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Coracoid osteotomy approach for open free bone grafting of anterior glenoid defects

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The utilization of free bone grafts to reconstruct large anterior glenoid defects has increased. Distal tibia allograft is commonly used due to its lack of donor site morbidity, ability to restore large bony defects, and near anatomic osteoarticular restoration. However, the intact coracoid and conjoint tendon often impair adequate visualization and access to perform an anatomic reconstruction during open free bone graft reconstruction and often requires violation of the subscapularis tendon to gain exposure. We present a surgical technique wherein we perform a coracoid osteotomy and subsequent repair to improve visualization when performing an open free glenoid bone graft in the setting when a patient has not undergone a prior coracoid transfer that does not require violation of the subscapularis tendon. This technique demonstrates excellent functional outcomes as well as radiographic healing of the coracoid osteotomy without pain or prominent hardware at the coracoid.

The management of attritional bone loss in the setting of recurrent anterior glenohumeral instability has developed increasing attention given the complexity of osseous defects and reconstructive options.[3] While various bone-grafting procedures have been developed to reconstruct large anterior glenoid bony defects, the utilization of a fresh distal tibia allograft (DTA) has recently gained popularity due to its ability to anatomically restore the osseous and cartilaginous components of the anterior glenoid.[6,9-11]

Despite a growing body of literature supporting its use, adequate techniques in preparing and fixing the graft are critical to the success of the operation. In our experience, when performing an open DTA reconstruction in patients who have not had a prior Latarjet procedure, the exposure to obtain adequate visualization as well as the ability to drill screws parallel to the glenoid face has been challenging due to obstruction from the conjoint tendon and coracoid process. As a result of limited exposure, the surgical approach for these reconstructions often necessitates a violation of the subscapularis tendon through a tenotomy instead of using a muscle splitting approach. Even in the setting of a subscapularis takedown approach, exposure of the anterior glenoid can still be challenging, especially to gain the appropriate trajectory for screws fixating glenoid bone grafts. Given these concerns, we have utilized a small coracoid osteotomy to obtain adequate exposure to the glenoid face, which is repaired at the conclusion of the procedure. Since utilizing this technique, we have been satisfied with the exposure obtained at the time of surgery, the ability to perform a free bone graft reconstruction anatomically, the strength of coracoid osteotomy fixation, the limited morbidity to the subscapularis tendon, as well as postoperative outcomes. As such, the purpose of this report is to describe our coracoid osteotomy technique and repair construct that is utilized during an open free bone graft reconstruction of anterior glenoid defects.

Methods

This was a retrospective case series of 4 patients who underwent open fresh distal tibial allograft glenoid reconstruction for recurrent anterior instability with significant glenoid deficiency

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with a coracoid osteotomy by a single surgeon (R.Z.T.). This study was performed in accordance with institutional review board approval. All patients underwent preoperative computed tomography (CT) and magnetic resonance imaging scans for preoperative planning. Preoperative CT scans were analyzed for bone loss according to the diameter method described by Hamamoto et al.[7] The medical record was queried for patient demographic, physical examination, patient-reported outcome, and surgical information. Preoperative scapular plane forward elevation and external rotation at the side was measured using a goniometer and recorded by the primary surgeon. Patients were administered American Shoulder and Elbow Surgeons (ASES) score and simple shoulder test (SST) questionnaires preoperatively. Patients were contacted for follow-up CT scans, range of motion measurements, and outcome questionnaires, which were performed by experienced research personnel at a minimum of 2 years postoperatively. To measure the range of motion postoperatively, research personnel recorded digital videos of research subjects performing active abduction, scapular plane forward elevation and external rotation at the side, as described previously.[4] Videos were then analyzed using a digital, on-screen protractor. Postoperative CT scans were assessed for complete bony union of both the coracoid osteotomy and distal tibial allograft, and screw angle in relationship to the face of the glenoid (alpha angle), as previously described.[13] Patients were administered ASES score and SST questionnaires at the time of postoperative CT scan.

Statistical analysis

Descriptive statistics were calculated. All data analyses were conducted using Excel 16 (Microsoft Corp., Redmond, WA, USA).

