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Does previous arthroscopic Bankart repair influence coracoid graft osteolysis in Latarjet procedure? A case-control study with computed tomography scan data

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Background: The Latarjet procedure is commonly performed in the treatment of recurrent shoulder instability and is also indicated as a salvage procedure for recurrence after failed arthroscopic Bankart repair. Although this procedure has shown success, there has been an increased awareness of complications in recent studies, especially graft osteolysis. Most relevant research has focused on the pathophysiology, incidence, or location of graft osteolysis or the risk factors for graft osteolysis; however, the data are limited to primary Latarjet procedures. This study aimed to investigate the effect of previous arthroscopic Bankart repair surgery on coracoid bone graft osteolysis in the Latarjet procedure.
Methods: This retrospective case-control study analyzed data from patients who underwent primary Latarjet procedures or revision Latarjet procedures following failed arthroscopic Bankart repair. Clinical outcome measures included range of motion, the Subjective Shoulder Value, and the Rowe score. Volumetric analysis of each transferred coracoid graft was performed using early postoperative and late postoperative computed tomography scan data, and the amount of graft osteolysis was then calculated as the percentage of volume reduction of each graft.
Results: A total of 32 patients who met the inclusion criteria were included in this study, with 24 patients in the primary Latarjet group (group I) and 8 patients in the revision Latarjet group (group II). The mean age of the patients was 32.5 $\pm$ 7.7 years, and the mean follow-up duration was 52.1 $\pm$ 8.9 months. Both study groups showed significant improvement in the Subjective Shoulder Value compared with baseline ($P < .05$). Comparison of postoperative clinical outcome measures showed no significant difference in any outcome parameter between the 2 study groups ($P > .05$). No recurrence was observed during the follow-up period. A positive apprehension sign was present in 6 patients (25%) in group I and 4 patients (50%) in group II ($P > .05$). Analysis of radiologic data revealed that all patients underwent some degree of graft osteolysis, with varying osteolysis ratios between 12% and 98%. The mean osteolysis ratio of the coracoid graft was 67.3% $\pm$ 22.6% in group I and 69.4% $\pm$ 25.6% in group II, with no significant difference between the 2 groups ($P > .05$).
Conclusion: The findings of this study suggest that a considerable amount of coracoid graft osteolysis is observed after both primary Latarjet procedures and revision Latarjet procedures following failed arthroscopic Bankart repair. Previous arthroscopic Bankart repair

Institutional review board approval was obtained from Bezmialem Vakif University (no. E-45446446-020-110376), and written informed consent was obtained from all included patients before study initiation.

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did not seem to have a significant influence on the amount of graft osteolysis, and both primary and revision Latarjet procedures showed satisfactory clinical outcomes.

Level of evidence: Level III; Retrospective Cohort Comparison; Prognosis Study

Keywords: Latarjet procedure; graft osteolysis; arthroscopic Bankart repair; revision Latarjet procedure; recurrent shoulder instability; shoulder instability

The Latarjet procedure, which was first described in 1954,[19] involves transfer of the coracoid process and conjoined tendon to the anteroinferior portion of the glenoid for the treatment of anteroinferior shoulder instability. Previous studies have shown this procedure to be a reliable and successful method for the treatment of glenohumeral instability with low recurrence rates[5,20,22]; hence, it is recommended in cases with significant glenoid bone loss and a high risk of recurrence.[4,21] The Latarjet procedure is also indicated as a revision procedure for recurrent shoulder instability following failed arthroscopic Bankart repair because good functional outcomes, low recurrence and reoperation rates, and high return-to-sport rates have been previously reported.[9,14]

Owing to the extensive use of the Latarjet procedure in the treatment of shoulder instability, as well as the development of novel techniques and advancements in surgical devices, awareness of complications associated with the Latarjet procedure such as graft osteolysis, graft nonunion, graft malpositioning, or prominent hardware has increased.[3,6,7,16] In recent studies, much emphasis has especially been put on graft osteolysis, which may lead to recurrent instability, screw prominence, persistent pain, or stiffness; however, its impact on clinical outcomes is still unclear. Most relevant research has focused on the pathophysiology, incidence, location, and classification of coracoid bone graft osteolysis and/or its risk factors[2,10-12,17,18,28]; however, available data on this issue are limited. To our knowledge, graft osteolysis in patients undergoing the Latarjet procedure following failed arthroscopic Bankart repair has not been studied.

