30) and 13.3% contact or collision athletes (4 of 30). The mean age at the time of surgery was 30 ± 12 years (Table 1); mean body mass index, 26 ± 5; mean number of prior dislocations, 12 ± 13; and mean length of time from the first dislocation to surgery, 56 ± 58 months. On imaging studies (CT if available or MRI if CT was not available), glenoid bone loss measured 16% ± 10% (range, 0%-41%). Of the patients, 29% (8 of 27) had glenoid bone loss > 20% and 67% (18 of 27) had glenoid bone loss ≥ 13.5%. An off-track shoulder was observed in 48% (13 of 27). In combination, 52% of patients (14 of 27) had an off-track shoulder and/or glenoid bone loss > 20%. Only double-loaded anchors were used; no single-loaded anchors were used. Intraoperatively, 3 anchors were used for anterior labral repair in each case. In 3 cases, concomitant biceps tenodesis was performed; and in 1 case, concomitant superior labral repair was performed.

Postoperative outcomes

At final follow-up, the mean VAS pain score was 0.8 ± 1.4; mean SST score, 11 ± 2; and mean ASES score, 90 ± 14. Of the patients, 3% (1 of 30) underwent further surgery, 13% (4 of 30) had recurrent dislocation, and 20% (6 of 30) had recurrent subluxation. Recurrence

Table 1

Data for all included patients

Patient no.	Age, yr	Length of follow-up, yr	Contact sports	Postoperative SST score	Postoperative ASES score	Recurrent dislocation
1	20	5	No	12	NA	No
2	22	4	No	12	100	No
3	12	9	No	12	82	Yes
4	19	8	No	11	68	Yes
5	47	2	No	6	47	No
6	57	9	No	12	100	No
7	36	7	No	12	100	No
8	16	5	Yes	12	100	No
9	19	1	Yes	12	100	No
10	24	8	Yes	11	65	Yes
11	23	11	No	12	100	No
12	46	4	No	12	100	No
13	37	6	No	9	86.67	No
14	50	8	No	12	85	No
15	21	11	No	11	98	No
16	28	6	No	11	88.33	No
17	28	8	No	11	82	No
18	33	8	No	6	88	No
19	51	3	No	12	100	No
20	23	4	No	12	100	No
21	18	4	No	7	65	Yes
22	37	6	No	11	97	No
23	40	9	No	12	100	No
24	37	7	No	12	100	No
25	17	8	Yes	12	100	No
26	35	11	No	12	100	No
27	24	10	No	12	100	No
28	30	6	No	7	NA	No
29	24	6	No	12	98	No
30	26	5	No	9	82	No

SST, Simple Shoulder Test; ASES, American Shoulder and Elbow Surgeons; NA, not available.

of subluxations increased with glenoid bone loss (Table II). Among the patients without glenoid bone loss, no recurrent dislocations occurred, no reoperations were performed, and only 11% had recurrent subluxation. Among patients aged < 25 years, a 29% recurrence rate (4 of 14) was found. There were no complications other than recurrent instability, with no hardware problems, stiffness, nerve injuries, infections, or early osteoarthritis.

Discussion

In our study, arthroscopic labral repair with double-loaded suture anchors provided a low risk of reoperation or recurrent dislocations in the treatment of anteroinferior glenohumeral instability. However, recurrent instability (dislocations and subluxations) increased with glenoid bone loss $\geq 13.5\%$. In cases of bone loss < 13.5%, arthroscopic labral repair in isolation results in very low recurrent instability rates at mid-term follow-up, with a very low complication rate.

In this study, arthroscopic labral repair with double-loaded suture anchors provided a mean VAS pain score of 0.8 ± 1.4 , mean SST score of 11 ± 2 , and mean ASES score of 90 ± 14 . In the single prior case series specifically devoted to arthroscopic glenoid labral repair with double-loaded anchors for the treatment of glenohumeral instability, Kim et al¹¹ examined 45 patients with a minimum of 2 years' follow-up and reported a mean final ASES score of 96.9, which is similar to the result reported in our study. Similarly, mean final ASES scores of 87,¹ 92,¹² 89,¹³ and 88–90²⁰ and mean final SST scores of 11^{4,18,22} and 11–12¹⁹ have been reported previously with arthroscopic labral repair. Mean final VAS pain scores of 0.3,³ 1,⁴ 2,¹⁹ and 0–1²⁶ have been reported previously with arthroscopic labral repair. These prior results are similar to ours, suggesting that double-loaded anchors do not influence the already very good patient-reported outcomes after arthroscopic labral repair.

In our study, recurrence was dependent on the definition, as reoperations for recurrent instability were uncommon whereas recurrent subluxation was more common. Comparing recurrence rates with prior literature is challenging because studies differ in their definitions of recurrence between reoperation, dislocation, subluxation, and apprehension. Previously, Kim et al¹¹ reported an 8.8% recurrence rate. The recurrence rates describe by Kim compared favorably with prior literature on arthroscopic labral repair using single-loaded anchors, with reported recurrence rates of 17%,¹⁶ 23%,²⁷ 26%,² 29%,³ 44%,¹⁸ and 51%.²⁸ Recurrence rates are multifactorial and influenced by glenoid bone loss. The rates of recurrence from studies evaluating arthroscopic repair can be difficult to directly compare as the patient populations are unlikely to be similar with respect to glenoid bone loss, despite having similar repair constructs. In our study, only 40% of patients had bone loss < 13.5%.