Surgical technique

Approach or osteotomy

General anesthesia is induced and neuromonitoring is initiated due to the proximity of the brachial plexus as well as planned manipulation of the conjoint tendon or coracoid. The patient is placed in the beach chair position with an arm positioner. A narrated video of the surgical technique can be found in video 1. A 12 to 14-cm incision is made along the deltopectoral interval to the superior aspect of the axillary fold. The cephalic vein is taken laterally with the deltoid, and a deltoid retractor is placed. Care is taken to identify and protect the axillary nerve. The arm is then placed in abduction and external rotation and a glenoid rim retractor is placed superior to the coracoid. The coracoid osteotomy is begun using an oscillating saw of 5 mm from the tip of the coracoid angled slightly medial to lateral. The osteotomy is then completed using a straight osteotome. The conjoint tendon muscles are subsequently dissected distally then retracted medially. At this point, the subscapularis is split, a capsulotomy is performed, and the DTA is placed.

Coracoid osteotomy repair

Two drill holes are made in the coracoid tip (one medial and one lateral), starting at the cut surface aiming distal and exiting dorsally (Fig. 1). A #5 nonabsorbable suture is passed through the lateral hole and run in a Krakow fashion distally along the conjoint tendon (approximately 2 cm), passed across the conjoint tendon, run back up proximally, and passed through the medial drill hole. The same technique is then performed using a #2 nonabsorbable suture. A second #2 nonabsorbable suture is then passed transversely across the bone-tendon interface of the coracoid tip. This stitch will act as a tension band stitch and will pass over the dorsal aspect of the coracoid bone fragment attached to the conjoint tendon (Fig. 2).

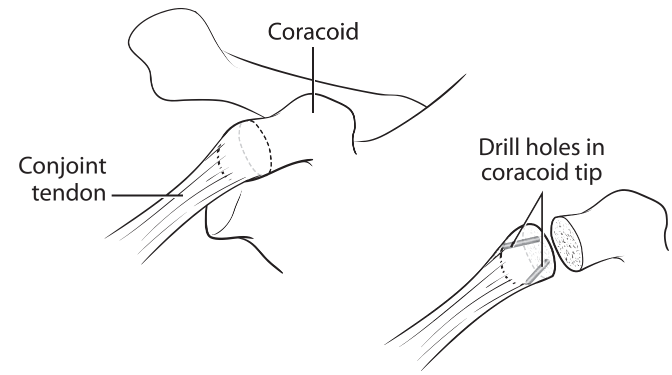

Figure 1 5 mm of the tip of the coracoid is resected, and bone tunnels are drilled from the cut surface exiting dorsal to the tendon insertion on the coracoid tip.

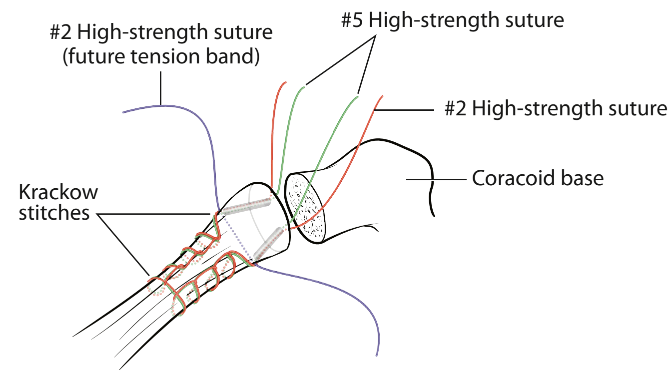

Figure 2 One # 5 high-strength suture (*green*) and one #2 high-strength suture (*red*) is passed from the cut surface through the bone tunnels, with each passed in a Krackow fashion. One # 2 high-strength suture is passed at the bone tendon junction of the osteotomy fragment (*blue*).

