Coracoid graft osteolysis after the Latarjet procedure for anteroinferior shoulder instability: a computed tomography scan study of twenty-six patients

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\textbf{Background:} The Latarjet procedure has been advocated as an option for the treatment of anteroinferior shoulder instability in certain patients. However, progression of the transferred coracoid bone graft to osteolysis has been reported in the literature. We propose that the coracoid bone graft osteolysis could be one of the causes of failure of the Latarjet procedure.

\textbf{Materials and methods:} A computed tomography scan analysis was done of 26 patients prospectively followed-up after the Latarjet procedure to determine the location and the amount of the coracoid graft osteolysis.

\textbf{Results:} The most relevant osteolysis was represented by the superficial part of the proximal coracoid, whereas the distal region of the coracoid bone graft, especially in the deep portion, was the least involved in osteolysis and had the best bone healing.

\textbf{Discussion:} To our knowledge, this is the first study to quantify and localize coracoid osteolysis after Latarjet procedure for anteroinferior shoulder instability using CT scan analysis.

\textbf{Conclusion:} Our study suggests that the bone-block effect from the Latarjet procedure may not be the principal effect in its treatment of anteroinferior shoulder instability in patients without significant bony defects.

\textbf{Level of evidence:} Level IV, Prospective Case Series, Treatment Study.

\textbf{Keywords:} Shoulder; instability; Latarjet; coracoid; osteolysis; bone graft

The Latarjet procedure, which was described in 1958, uses coracoid process transfer to stabilize the shoulder by the static action of the transferred bone block and its attached common tendon sling. The glenoid bone graft prevents engagement of a humeral head bone lesion by extending the glenoid arch to such a degree that the shoulder cannot externally rotate far enough for the Hill-Sachs lesion to engage the front of the graft. Furthermore, transfer of the coracoid and conjoined tendon over the top of the lower subscapularis causes increased tension in the inferior fibers of the subscapularis, thus enhancing anterior stability, particularly in the position of abduction and external rotation (muscle effect).
An important factor contributing to the shoulder stability after a Latarjet procedure is the "sling effect" from the conjoined tendon, which slings across the anteroinferior capsule when the shoulder is in 90° abduction and full external rotation. This mechanism acts to prevent engagement of the Hill-Sachs lesion even before the anterior capsule is repaired. Nevertheless, the percentage with which these effects influence shoulder stabilization, at different degrees of abduction and external rotation, is still being debated.18-20,24

Coracoid graft transfers are often successful for anteroinferior shoulder stabilization, with an extremely low failure rate.5,6,12,14 However, progression of the transferred coracoid bone graft to osteolysis or fibrous union has been reported.1,7,10,11 This could be one of the causes of Latarjet procedure failure, documented as recurrent dislocation, subtle instability, pain, and stiffness.1,5,6,12,14,25

The aim of this study was to determine the location and the amount of coracoid graft osteolysis after the Latarjet procedure for anteroinferior shoulder instability by prospectively using computed tomography (CT) scan analysis. Potential correlations between radiologic findings and clinical failure were also assessed.

Materials and methods

The inclusion criteria for this study were recurrent anteroinferior dislocation, with or without ligamentous hyperlaxity. The exclusion criteria were concomitant rotator cuff lesion, previous surgery for recurrent anteroinferior dislocation, and multidirectional instability. High-risk sports and activities were not exclusion criteria. The Latarjet procedure was performed for patients with a score of more than 6 points (average, 8 points) according to The Instability Severity Index Score (ISIS) as described by Boileau.2 Patients with a score exceeding 6 points have a higher recurrence risk of anteroinferior shoulder instability and should be advised to have an open shoulder stabilization procedure.

From August 2007 to December 2008, we prospectively monitored 26 consecutive patients (19 males, 7 females) who had undergone the Latarjet procedure. The patients were a mean age 28.6 ± 12.5 years. There were 20 right shoulders and 6 left shoulders. The dominant side was treated in 21 patients (80.8%). All patients had more than one event of anteroinferior shoulder dislocation (average, 7.3 ± 6.3 dislocations): 16 (61.5%) had 2 to 5 dislocations, 7 (26.9%) had 6 to 15 dislocations, and 3 (11.5%) had more than 15 dislocations. Eighteen patients (69.2%) were involved in high-impact sports, including rugby, volleyball, water polo, and soccer.

All patients had positive results on preoperative apprehension and relocation tests, 8 (30.8%) had a positive Gagey test, and 7 (26.9%) had a positive sulcus sign. All the patients also had a standard range of motion, with a mean active forward elevation of 176.2° ± 4.1° and mean external rotation with the arm at the side of 48.8° ± 14.8°. Only 3 patients (11.5%) had an external rotation exceeding 85°. As quantified by the Pico method, 8 patients (30.8%) had glenoid bone loss,3 which averaged 18% (range, 15%-24%).

