Does the presence of glenoid bone loss influence coracoid bone graft osteolysis after the Latarjet procedure? A computed tomography scan study in 2 groups of patients with and without glenoid bone loss

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Background: Coracoid bone graft osteolysis and fibrous union are the principal causes of failure in patients treated with the Latarjet procedure. This study aims to investigate the hypothesis that coracoid bone graft osteolysis is more pronounced in cases without glenoid bone loss, which may be due to a diminished mechanotransduction effect at the bone healing site.

Methods: We prospectively followed up 34 patients, treated with a mini-plate Latarjet procedure, divided into 2 groups (group A patients had glenoid bone loss >15% and group B patients had no glenoid bone loss). A computed tomography scan evaluation with 3-dimensional reconstruction was then performed on all patients to evaluate coracoid bone graft osteolysis according to our coracoid bone graft osteolysis classification.

Results: The computed tomography scan analysis showed a different distribution of osteolysis between group A and group B. The statistical analysis showed a significant difference (P < .01, Bonferroni test) between groups A and B for the following sections: proximal/lateral/superficial, proximal/medial/deep, distal/lateral/superficial, and distal/lateral/deep. On average, the coracoid grafts in group A patients showed less osteolysis than the coracoid grafts in group B patients (39.6% vs 65.1%).

Discussion: The coracoid bone graft underwent much less osteolysis in patients with significant glenoid bone loss (>15%) than in those without it. Because factors of blood supply, compression, and surgical technique were the same for both groups, we believe that the mechanotransduction effect from the humeral head on the graft influences its remodeling.

Conclusion: The results of this study suggest that the bone graft part of the Latarjet procedure plays a role in patients with significant coracoid bone loss but much less so when there is no bone loss.

Approved by the Concordia Hospital Ethical Committee (study No. 2/2012).

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Coracoid bone graft osteolysis and fibrous nonunion are considered the principal causes of failure (recurrent dislocation, subtle instability, pain, and stiffness) in patients treated with the Latarjet procedure for anteroinferior shoulder instability.1,5-7,13-15,17,26

Osteolysis is influenced by biological and biomechanical factors. Biological factors include bone contact between the coracoid bone graft and the glenoid bone bed in the lateral region, influenced by the shape of the glenoid neck and the graft, as well as blood supply to the graft from the bleeding surface of the decorticated glenoid neck and coracoid graft and from the conjoined tendon to the distal part of the coracoid graft. Infection may also induce osteolysis. Biomechanical factors are related to stability at the bone contact area and mechanical cues that remodel bone. Wolff’s law states that bone in a healthy person or animal will adapt to the loads under which it is placed. If loading on a particular bone increases, the bone will remodel itself over time to become stronger to resist that sort of loading. The inverse is true as well: if the loading on a bone decreases, the bone will become weaker because of turnover, it is less metabolically costly to maintain, and there is no stimulus for continued remodeling that is required to maintain bone mass. In particular, the coracoid bone graft will be subjected to bending forces from the conjoined tendon in its inferior part and by shearing forces from the humeral head in its lateral part.7

With the aim of better understanding these factors, we have been quantifying and localizing osteolysis of coracoid bone grafts. An initial study showed that the superficial part of the proximal coracoid bone graft underwent the greatest amount of osteolysis.9 In a subsequent study, we tried to influence one of the biological factors by increasing contact and compression between the coracoid graft and the glenoid neck through the use of a wedged profile plate; however, this did not seem to reduce the amount of coracoid bone graft osteolysis.8

This study aims to investigate our hypothesis that coracoid bone graft osteolysis is more pronounced in cases without glenoid bone loss, which may be due to a diminished mechanotransduction effect at the bone healing site because the shearing forces of the humeral head would then be less on the more superficial and superior sections of the graft.

Materials and methods

The database for this study consisted of 191 patients who underwent the Latarjet procedure with a mini-plate fixation technique for anteroinferior dislocation with or without ligamentous hyperlaxity by the same surgeon (G.D.G.) from April 2009 to September 2012. The main criterion for the procedure was an instability severity index score of at least 6 points. Except for 4 patients who underwent surgery after their first dislocation, all patients had recurrent dislocations. The exclusion criteria were concomitant rotator cuff lesions, previous surgery for recurrent anteroinferior dislocation, and multidirectional instability. High-risk sports and activities were not exclusion criteria.