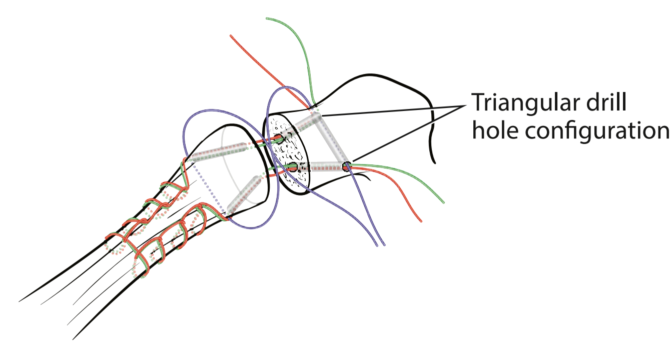

Figure 3 Three drill holes are created in the base of the coracoid with two starting on the cut surface and exiting either medial or laterally with a third drilled from medial to lateral transversely at the base of the coracoid. The Krackow suture tails are passed through the cut surface tunnels with one tail entering each tunnel. The tension band stitch (*blue*) is crossed dorsally over the coracoid fragment with one tail passed medial to lateral through the transverse tunnel.

Attention is then moved to the coracoid base, where a drill hole is made from lateral to medial across the coracoid base. A passing stitch is then placed through this hole for later use. Two additional drill holes are then made, starting at the center of the cut surface of the coracoid base. One drill hole exits at the medial point of the transverse drill hole, and the second drill hole exits at the most lateral aspect of the transverse drill hole. Passing stitches are placed from the cut surface out the medial and lateral coracoid base drill holes. The three drill holes in the coracoid base make a triangle configuration (Fig. 3). The two sutures exiting the medial aspect of the coracoid tip (one strand each of #2 and #5 nonabsorbable suture, which were run in Krakow fashion) are passed through the cut surface of the coracoid base and out the medial coracoid base drill hole using the previously placed passing stitch. The two sutures exiting out the lateral aspect of the cut surface of the coracoid tip are then passed similarly through the cut surface of the coracoid base and then out the lateral coracoid base drill hole using the corresponding previously placed passing stitch. Finally, the lateral tail of the tension band stitch is then passed from medial to lateral through the transverse tunnel, creating a cruciform pattern of the tension band stitch (Fig. 2). The osteotomy is then reduced, and the two ends of the #5 suture are tied across the bone bridge of the coracoid. The same is then performed for the #2 suture ends that were passed through the cut surface of the coracoid. Lastly, the tension band #2 stitch is tied, completing the repair (Fig. 4).

Postoperative care

The patient is kept in a sling with an abduction pillow for 1 month postoperatively. Physical therapy begins 2 weeks postoperatively and is continued until approximately 6 months postoperatively. Weight restriction is 5 lbs at 1 month and 15-20 lbs at 2 months, with return to full activity at 6 months postoperatively.

Results

The study included a total of 4 patients, all male, with a mean age of 37.8±13.4 years at the time of surgery and a body mass index of 24.1±2.5 (Table I). The average preoperative bone loss was 40.8±9.8% (Table I) (Fig. 5). The mean follow-up was 4.3±1.6 years. Additional patient demographics can be found in Table I.

Patient-reported outcomes were improved postoperatively. ASES scores improved from 68.7±10.1 to 96.8±6.5 postoperatively, while SST improved from 9.0±0.0 to 11.5±1.0 and visual analog pain scale pain decreased from 2.0±2.0 to 0.3±0.5, postoperatively (Table II). Postoperative forward elevation of 159.0±9.8° was comparable to preoperative forward elevation of 160.0±10.0°, while external rotation improved from 35.0±13.2° to 40.5±22.3°, postoperatively (Table II).

No patients reported recurrent dislocations or subsequent surgeries at the time of final follow-up (Tables I and III). No postoperative nerve injuries were noted. On radiographic follow-up, all patients showed evidence of a healed distal tibial allograft. Overall, 3 patients showed full healing, and 1 patient demonstrated a fibrous union at the site of the coracoid osteotomy (Table III) (Fig. 6). Additionally, no patients reported pain over the coracoid at the final follow-up (Table III). The average angular difference between the screw and glenoid face was 10.3±1.1° (Table III) (Fig. 7).