This study aimed to investigate the effect of previous arthroscopic Bankart repair surgery on coracoid bone graft osteolysis in revision Latarjet procedures. We hypothesized that coracoid bone graft would be prone to higher degrees of osteolysis in revision Latarjet procedures than in primary Latarjet procedures owing to impaired biology of the glenoid bone caused by previous Bankart repair surgery.

Materials and methods

Study design

This retrospective case-control study was conducted in a single tertiary university hospital clinic that is a referral center for shoulder disorders. The data of patients who underwent either primary Latarjet procedures with a diagnosis of recurrent anterior shoulder instability or revision Latarjet procedures following failed previous arthroscopic Bankart repair between September 2017 and March 2020 were used to conduct this study.

Patient selection

The records of patients who underwent the Latarjet procedure during the study period were reviewed. For primary cases, surgery was indicated in case of a history of recurrent anterior shoulder instability with a positive apprehension sign of the affected shoulder and the presence of glenoid bone loss > 20% on en face views of preoperative computed tomography (CT) scans. For revision cases, the decision for surgery was made in case of a history of multiple anterior shoulder dislocations following index arthroscopic Bankart repair surgery and the presence of apprehension of the affected shoulder. All indications for surgery were given by the senior author following clinical and radiologic evaluation of each patient.

The inclusion criteria were (1) the availability of a postoperative CT scan obtained immediately after surgery and a second postoperative CT scan obtained ≥12 months after surgery, (2) the availability of clinical follow-up data for >2 years, and (3) patients' agreement to participate. The exclusion criteria were (1) a history of surgery on the affected shoulder other than arthroscopic Bankart repair; (2) the presence of multidirectional shoulder instability, hyperlaxity, or voluntary instability; (3) the presence of concomitant rotator cuff lesions; (4) the presence of pre-existing glenohumeral osteoarthritis; and (5) a history of any neurologic or rheumatoid condition.

A total of 32 patients (30 male and 2 female patients) who met the inclusion criteria were included in this study. The mean age of the patients was 32.5 ± 7.7 years, and the mean follow-up duration was 52.1 ± 8.9 months. Patients who underwent primary Latarjet procedures for recurrent anterior shoulder instability constituted group I. Group II consisted of patients who underwent Latarjet procedures as revision surgery owing to recurrent anterior shoulder instability following previous failed arthroscopic Bankart repair.

Surgical technique

All interventions were performed by the senior author with patients positioned in the beach-chair position under general anesthesia. A sterile drape was folded and inserted under the shoulder along the medial border of the scapula to stabilize the scapula and facilitate the exposure. A 5- to 7-cm vertical skin incision was made starting from the coracoid process toward the axilla. After establishment of the medial and lateral subcutaneous flaps, exposure was further developed through the deltopectoral interval.

The coracoid process was then exposed. The pectoralis minor tendon was released from its attachment to the coracoid process.

The coracoacromial ligament was incised, with a 1-cm stump remaining attached to the coracoid process to be used for anterior capsular reconstruction in subsequent steps. Osteotomy of the coracoid process was performed using a curved osteotome in a medial-to-lateral direction. Then, the harvested coracoid graft was decorticated using a burr until smooth cancellous bone was obtained on the healing surface of the graft. Two 1.2-mm Kirschner wires were inserted into the graft from anterior to posterior, parallel to each other, to determine the locations for the screws. Then, screw holes were drilled through the Kirschner wires using a 2.7-mm cannulated drill bit.

