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Operative Techniques in

Sports Medicine

Arthroscopic Glenoid Bone Grafting: Preserving the Subscapularis—A Reproducible Technique

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The ideal technique for the treatment of anterior shoulder instability with glenoid bone loss is a topic of debate. Several techniques have been described by the orthopaedic surgeons including bony reconstruction as well as soft tissue repair. The clinical outcomes and complication rate (recurrent instability and graft failure) of these procedures vary significantly. It is believed that arthroscopic anatomic bony reconstruction might be a suitable option for the treatment of anterior shoulder instability with significant glenoid bone loss. We have discussed the technique of arthroscopic anatomic glenoid reconstruction using distal tibial allograft preserving the subscapularis muscle which seems to be very safe with excellent outcome.
Oper Tech Sports Med 27:81-88

KEYWORDS Shoulder instability, boney augmentation, arthroscopic anatomic glenoid reconstruction

Introduction

The use of bone grafting procedures to address bone loss and shoulder instability was first reported by Eden in 1918 who described his technique using distal tibial autograft augmentation.[1] Another bone grafting technique was described by Hybinette in 1932, who described the use of iliac crest autograft.[2] Years later, Latarjet and Helfet both described coracoid transfer procedures to address shoulder instability.[3,4]

While these were all described as open procedures, in recent years, arthroscopic techniques have been developed. The arthroscopic Latarjet procedure was first described by Lafosse et al in 2007.[5] In 2008, Scheibel et al described an arthroscopic anatomic glenoid reconstruction with an iliac crest autograft bone block.[6] We present our experience and modification in technique to allow for anatomic glenoid reconstruction of glenoid bone with inferior to superior capsular shift (Bankart repair) without damage to the subscapularis muscle.

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This investigation is done at Nova Scotia Health Authority, Halifax, Canada.
The authors do not have anything to disclose regarding this publication.
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Indications

Glenoid bone loss has been observed in a large percentage of patients after first-time dislocation and is even more prevalent in patients with recurrent instability.[7] Burkhart and De Beer reported high rates of recurrent instability (67%) when soft tissue stabilization procedures were performed in the setting of bone loss.[8] After changing to bony procedures in the same patient population, recurrent instability dropped to 4.9%.[9]

Cadaveric studies have demonstrated significant instability with 20%-21% bone loss from the glenoid.[10,11] Tauber has even suggested that any bony defect thicker than the cortex should be treated with bone graft.[12] In addition to bone loss, other risk factors have also been identified that contribute to instability. These include young age (<22), gender (male), timing to surgery (>6 months), and participation in high level athletes.[12-14]

In general, bone loss of 20% would be an indication for a bony procedure.[15-17] However, the amount of bone loss needed to implicate a bony procedure is steadily decreasing. It has been shown that patients with 10% bone loss treated with a Bankart repair have higher recurrence rates as compared to patients treated with bony augmentation.[18,19] Bony procedures should also be considered in patients with less bone loss when there are other risk factors for instability.

https://doi.org/10.1053/j.otsm.2019.03.006

Patient Assessment

Initial assessment of a patient referred for anterior shoulder instability starts with a thorough history. This should include the history of initial dislocation, subsequent dislocations, and treatment to date. History of any other joint dislocations and personal or family history to suggest ligamentous laxity is also important. A social history, including occupation, sports, and other leisure activities should be included.

A focused physical exam should include a full neurovascular exam of the affected limb, assessment of range of motion (ROM) and strength of rotator cuff and other muscles around the shoulder girdle, assessment of generalized laxity with the Beighton score, and special tests for instability, including apprehension test, relocation test, load and shift test, and assessment for a sulcus sign.

Radiographic evaluation starts with X-rays, including an anteroposterior of the glenohumeral joint, axillary view, and Bernageau view. Some surgeons or centers may include a scapular Y-view, but we feel that this is of limited utility in the assessment of shoulder instability. Advanced imaging with computed tomography (CT) and 3D reconstructions is performed to better assess bone loss (Fig. 1). Magnetic resonance imaging may be of value to assess labral pathology and rotator cuff integrity, but it is not part of our routine assessment.