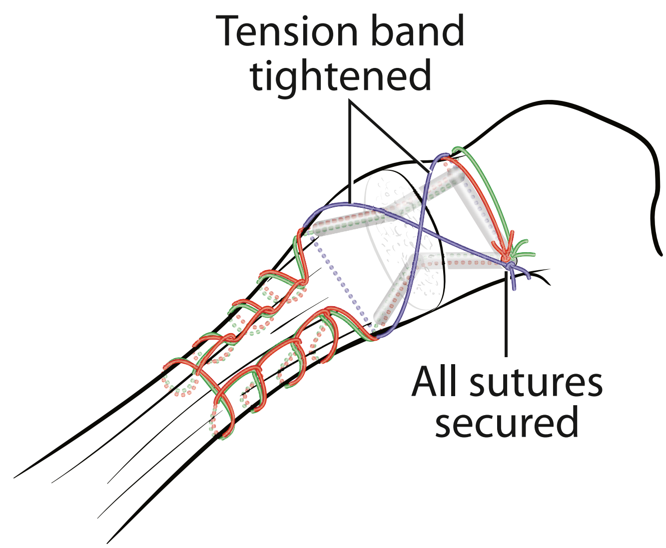

Figure 4 The coracoid is reduced and the Krackow stitches (*red and green*) are tied first followed by the tension band stitch (*blue*).

Table I
Demographic summary of the patient population.

Parameter	All patients
Total[†]	4 (100%)
Age[*] (y)	37.8±13.4
Sex[†]	
Female	0 (0.0%)
Male	4 (100%)
Prior surgery[†]	
Yes	0 (0.0%)
No	4 (57.1%)
Prior PT[†]	
Yes	3 (75.0%)
No	1 (25.0%)
ASA[†]	
≤2	4 (100%)
BMI[*]	25.1±2.5
Smoking status[†]	
Never	3 (75.0%)
Former	1 (25.0%)
Preoperative bone loss (%)[*]	40.8±9.8
Follow-up (y)[*]	4.3±1.6

ASA, American Society of Anaesthesiologists; *BMI*, Body Mass Index; *PT*, Physical Therapy.
[*]The values are given as the mean and the standard deviation.
[†]The values are given as the number of patients, with the percentage in parentheses.

Discussion

Despite the historical success of the Latarjet procedure, anterior glenoid reconstruction with open free bone grafts, including DTA, has gained increasing attention due to its lack of donor site morbidity, ability to restore large bony defects, and osteoarticular restoration.[5,10,12] In the primary setting, however, the intact coracoid and conjoint tendon often impair adequate visualization and access to perform an anatomic reconstruction. This will often necessitate surgeons to take down the subscapularis tendon using a tenotomy instead of a subscapularis muscle split. In this manuscript, we describe our technique for a coracoid osteotomy and subsequent repair, which we have utilized when performing an open DTA in the setting when a patient has not undergone a prior Latarjet procedure. The procedure allows access to the glenohumeral joint while still preserving the tendon status of the subscapularis.

Prior studies have demonstrated that fresh DTA demonstrates excellent functional outcomes, low recurrent instability rates, high healing rates of up to 89%, and only mild graft resorption (3%).[6,9] However, despite these results, optimizing the preparation and placement of the graft as well as obtaining adequate visualization are integral to optimizing outcomes.[1] Inadequate visualization may lead to incorrect positioning of the graft as well as aberrant screw trajectories.[1,8] As a result, many surgeons will perform a subscapularis tenotomy instead of subscapularis muscle split to gain exposure. Our coracoid osteotomy technique, in which we perform when a patient has an intact coracoid process and conjoint tendon (eg, no prior Latarjet procedure), has allowed us to obtain adequate visualization of the glenoid face, allowing us to mitigate concerns