The shoulder was externally rotated, and the subscapularis muscle was exposed until the lower margin marked by the "three sisters" vessels was seen. A subscapularis split was performed on the lower third of the muscle, and a vertical incision was made to the anterior capsule. A Fukuda retractor was inserted through the split, and the humeral head was retracted. Labral tissue and periosteum covering the anteroinferior glenoid rim and glenoid neck were excised. In case of a revision procedure, anchors that had been inserted during arthroscopic Bankart repair were removed. The glenoid neck was then decorticated using a curved osteotome until a bleeding cancellous bone surface was achieved to promote graft union. The inferior screw hole was established at the 5- or 7-o'clock position using a 2.7-mm drill bit, and the position of the coracoid graft was secured by inserting the inferior screw; the graft position was checked using a 4.0-mm titanium partially threaded screw. Then, the superior screw hole to the glenoid neck was established through the superior hole of the graft, and fixation of the graft was completed by inserting the superior screw. The remaining stump of the coracoacromial ligament was sutured to the anterior capsule using No. 2-0 Ethibond sutures (Ethicon, Somerville, NJ, USA).

Postoperative care

A standard postoperative rehabilitation protocol was performed by all patients. All patients were followed up by a single physiotherapist after discharge. Immobilization using a shoulder sling was performed for a duration of 6 weeks postoperatively. Active hand and wrist motion and passive elbow motion were allowed immediately after surgery. Passive shoulder range-of-motion (ROM) exercises were initiated at the sixth postoperative week. Rotator cuff and deltoid strengthening, periscapular stabilization, and proprioception exercises were allowed at the third postoperative month after the achievement of full shoulder ROM. Return to sports was allowed, depending on the recovery of each individual, after the sixth postoperative month.

Postoperative clinical follow-up and outcome measures

Postoperative clinical follow-up of all patients was performed by a single author (M.S.) at 2 weeks, 6 weeks, 12 weeks, 6 months, and 12 months after surgery, as well as yearly thereafter. Data from the final follow-up visit were used for the final analysis.

Postoperative clinical outcome measures included ROM, the Subjective Shoulder Value (SSV),[15] and the Rowe score.[25] The SSV was used as a preoperative clinical measure to compare postoperative outcomes with baseline status. ROM measurements were performed using a goniometer and included active abduction, forward flexion, external rotation at the side with the elbow at 90° of flexion, external rotation with the shoulder at 90° of abduction and the elbow at 90° of flexion, and internal rotation with the shoulder at 90° of abduction and the elbow at 90° of flexion.

The recurrence of instability after surgery was also noted. Recurrence was defined as a total dislocation or subluxation event. In addition, all patients were assessed for the apprehension sign postoperatively.

Radiologic evaluation of graft osteolysis

CT scans of all included patients were obtained immediately after surgery and at a minimum of the 12th postoperative month. The mean time to late postoperative CT scan control was 16.4 $\pm$ 3.2 months. All CT images were obtained using a 128-slice CT scanner (SOMATOM Definition AS; Siemens, Erlangen, Germany). The patients were instructed to perform free inspiration during the examination. Axial section images were acquired at 250 mA and 120 kV (peak) with a slice thickness of 1 mm. Sagittal and coronal images were then reconstructed at a thickness of 2 mm with 1-mm increments.

By use of early and late CT scan image data, volumetric analysis of the coracoid bone grafts was performed by a senior musculoskeletal radiologist who was blinded to the study data. Three-dimensional semiautomated quantitative assessment software (syngo.via) in the Siemens workstation was used to perform the volumetric analysis. The borders of the coracoid bone grafts were marked on axial images, and volumetric calculations in cubic centimeters were performed by the semiautomated software (Fig. 1). Volumetric data of each graft were obtained for both early postoperative ($V_{initial}$) and late postoperative (V_{final}) CT scan images. The amount of osteolysis was then calculated as a percentage using the following formula: $\frac{(Vinitial-Vfinal)}{Vinitial} \times 100$.