Preoperative plain x-ray studies were performed in anteroposterior, internal and external rotation, lateral, axillary, and Bernageau views. Preoperative CT scans were obtained for all patients to better evaluated the glenoid bone surface.3

Our surgical technique is performed using a local bone graft by the osteotomy of the terminal 2-cm of the coracoid process, detaching the insertion of the pectoralis minor tendon. The coracoid bone graft is decorticated in the inferior surface until cancellous bone is reached. The subscapularis tendon is split, and the coracoid bone graft is transplanted along with the conjoined tendon to the anteroinferior glenoid rim, which is decorticated to cancellous bone as well.15 The coracoid graft is positioned below the equator and no less than 2 mm from the glenoid cartilage. The coracoid is laid lengthwise and held in place with 2 partially threaded bicortical cannulated screws.

Figure 1 Diagram shows Latarjet procedure in the lateral view. The coracoid is laid lengthwise and held in place with 2 partially threaded bicortical cannulated screws.

Postoperative plain x-ray studies in anteroposterior and lateral views were used to evaluate the correct position of the bone graft and the screws. A CT scan evaluation with 3-dimensional reconstruction was performed 3 days after surgery to evaluate the
Coracoid bone graft. A latest generation 64-slice CT scanner (Siemens Somatom dual source scanner [Munich, Germany], 200 mA, 120 Kvp, and slice thickness of 1 mm) was used.

The coracoid bone graft was divided into 8 parts. The 2 major regions were superficial and deep, which in turn were each divided into proximal, distal, medial, and lateral (Fig. 2 and Fig. 3). The area of the middle portion over the superior screw (4 proximal parts) and under the inferior screw (4 distal parts) in the CT scan axial cut, of the 8 parts of the coracoid graft, was measured using a semiautomated edge detection module in Photoshop 7.0 (Adobe, San Jose, Calif), according to the method described by Puri et al and Whang et al. The glenoid apex was used as a reference point during CT scan evaluation after surgery to ensure a constant measurement during the follow-up CT scan assessment.

A second CT assessment with 3-dimensional reconstruction was done at a mean of 17.5 ± 6.7 months after the Latarjet procedure. Bone resorption studies have been reported in the literature after 3 months and 8 months.

X-ray imaging was not performed because it is not as accurate as the CT scan for the evaluation of the coracoid graft osteolysis. The same method as described above was used for the follow-up study. The area of the 8 parts of the coracoid bone graft was measured as described and compared with the previous measurements done at 3 days after the Latarjet surgery. All CT scan measurements were made by an independent radiologist who did not participate in the study.

At the follow-up examination, we determined the functional status, range of motion, and the stability of the treated shoulder by means of 2 functional scoring systems: the Rowe score and the Walch-Duplay score. Results of the Simple Shoulder Test (SST) were also obtained from all the patients.

Statistical analysis was performed by STATISTICA 6.0 software (StatSoft Inc, Tulsa, OK). Continuous data for the 26 patients are reported as mean and standard deviation. We considered the

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**Figure 2** Diagram shows how the 8 parts of the coracoid bone graft are partitioned in the right shoulder (frontal view).

**Figure 3** A computed tomography scan (axial view) shows the 4 proximal part of the coracoid bone graft. It is possible to see the osteolysis in the superficial and medial regions.
Results

The mean follow-up for the 26 patients treated with the Latarjet procedure was 17.5 ± 6.7 months. At the postoperative clinical examination, the mean active forward elevation was 174.9° ± 4.7° (average loss, 1.3°), and the mean external rotation with the arm at the side was 46.4° ± 13.5° (average loss, 2.4°).

According to the Rowe score, 18 patients (69.2%) had an excellent result (90 to 100 points), 6 (23.1%) had a good result (75 to 89 points), 2 (7.7%) had fair result (51 to 74 points), and no patient had a poor result (<50 points). According to the Walch Duplay score, 12 patients (46.1%) had an excellent result (90 to 100 points), 9 (34.6%) had a good result (75 to 90 points), 2 (7.7%) had a medium result (51 to 70 points), and 3 (11.5%) had a poor result (<50 points). The SST showed that 92.3% of the patients were satisfied after surgery, especially in daily activities as well as in work or sports. No failure, defined as recurrent dislocation, subtle instability, pain, or stiffness has been reported.

Using CT scan analysis, we were able to study the evolving progress of coracoid graft osteolysis in the described 8 parts of the coracoid graft. The most relevant mean osteolysis percentage was represented by the superficial and medial part of the proximal coracoid (93.4% ± 12.1%) and by the superficial and lateral part of the proximal coracoid (88.5% ± 17.8%). The parts with the least amount of osteolysis were the deep and lateral portion of the distal coracoid graft (37.5% ± 19.8%) and the deep and medial portion of the distal coracoid graft (36.2% ± 26.8%; Tables I and II). On average, 59.5% of the entire coracoid graft underwent osteolysis.

The ANOVA for repeated measures showed a significant effect both for the between variance ($F_{1,25} = 426.02; P < .01$) and for the within variance ($F_{7,175} = 26.86; P < .01$). The differences between the mean osteolysis percentages of the 8 parts are reported in Table III. In particular, the 2 proximal and superficial parts were significantly different in respect of every other part (Table III, rows 1 and 2; $P < .01$), but not between them (ie, prox/sup/lat vs prox/sup/med). In the opposite side, the 2 distal and deep parts were significantly different with respect to every proximal part (Table III, rows 7 and 8; $P < .01$). The last result could be extended to the dist/sup/lat part, if we used a wider significance level of $P < .09$, whereas the dist/sup/med part was only statistically different with respect to the 2 proximal and superficial parts as mentioned above.