All patients were operated on by the same technique with the modified Latarjet procedure. The coracoid bone graft was laid lengthwise below the equator and no less than 2 mm from the glenoid cartilage. Both the neck and the graft were decorticated to bleeding cancellous bone. In our modification, fixation of the coracoid bone graft is performed with 2 bicortical cannulated screws that are partially threaded (diameter, 4 mm) through a custom-made mini-plate.8,9,16,18

All patients underwent preoperative computed tomography (CT) scans to quantify glenoid bone loss according to the Pico method.3 A CT scan evaluation with 3-dimensional reconstruction was then performed on all patients to evaluate the coracoid bone graft 3 days after surgery. On the basis of the CT scan, we prospectively included 25 patients with bone loss greater than 15% (group A) and 25 patients with no bone loss (group B) who consented to undergo another CT scan at a follow-up of greater than 1 year. The method for determining and statistically analyzing coracoid graft osteolysis was the same as that used in the previous studies.8,9

The postoperative and follow-up CT scans were performed on a latest-generation 64-slice Siemens Somatom dual-source scanner (200 mA, 120 kV [peak], and slice thickness of 1 mm) (Siemens, Erlangen, Germany). The graft was divided into 8 sections with the glenoid apex as a reference point to ensure reproducible measurements between both CT scans. The 8 sections were defined by 3 planes on an axial slice: (1) 2 regions, respectively, through the mid portion over the superior screw (4 proximal sections) and under the inferior screw (4 distal sections); (2) superficial and deep in relation to contact with the glenoid; and (3) medial and lateral (Fig. 1). All 8 sections were measured by use of a semiautomated edge detection module (Adobe Photoshop, version 7.0; Adobe Systems, San Jose, CA, USA), according to the method described by Puri et al20 and Whang et al.21 All CT scans measurements were performed by an independent radiologist not involved in the study.

Two independent groups were defined by the amount of glenoid bone loss, age, number of dislocations, and percentage of reabsorption of the 8 coracoid sections. To normalize the data expressed by the percentage, the values (v) were scaled into angular values (φ), from 0° to 90°, by the following formula: φ = arcsin √v. This trigonometric transformation causes magnification of the differences at the scale ends (around 0% and 100% of reabsorption). Because this transformation brings the variance

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of the graft showed low amounts of osteolysis, ranging from a mean of 24.4% (69.3%) to the superficial and medial sections of the proximal graft (24.1% to 6.3%). The remainder of the graft showed low amounts of osteolysis, ranging from a mean of 24.4% ± 10.4% to 30.8% ± 10.6% (Fig. 2).

In group B, the greatest amount of osteolysis occurred in the same sections but to a much greater extent, with 86.3% ± 5.1% in the superficial and medial sections of the proximal graft and 42.4% ± 7.6% in the deep and lateral sections of the proximal graft. All other sections of the graft showed osteolysis of at least 55.2% ± 6.6% (Fig. 3).

Discussion

The results of this study confirm that less osteolysis of a coracoid bone graft occurred when it was placed in a group of patients with significant glenoid bone loss (>15%) in comparison with a group of patients without glenoid bone loss.

Although osteolysis and fibrous union are well-known mechanisms of failure of the Latarjet procedure,1-5,7,10,13-15,17,26 studies on the causes of osteolysis are lacking. In a previous study, we observed a huge amount of osteolysis of the coracoid bone graft after the Latarjet procedure in 26 patients (mean, 59.5%).9

An initial hypothesis concerned insufficient contact between the coracoid graft and glenoid bone. Therefore, we developed a modified technique that aimed to improve this contact with increased compression by using a mini-plate. This did not improve the rates of osteolysis, however.8

In consequence, we wanted to investigate a second hypothesis. Bone remodeling is governed by Wolff’s law and mechanotransduction. In the shoulder, shearing forces and contact pressure from the humeral head on the glenoid are involved. Greis et al12 noted that a glenoid defect of 30% increases glenohumeral anteroinferior contact pressure by 300% to 400%. In a cadaveric study, Ghodadra et al11 showed that flush positioning of a coracoid graft, as part of the glenoid arc, optimally restored normal glenohumeral contact pressure and area. Moroder et al19 found anatomic graft remodeling in patients with significant preoperative glenoid bone loss who were treated with iliac crest bone grafting. Mechanotransduction, therefore, helps to maintain the graft in those areas that are subject to contact pressure and shear forces. The lack of mechanical stimuli in certain areas of the graft, in contrast, may contribute to osteopenia and bone resorption in these areas. We believe that this may result in osteolysis of the coracoid bone graft that would be more pronounced in patients without (significant) glenoid bone loss. In that case, a greater part of the graft would be superfluous and therefore lack impulses of mechanotransduction. In contrast, a larger part of the graft would be subject to maintaining forces when the coracoid bone graft replaces a large bone defect. Of course, other causes of osteolysis need to be excluded. In our 2 groups, infection was ruled out and factors affecting stability and positioning of the graft were identical for both groups.