Statistical analysis

Mean, median, standard deviation, range, frequency, and percentage were the descriptive statistics used to analyze the study data. The Shapiro-Wilk test, the Kolmogorov-Smirnov test, and histograms were used to assess the normality of distribution of continuous variables. Comparisons between the 2 study groups were performed using the unpaired t test for normally distributed continuous variables and the Fisher exact test for categorical variables. Comparisons of continuous variables that were not normally distributed were performed using the Mann-Whitney U test. The paired-samples t test was used to perform intragroup comparisons for normally distributed data; the Wilcoxon signed rank test was performed otherwise. The level of significance was set at $P = .05$ for all analyses. GraphPad Prism software for Windows (version 9.3.0; GraphPad Software, San Diego, CA, USA) was used to perform all statistical analyses.

Results

There were 24 patients (22 male and 2 female patients) in group I and 8 patients (8 male and 0 female patients) in group II. The mean follow-up duration was 53.5 $\pm$ 9.9

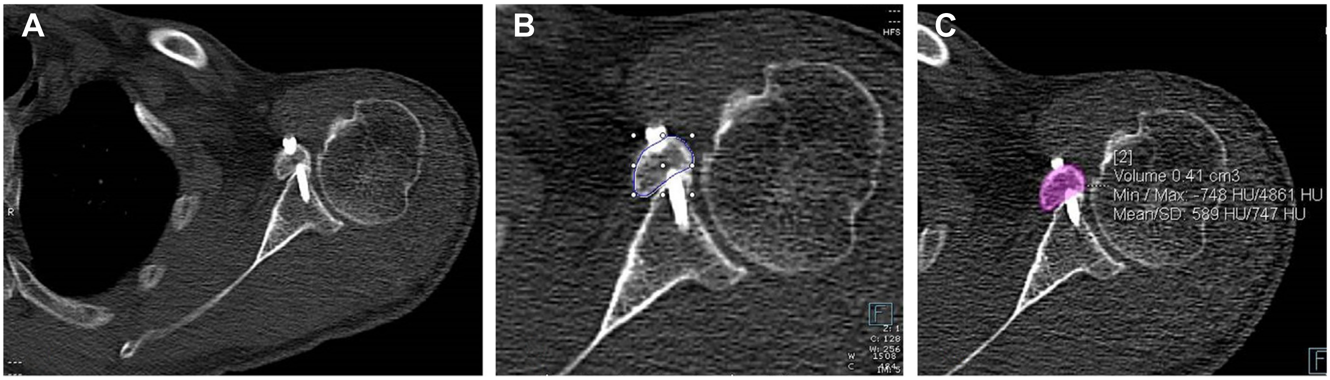

Figure 1 **(A)** Early postoperative axial computed tomography scan image showing transferred coracoid bone graft. **(B)** Marking of borders of coracoid graft on computed tomography scan image using 3-dimensional quantitative assessment software. **(C)** Volumetric calculation of coracoid graft. *Min*, minimum; *Max*, maximum; *SD*, standard deviation.

months in group I and 47.8 ± 2.4 months in group II. Demographic and preoperative clinical data of both study groups are presented in Table I. Comparison of the 2 study groups showed no significant difference in terms of preoperative demographic and clinical variables ($P > .05$).

The mean preoperative SSV and postoperative SSV were 33.5 ± 19.5 and 87.2 ± 11.3, respectively, in group I. In group II, the mean preoperative SSV and postoperative SSV were 39.4 ± 20.8 and 84.4 ± 10.2, respectively. Statistical analysis revealed that both study groups showed significant improvement in terms of the SSV compared with baseline ($P < .05$).

Comparison of postoperative clinical outcome measures revealed that both study groups had comparable clinical outcomes ($P > .05$). Postoperative clinical outcome data of the 2 study groups are presented in Table II. No recurrence was observed in any patient during the study period. A positive apprehension sign was present in 10 patients (6 of 24 patients [25%] in group I and 4 of 8 patients [50%] in group II). Both study groups were comparable in terms of the apprehension sign ($P = .22$).