Table II

Rates of reoperation, subsequent dislocation, and subsequent subluxation after arthroscopic rotator cuff repair with double-loaded anchors in treatment of recurrent anteroinferior glenohumeral instability

	n	Reoperation, %	Dislocation, %	Subluxation, %
Total cohort	30	3	13	20
Cohort with advanced imaging	27	4	15	19
Glenoid bone loss				
0%–13.4%	9	0	0	11
13.5%–20%	10	10	30	20
>20%	8	0	13	25
On track vs. off track				
On track	14	7	21	29
Off track	13	0	8	8

Double-loaded anchors offer several specific theoretical advantages. First, double-loaded anchors may increase the strength of the initial fixation by providing twice the fixation per number of anchors placed. This is especially helpful when a limited osseous area is available for anchor placement. It may allow an accelerated rehabilitation protocol, although we have not altered our rehabilitation protocol with the change to double-loaded anchors. Second, a double-loaded anchor allows the surgeon to separate the labral repair from the capsulorrhaphy, which may allow both a more secure labral repair and a more precisely tensioned capsulorrhaphy, although this technique was not used in our series. Third, a double-loaded anchor allows the first stitch to reduce a capsulolabral complex that has subluxated in an inferomedial manner, whereas the second stitch can subsequently reinforce the then-reduced repair, in a “provisional fixation–final fixation” combination similar to fracture repair. Fourth, double-loaded anchors allow the surgeon to place fewer anchors for the same number of capsulolabral points of fixation, which may reduce the risk of postage-stamp fractures. However, double-loaded anchors may require a larger pilot hole, which may mitigate this advantage. One disadvantage of double-loaded anchors is the increased demand on the surgeon for suture management to avoid tangling.

Glenoid bone loss has been shown to influence recurrence rates after arthroscopic instability repairs. Bone loss $\geq 13.5\%$ has been previously shown to lead to inferior clinical results after arthroscopic labral repair.²⁴ Our data support these findings by demonstrating that bone loss $\geq 13.5\%$ may influence recurrence rates. In our study, in patients with glenoid bone loss < 13.5%, there were no recurrent dislocations with mid-term follow-up, suggesting that isolated arthroscopic anterior labral repair is a good surgical option in these patients. However, of the patients with between 13.5% and 20% of bone loss,^{5,24} 30% had a recurrent dislocation with mid-term follow-up, suggesting that this subgroup of patients might benefit from alternative procedures to improve recurrence rates—either arthroscopic labral repair with associated remplissage, an open soft-tissue procedure, or anterior glenoid bone grafting. Arthroscopic labral repair with remplissage has previously been shown to be effective in providing low recurrence rates in patients with 13.5%–20% bone loss.¹⁵ On the basis of these prior data and our study results, our clinical practice is now to treat bone loss between 13.5% and 20% with anterior labral repair and remplissage or open Bankart repair depending on the presence of a Hill–Sachs lesion and its size. Patients with bone loss > 20% are treated with anterior glenoid bone grafting (distal tibial allograft or Latarjet procedure). Although our study did not show the on-track–off-track concept to be as useful as glenoid bone loss in predicting recurrence, it may have been underpowered to test this concept; moreover, it is our preference to treat off-track lesions with bone loss < 20% with arthroscopic labral repair with remplissage.

Limitations

This study has several limitations. First, this was a retrospective study conducted via telephone follow-up. Thus, physical examination data were not available. Second, our sample size was limited, which precluded us from performing any statistical subgroup analysis and increased study fragility. Third, the minimum length of follow-up was short-term, although our mean length of follow-up was mid-term. With longer-term follow-up, is it possible that the observed recurrence rate would increase. Fourth, this study did not include instability-specific outcome scores such as the Rowe or Western Ontario Shoulder Instability Index and instead only included shoulder-specific outcome scores. The inclusion of specific questions regarding subluxation and apprehension helped to mitigate this limitation. We also did not have preoperative outcome

scores. Fifth, our sample was heterogeneous and included patients with glenoid bone loss, as many of these cases were performed before it was commonplace knowledge that Latarjet or arthroscopic labral repair with remplissage may be preferable in these cases. The study also included patients with heterogeneous preoperative imaging. Sixth, no control group of single-loaded anchors was included, and thus, we can only compare our patients with historical controls. Seventh, the study took place over an extended period, and thus, some slight modifications in surgical technique may have occurred during the study period. Eighth, we did not include postoperative advanced imaging. Ninth, not all patients were able to be contacted for follow-up, which can create selection bias. Tenth, we excluded patients who underwent concomitant remplissage or posterior labral repair. These patients were excluded to create a homogeneous patient population with isolated anterior instability for analysis as both procedures may alter outcomes with arthroscopic anteroinferior labral repair.

Conclusion

Arthroscopic labral repair with double-loaded anchors provides satisfactory clinical results at early to mid-term outcome assessment when glenoid bone loss is <13.5%.

Disclaimer

Peter N. Chalmers is a paid consultant for Arthrex and DePuy-Mitek; is a paid speaker for DePuy; receives intellectual property royalties from DePuy; and serves on the editorial board of the *Journal of Shoulder and Elbow Surgery*.

Robert Z. Tashjian is a paid consultant for Zimmer/Biomet, Wright Medical, and DePuy-Mitek; owns stock in Conexions, Intrafuse, Genesis, and Kator; receives intellectual property royalties from Wright Medical, Shoulder Innovations, and Zimmer/Biomet; receives publishing royalties from Springer and the *Journal of Bone and Joint Surgery*; and serves on the editorial board of the *Journal of Shoulder and Elbow Arthroplasty* and the *Journal of the American Academy of Orthopaedic Surgeons*.

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