Surgical Technique

Positioning

As with most arthroscopic shoulder procedures, the patient can be positioned in either the beach-chair position, or the lateral decubitus position. We prefer the lateral decubitus position as we feel it allows better visualization of the anterior to inferior glenoid and access for instruments. Ultimately, the selection of patient position will be based on the surgeon's experience and personal preference.

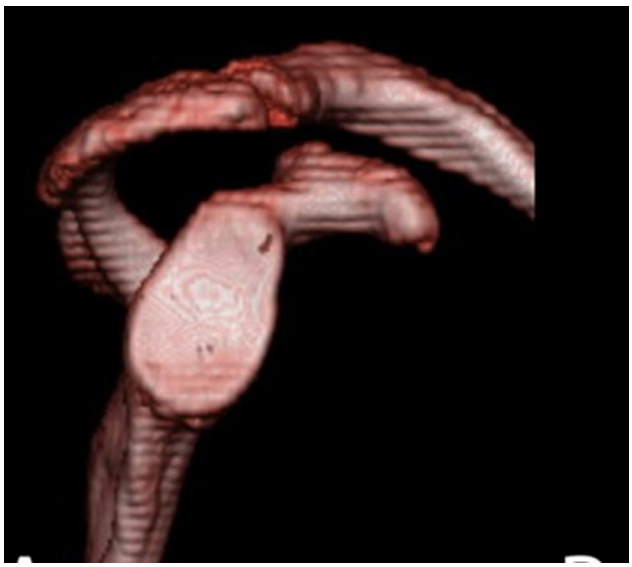

Figure 1 Preoperative 3D CT scan showing glenoid bone loss.

Portal Placement

Diagnostic arthroscopy is performed through a standard posterior portal. Standard anterior to superior and anterior to inferior portals are created with an outside-in technique (Fig. 2A). The anterior to superior portal is the ideal viewing portal for this procedure and allows direct measurement of glenoid and humeral bone loss for comparison to preoperative imaging (Fig. 2B).

For rigid fixation, an additional anterior portal with either subscapularis tenotomy or subscapularis split has traditionally been described. This can result in subscapularis dysfunction.[20-23] Therefore, we use a subscapularis-sparring approach.

The far-medial portal or "Halifax Portal" was described by Wong and Urquhart.[24] It is created using an inside-out technique. In this technique, a switching stick is passed through the posterior portal, parallel to the surface of the glenoid, and advanced anteriorly. It is passed superior to the subscapularis and lateral to the conjoined tendon. The switching stick is advanced through the deltoid and a skin incision is made (Fig. 3A). Dilation of this portal will allow graft placement and fixation (Fig. 3B). The safety and ease of creating this portal has been demonstrated in both cadaveric and clinical studies.[25,26]

More recently, we have also used a nonrigid suspensory fixation technique using button and suture fixation. Only the standard 3 portals for Bankart surgery are required, and the