In our series, all patients had some degree of osteolysis, with varying osteolysis ratios between 12% and 98%. Statistical analysis of the radiologic data revealed that the mean osteolysis ratio of the coracoid graft was 67.3% ± 22.6% in group I and 69.4% ± 25.6% in group II. No significant difference was observed between the 2 study groups regarding the ratio of the coracoid graft volume that underwent osteolysis ($P = .83$) (Fig. 2).

Discussion

This study has several important findings that should be underlined. First, coracoid bone grafts were observed to have lost nearly two-thirds of their volume owing to osteolysis at a mean of 16.4 ± 3.2 months after surgery. Second, previous arthroscopic Bankart repair did not seem to have a significant impact on the amount of osteolysis. Ratios of osteolysis were comparable between primary Latarjet procedures (67.3%) and revision Latarjet procedures following failed arthroscopic Bankart repair (69.4%). Third, both primary and revision Latarjet procedures showed satisfactory clinical outcomes, with no significant difference between the 2 groups.

Osteolysis of the transferred coracoid bone graft has been reported in previous studies.[1,8] However, Di Giacomo et al[11] were the first authors to study coracoid bone osteolysis using CT scan imaging to determine the incidence, amount, and location of bone resorption in the graft. They compared the radiologic data of CT scan examinations of 26 patients performed on the third postoperative day and at 17.5 months after surgery. Similarly to our results, they observed coracoid bone resorption of some degree in all patients, with a mean rate of graft osteolysis of 59.5%. They also reported that whereas the proximal-superficial region was the most involved portion of the graft, the distal-deep region was the least involved portion in osteolysis. The authors related these findings to the biological and biomechanical properties of bone healing. They postulated that the blood supply from the glenoid surface and conjoined tendon to the coracoid graft caused less involvement of osteolysis in the deep and distal regions of the graft. Another mechanism that has been attributed to their findings is the mechanotransduction and mechanical cues affecting bone remodeling at the bone healing site. Wolff's law states that bone remodeling depends on the loads affecting bone tissue and that bone will remodel to become stronger under loading. The authors indicated that bending forces from the conjoined tendon in the inferior portion of the graft and shearing forces by the humeral head in the lateral portion of the graft resulted in less osteolysis in these regions and more osteolysis in proximal-superficial regions. Similar results have been reported by other studies, supporting these findings.[17,28] In another study, Di Giacomo et al[12] compared the amount of graft osteolysis in patients with and without glenoid bone loss to reflect the impact of mechanical loads and bone remodeling on graft

Table I Preoperative demographic and clinical data of patients

Variable	Group I (primary) (n = 24)	Group II (revision) (n = 8)	*P* value
Sex			>.99*
Male	22 (91.7)	8 (100)	
Female	2 (8.3)	0 (0)	
Age, yr	33.0 ± 7.8	31.1 ± 7.8	.56†
Follow-up duration, mo	53.5 ± 9.9	47.8 ± 2.4	.12†
Postoperative late CT scan time, mo	16.5 ± 3.3	16.3 ± 3.0	.88†
BMI, kg/m^2	25.4 ± 3.8	25.7 ± 3.3	.85†
Tobacco use			>.99*
Yes	15 (62.5)	5 (62.5)	
No	9 (37.5)	3 (37.5)	
Preoperative SSV	33.5 ± 19.5	39.4 ± 20.8	.48†

CT, computed tomography; *BMI*, body mass index; *SSV*, Subjective Shoulder Value.
Data are reported as mean ± standard deviation or number (percentage).
* Fisher exact test.
† Unpaired *t* test.