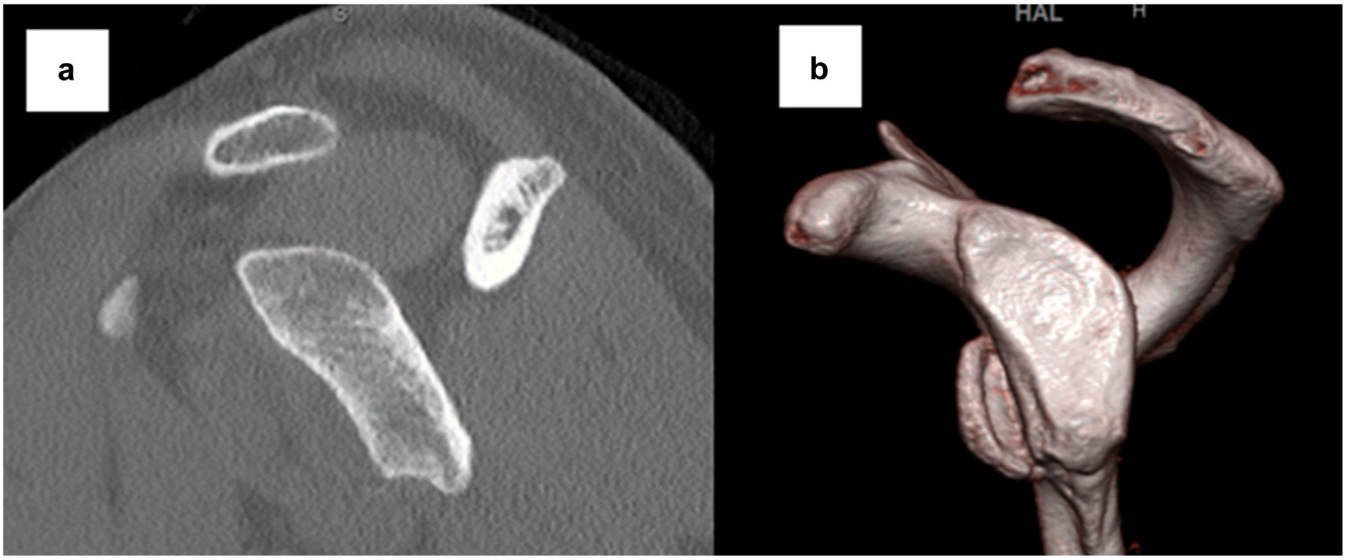

Figure 5 Two preoperative images showing bone loss. Panel (**a**) (left) demonstrates glenoid bone loss on sagittal T2. Panel (**b**) (right) demonstrates glenoid bone loss and aberrant bone formation on 3 dimensional reconstructions.

Table II
Comparison of preoperative and postoperative patient-reported outcome measures.

Parameter	Preoperative	Postoperative
Range of motion*		
Forward elevation	160.0 ± 10.0°	159.0 ± 9.8°
External rotation	35.0 ± 13.2°	40.5 ± 22.3°
Abduction		162.8 ± 9.8°
Patient-reported outcomes*		
ASES	68.7 ± 10.1	96.8 ± 6.5
SST	9.0 ± 0.0	11.5 ± 1.0
VAS	2.0 ± 2.0	0.3 ± 0.5

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *VAS*, visual analog pain scale.
*The values are given as the mean and the standard deviation. Statistical analysis deferred given small sample size.

Table III
Radiographic and clinical summary of patients who presented for follow-up.

Parameter	All patients
Subsequent dislocations†	
Yes	0 (0%)
No	4 (100%)
Subsequent surgeries†	
Yes	0 (0%)
No	4 (100%)
Radiographic healing of distal tibia allograft†	
Yes	4 (100%)
No	0 (0%)
Radiographic healing of coracoid†	
Yes	3 (75.0%)
Fibrous union	1 (25.0%)
No	0 (0%)
Angular difference between screw and glenoid face*	10.3±1.1°
Pain over coracoid at last follow-up†	
Yes	0 (0%)
No	4 (100%)

*The values are given as the mean and the standard deviation.
†The values are given as the number of patients, with the percentage in parentheses.

over screw trajectory and graft placement while maintaining the status of the subscapularis tendon with reliable healing of the coracoid process.