Discussion

The Latarjet procedure has been advocated as an option for the treatment of anteroinferior shoulder instability in certain patients, but progression of the transferred coracoid bone graft to osteolysis or fibrous union has been reported.1,7,10,11 This could be one of the causes of Latarjet procedure failure, such as subtle instability or recurrent dislocation.1,5,6,12,14,25

To our knowledge, there are no studies that have used CT scan analysis to quantify coracoid osteolysis. Doursounian et al8 performed a CT scan analysis in 11 of 34 patients treated with the Bristow procedure to study the position of the coracoid graft and to evaluate the presence of pseudarthrosis. Cassagnaud et al7 performed a CT scan analysis in 80 of 106 patients treated with the Latarjet-Patte procedure to assess the position of the bone block and the presence of osteoarthritis.

Our study revealed the coracoid graft region most involved in osteolysis is the proximal and superficial zone. We can also assert that the distal region of the coracoid bone graft, especially in the deep portion, is the one least involved in osteolysis and with the best bone healing (Fig. 4).

We postulate that these results could be due to both biologic and biomechanical factors:

- a better bone contact between the coracoid bone graft and the glenoid bone bed on the lateral region because of the glenoid neck shape;
- a better blood supply from the glenoid bone surface to the deep region of coracoid bone graft, both of which are decorticated to cancellous bone;
- a better blood supply from the conjoined tendon to the distal part of the coracoid bone graft; and
- a better mechanotransduction at the bone-healing site (mechanisms by which mechanical cues modulate bone healing) in the inferior part (bending forces by the conjoined tendon) and in the lateral part (shearing forces by the humeral head) of the coracoid graft.4

To date, no classification for coracoid bone graft osteolysis has been described that illustrates how these different factors come into play.

The role of the bone block reported in the literature is quite controversial.11,18,22 Thomas et al19 say there is no difference between the Bristow procedure and the
conjoined tendon transfer alone in restoring anterior translation. Yamamoto et al.24 offer a contrary view, saying that the bone grafting is the main factor for the stabilizing mechanism in patients with glenoid osseous defects.

Our study suggests that the bone block effect from the Latarjet procedure may not be the principal effect of its treatment of anteroinferior shoulder instability because of the huge osteolysis that involves the coracoid bone graft (mean percentage, 59.5%). The coracoid bone graft osteolysis could also be the principal cause of bone graft breaking and Latarjet procedure failure. In this study, there was no patient with recurrent shoulder dislocation, subtle instability, pain, or stiffness after surgery despite the huge osteolysis that involves the coracoid bone graft. This reinforced the hypothesis that the coracoid bone graft is not the principal factor in the Latarjet procedure for anteroinferior shoulder stabilization.

This study has some limitations, however. First, it is difficult to understand if the radiologic findings indicate a real graft osteolysis or are just a remodeling process of the coracoid bone graft due to the forces transmitted from the conjoined tendon and the humeral head onto the bony graft (Wolff’s law). Second, because no failure has been reported, we are therefore not sure any correlation exists between the radiologic findings of coracoid osteolysis and clinical failure. The third limitation is the low number of patients recruited due to the high cost of the CT scan examination.

In conclusion, we believe this is the first study of prospective coracoid graft osteolysis after the Latarjet procedure.

### Table I

Descriptive percentage of osteolysis for the 8 parts of the coracoid process in the 26 patients

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Dis, distal; Lat, lateral; Med, medial; Prox, proximal; Sup, superficial.

### Table II

Descriptive statistic for the 8 parts of the coracoids process in the 26 patients

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Dis, distal; Lat, lateral; Med, medial; Prox, proximal; Sup, superficial.

* Mean represents the mean percentage of the reabsorption with the relative standard deviation (SD) and minimum and maximum observed value.
procedure to use CT scan analysis. Although the most relevant osteolysis was represented on the proximal part of the coracoid, osteolysis was also found on the distal part that should be considered the most important for the bone-block effect.

It is difficult to quantify the amount of inferior coracoid bone graft needed to improve the glenoid platform to ensure anteroinferior shoulder stability. Recurrent shoulder instability is influenced by the scapula position, the shoulder ligamentous hyperlaxity, and the bony defects. According to Yamamoto et al., the bony defects on the humeral head (Hill-Sachs lesion) and on the glenoid rim both need to be evaluated simultaneously; the more medial the Hill-Sachs lesion, the more frequent the possibility of engaging the glenoid bony defect (glenoid track concept). In this case, standard stabilization procedures (open or arthroscopic Bankart repair and capsular shift) are unlikely to restore the shoulder stability.

### Conclusion

This study suggests that the bone-block effect is an important factor in patients with significant bony defects but is not the main factor for shoulder stability in patients without significant bony defects. Further studies are needed to understand the process of coracoid graft osteolysis after the Latarjet procedure and ways to prevent and reduce this osteolysis process.

### Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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