Table II Postoperative clinical data of patients

Variable	Group I (primary) (n = 24)	Group II (revision) (n = 8)	*P* value
SSV	87.2 ± 11.3	84.4 ± 10.2	.43*
Rowe score	91.3 ± 9.0	86.3 ± 9.5	.19*
Abduction, °	160.8 ± 17.2	149.3 ± 19.8	.09*
Forward flexion, °	172.9 ± 13.3	170.4 ± 4.9	.07*
ER-1, °	44.2 ± 19.4	46.5 ± 9.9	.75†
ER-2, °	70.2 ± 16.5	67.9 ± 10.4	.48*
Internal rotation, °	68.1 ± 13.3	68.8 ± 8.1	.98*

SSV, Subjective Shoulder Value; *ER-1*, external rotation at side with elbow at 90° of flexion; *ER-2*, external rotation with shoulder at 90° of abduction and elbow at 90° of flexion.
Data are reported as mean ± standard deviation.
* Mann-Whitney *U* test.
† Unpaired *t* test.

osteolysis. They reported more osteolysis in patients without glenoid bone loss compared with patients with glenoid bone loss (65.1% vs. 39.6%). These findings confirm that coracoid grafts transferred in the Latarjet procedure undergo physiological remodeling rather than a pathologic osteolytic process according to Wolff's law, given that grafts are exposed to less mechanical stimuli by the humeral head and diminished mechanotransduction when there is no significant glenoid bone loss. A previous study by Kee et al[18] reported findings supporting this hypothesis. They compared the size of the glenoid bone surface on CT scan images obtained preoperatively and postoperatively at 7.7 and 31.7 months after surgery. Their results showed that the superior-superficial portion of the graft underwent the greatest amount of osteolysis, resulting in a shape and dimension of the glenoid surface analogous to the native glenoid. In addition, they indicated that there was no significant difference in the shape or size of the glenoid between 7.7 and 31.7 months postoperatively. They concluded that osteolysis of the graft following the Latarjet procedure is a physiological remodeling process in an attempt to obtain the shape and dimensions of the native glenoid and that this process is completed by the eighth month postoperatively.

The primary purpose of our study was to investigate the effect of previous arthroscopic Bankart repair on osteolysis of coracoid bone grafts. The Latarjet procedure has been recommended as a salvage procedure option for the recurrence of instability following failed arthroscopic Bankart repair.[14,23,26] The revision Latarjet procedure has been broadly studied in previous literature regarding clinical aspects. However, to our knowledge, there are no available data in the current literature on the survival of the transferred coracoid bone after revision Latarjet procedures. As previously mentioned, biological and biomechanical factors affecting bone healing and remodeling between the glenoid and coracoid bone graft determine the eventual amount of graft osteolysis. We hypothesized that owing to

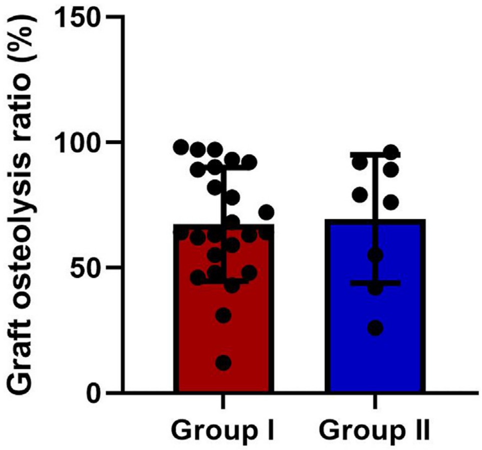

Figure 2 Mean ratios of graft osteolysis observed in group I (primary Latarjet procedure) and group II (revision Latarjet procedure after failed arthroscopic Bankart repair).

impaired biology and blood supply caused by previous arthroscopic Bankart repair and loss of bone tissue caused by anchors inserted in the glenoid, revision Latarjet procedures would be prone to higher degrees of osteolysis compared with primary Latarjet procedures. However, in contrast to our hypothesis, previous arthroscopic Bankart repair did not seem to have a significant effect on coracoid bone graft osteolysis. Both study groups showed comparable degrees of osteolysis similar to previous reports evaluating primary Latarjet procedures.[11,12,17,18,28] These findings confirm that survival of the coracoid bone graft is determined by biomechanical factors and osteolysis is a physiological bone remodeling process rather than a pathologic bone resorption process; moreover, our results show that similar graft survival might be achieved even in revision surgery with meticulous surgical technique.