In addition to the improved visualization of the glenoid face obtained using a coracoid osteotomy, additional advantages of our technique include the fact that it is repaired utilizing an all-suture technique and the fact that it does not violate the coracoacromial ligament, the coracoclavicular ligaments, or the pectoralis minor tendon. As such, at the conclusion of the procedure, there is anatomic restoration of the coracoid tip and conjoint tendon, without concern over prominent hardware or disruption of shoulder girdle stability. While we have utilized this technique primarily during free bone block procedures, it can also be utilized in cases where access posterior to the conjoint tendon is necessary (eg, access to brachial plexus or vascular structures, glenoid reconstruction of large bony defects during reverse shoulder arthroplasty, proximal humerus fracture dislocation with humeral head medial to glenoid, and large anterior glenoid fracture repair).

This technique, however, is not without limitations. Given the proximity to neurovascular structures, surgeons must be careful to avoid excessive retraction and tension on the osteotomized fragment. While not always necessary, it is our preference to utilize intraoperative neuromonitoring in these cases. Second, given the small size of our cohort, it is possible that when used more frequently, patients may develop coracoid tip nonunions or tenderness over their osteotomy site. However, among our cohort, this was not noted. Lastly, it should be noted that as DTA has gained popularity, recent evidence has begun to suggest that arthroscopic DTA reconstruction is a viable option, which does not require an open incision, subscapularis violation, or a coracoid osteotomy.[2] While arthroscopic DTA does appear to be an excellent option, it is technically challenging and does have an extended learning curve. As such, our technique describes a simple technique that can be used during an open DTA reconstruction to obtain adequate visualization and access to the anterior glenoid face with minimal morbidity and no violation of the subscapularis tendon.

Conclusion

Coracoid osteotomy and subsequent repair when performing an open free glenoid bone grafting in the setting of anterior glenoid reconstruction for recurrent anterior glenohumeral instability, when a patient has not undergone a prior coracoid transfer,

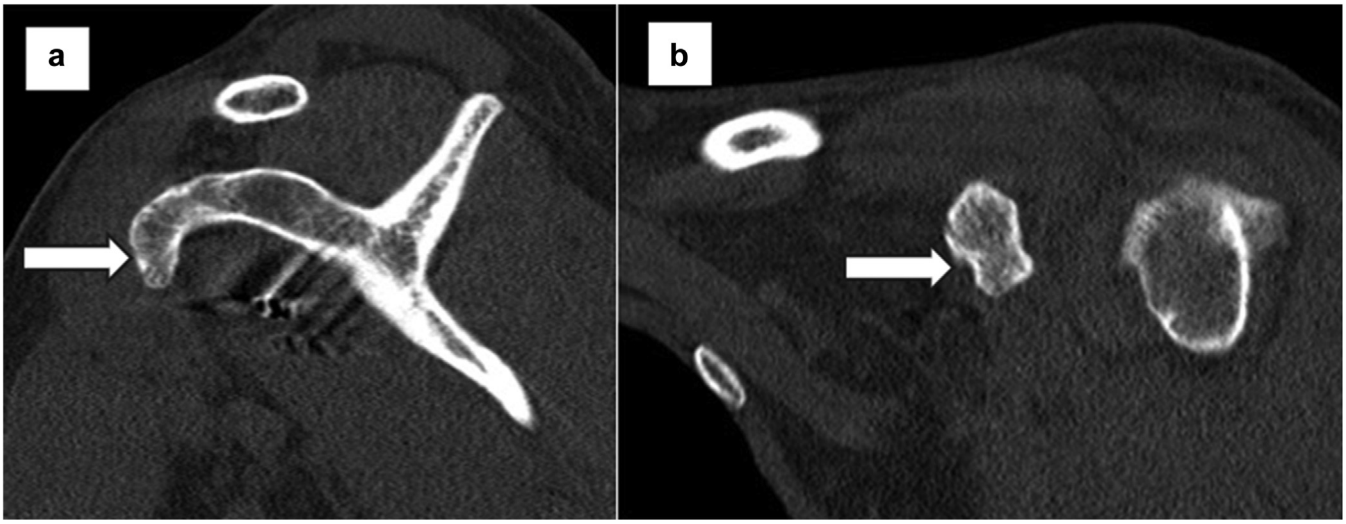

Figure 6 Two panels demonstrating postoperative healing of the coracoid process. Panel (**a**) on the left demonstrates healing of the coracoid on a sagittal T2 cut, with an arrow indicating the site of the osteotomy. Panel (**b**) on the right demonstrates a coronal cut, with an arrow pointing to the healed site of the osteotomy on the coracoid.