In this study, the difference in bone reabsorption between groups was significant, with a mean rate for the entire graft of 39.6% in patients with greater than 15% glenoid bone loss (group A) versus 65.1% in patients without bone loss (group B). The highest amount of resorption occurred in the sections that were least subjected to mechanical forces from the humeral head and the tendon. These results support our hypothesis.

The results may also offer an explanation for some of the findings in the literature that question the role of the bone grafting.
block in regaining stability. Thomas et al reported that there is no difference between the Bristow procedure and the conjoined tendon transfer alone in restoring anterior translation. Yamamoto et al concluded that the coracoid bone graft is the main factor for the stabilizing mechanism in patients with glenoid osseous defects. Our previous studies, with and without the mini-plate, noted a significant amount of osteolysis of the coracoid bone graft but considered all patients regardless of the size of the glenoid bone defect addressed. This supports the idea that the bone block itself does not seem to be the principal factor for stabilization.

This study allows us to conclude that the bone block is important in restoring the osseous arc and therefore plays a role in cases with significant glenoid bone loss. In cases without significant bone loss, the graft undergoes so much osteolysis that the stabilizing effect of the Latarjet procedure must be due to other components of the technique (sling effect, capsular effect).

The principal limitations of this study are the low number of patients finally recruited, the number of dropouts from the original group, and the unequal numbers of patients in the 2 groups. With 25 patients in each group, we would have reached a power of greater than 80%. Several patients were reluctant to undergo another CT scan at final follow-up. This obviously decreases the power of the study, especially for those sections for which no significant

<table>
<thead>
<tr>
<th>Table I Patient characteristics</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone loss (mean (range))</td>
<td>16.9% (15%-25%)</td>
<td>None</td>
</tr>
<tr>
<td>Gender</td>
<td>12 men and 1 woman</td>
<td>17 men and 4 women</td>
</tr>
<tr>
<td>Age (mean years ± SD)</td>
<td>31.4 ± 3.6</td>
<td>31.9 ± 1.9</td>
</tr>
<tr>
<td>Side</td>
<td>5 right and 8 left</td>
<td>10 right and 11 left</td>
</tr>
<tr>
<td>Dominant side</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Professional in high-demand sports</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>No. of dislocations (mean number ± SD)</td>
<td>10.8 ± 2.8</td>
<td>6.4 ± 1.2</td>
</tr>
<tr>
<td>No. of patients with 1 dislocation preoperatively</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No. of patients with 2-5 dislocations preoperatively</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>No. of patients with 6-15 dislocations preoperatively</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>No. of patients with &gt;15 dislocations preoperatively</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table II Percentage of reabsorption</th>
<th>Group A (%)</th>
<th>Group B (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>54.4 ± 11.0</td>
<td>81.6 ± 5.7</td>
<td>.009</td>
</tr>
<tr>
<td>Medial</td>
<td>69.3 ± 9.6</td>
<td>86.3 ± 5.1</td>
<td>.065</td>
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<tr>
<td>Deep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>24.1 ± 6.3</td>
<td>42.4 ± 7.6</td>
<td>.065</td>
</tr>
<tr>
<td>Medial</td>
<td>27.4 ± 6.5</td>
<td>57.9 ± 7.8</td>
<td>.007</td>
</tr>
<tr>
<td>Distal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>26.4 ± 10.4</td>
<td>55.2 ± 6.6</td>
<td>.007</td>
</tr>
<tr>
<td>Medial</td>
<td>42.4 ± 8.1</td>
<td>62.3 ± 6.8</td>
<td>.054</td>
</tr>
<tr>
<td>Deep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>30.8 ± 10.6</td>
<td>62.8 ± 5.7</td>
<td>.007</td>
</tr>
<tr>
<td>Medial</td>
<td>42.4 ± 9.2</td>
<td>65.9 ± 6.8</td>
<td>.030</td>
</tr>
</tbody>
</table>

Data are presented as mean ± standard error.
difference was observed. Another limitation is the follow-up of less than 2 years because osteolysis may further increase with time. We intend to perform another evaluation with longer-term follow-up.

Conclusion

Bone grafts at the glenoid neck undergo remodeling according to Wolff’s law. The graft undergoes limited remodeling and has a much higher incidence of osteolysis in cases with a large glenoid bone defect (>15%) than in patients with lesser glenoid bone defects. In patients without glenoid bone loss, we hypothesize that a lack of mechanotransduction leads to major reabsorption and increased osteolysis of the coracoid bone graft.

Disclaimer

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References