Previous studies have shown that the Latarjet procedure could be a salvage option following failed Bankart repair; however, the reported results are conflicting owing to the different evaluation perspectives of these studies. Whereas some studies have favored the revision Latarjet procedure because of low recurrence and reoperation rates and high return-to-sport rates,[9,14,23,26] others have emphasized the higher complication rates and inferior functional outcomes of revision surgery compared with the primary Latarjet procedure.[13,24,27] In our study, both the primary and revision Latarjet procedure groups showed comparable clinical and functional outcomes, with significant functional improvement compared with baseline. No recurrent dislocation was observed in either group, and the apprehension rates were comparable (25% in group I vs. 50% in group II). However, we think that these results are insufficient to allow one to draw the conclusion that primary and revision Latarjet procedures are comparable in terms of clinical outcomes because of the low cohort size in this study for clinical comparison. Nonetheless, these findings reveal another question regarding the effect of coracoid bone block on final glenohumeral stability after the Latarjet procedure. In our series, coracoid bone grafts were observed to have lost nearly two-thirds of their volume, reaching a rate of up to 98% in some patients, without any recurrence of instability. This finding brings discussion about the importance of the bone block effect and suggests that stability would be maintained with other stabilizing components of this procedure (sling effect by the conjoined tendon and capsular effect by the coracoacromial ligament).

There are some limitations to this study that need to be mentioned. The principal limitations are the low patient number and the unequal numbers of patients between the 2 study groups. Given the rarity of the revision Latarjet procedure after failed arthroscopic Bankart repair, the revision group only consisted of 8 patients. However, the sample size of our study is comparable to that of previous reports that studied graft osteolysis using radiologic data.[10-12,17] Nonetheless, we think that this study lacks the power to compare primary and revision Latarjet procedures in terms of clinical outcomes. Another limitation that needs to be mentioned is the unavailability of preoperative clinical and radiologic data of patients. The only available preoperative clinical data of the patients were the SSV scores. It would have been possible to make a more precise comparison if other preoperative clinical data were available. Data on the degree of preoperative glenoid bone loss were also unavailable and could not be evaluated. This issue definitely decreases the impact of the study because glenoid bone loss is a major factor affecting the degree of coracoid graft osteolysis, as previously discussed. Another limitation is the retrospective nature of the study, which may have caused selection bias, and other unanticipated factors may have distorted the results. There is also a risk of evaluation bias that needs to be mentioned because all clinical evaluations were performed by a single author.

We think that this study also has some strengths that need to be mentioned. The study was conducted in a single center, and all interventions were performed by a single surgeon using the same standard technique. Moreover, this study has a relatively longer follow-up duration than previous reports, which allows the opportunity to assess midterm outcomes. In addition, this is the first study to assess coracoid bone graft osteolysis in Latarjet procedures that were performed after failed Bankart repair, and we think that this study makes a significantly valuable contribution to the existing knowledge. However, further research with higher-level evidence is still needed to clarify the reasons for graft osteolysis and its influence on clinical outcomes.

Conclusion

Coracoid bone graft undergoes a considerable amount of osteolysis following both primary and revision Latarjet procedures after failed arthroscopic Bankart repair, with an average volume reduction of nearly two-thirds of the native graft. Previous arthroscopic Bankart repair surgery does not seem to have a significant influence on the amount of graft osteolysis, without a significant difference compared with primary cases. The Latarjet procedure is safe and effective with low recurrence rates and satisfactory clinical outcomes in both primary and revision cases after failed arthroscopic Bankart repair surgery.

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