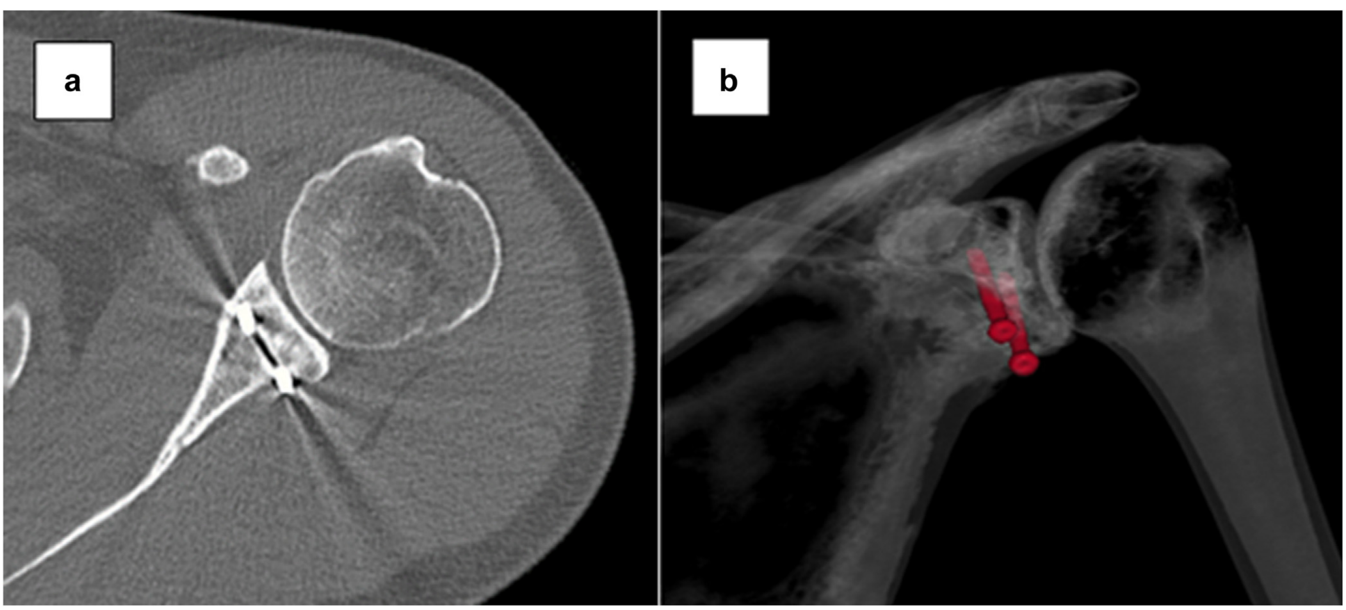

Figure 7 Postoperative images demonstrating screw trajectory. Panel (**a**) on the left is an axial computed tomography demonstrating screw trajectory in the glenoid. Panel (**b**) on the left demonstrates a 3 dimensional image demonstrating screw trajectory parallel to the face of the glenoid.

demonstrates excellent functional outcomes as well as radiographic healing of the osteotomy without pain or prominent hardware at the coracoid.

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Conflicts of interest: Christopher Joyce is a paid consultant for Zimmer-Biomet. Robert Z. Tashjian is a paid consultant for Stryker, Zimmer-Biomet, Depuy-Mitek, and Enovis; has stock in Conextions and Genesis; receives intellectual property royalties from Stryker, Shoulder Innovations, and Zimmer-Biomet; receives publishing royalties from Springer and the *Journal of Bone and Joint Surgery*; and serves on the editorial board for the *Journal of Bone and Joint Surgery*. The other authors, their immediate families, and any research foundation 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.

Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.xrrt.2024.09.008.

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