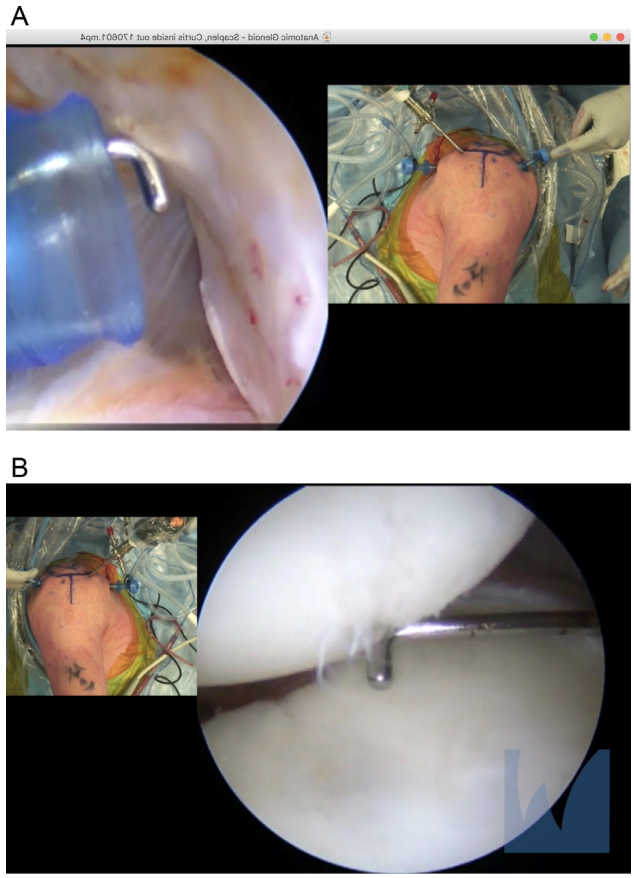

Figure 2 (A) Diagnostic arthroscopy is performed. (B) Measurement of glenoid bone loss.

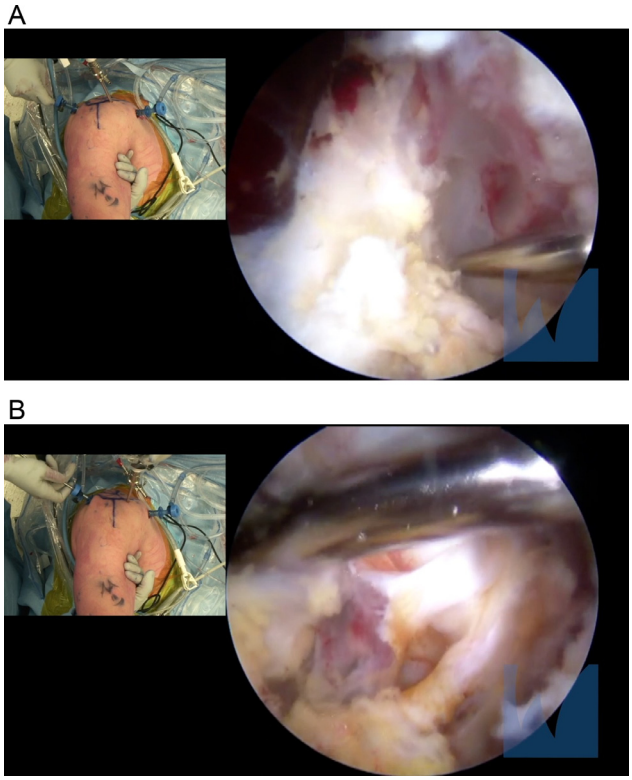

Figure 3 (A) Creation of Halifax portal. (B) Dilatation of Halifax portal.

graft can be passed through the anterior to inferior portal after dilation. The tunnels for suspensory fixation are created by transglenoid drilling with a targeted guide from posterior to anterior using a second posterior portal approximately 2 cm medial to the posterior portal.

Glenoid Preparation

A free "traction" suture can be placed around the labrum anterior to the biceps origin for control of the labral-capsule complex to assist in visualization of the bone defect and for improved inferior to superior capsular shift after fixation of bone graft. The labrum is then divided between the biceps insertion and traction suture. Any hardware from previous procedures should be removed. A labral knife can then be used to free any labral or soft tissue adhesions. It is important to be able to see the subscapularis muscle belly free of adhesions to the glenoid and inferior coracoid to allow adequate space for graft passage. Finally, the glenoid bone defect should be decorticated and flattened with a burr to expose bleeding cancellous bone to maximize healing of the bone graft.

Graft Preparation

Our preferred graft is a distal tibia allograft. We harvest a block of bone from the posterolateral portion of the tibial plafond (Fig. 4A,B). Our standard preparation has dimensions of 20 mm (superior to inferior) × 10 mm (anterior to posterior) × 15 mm (medial to lateral), for a volume of bone

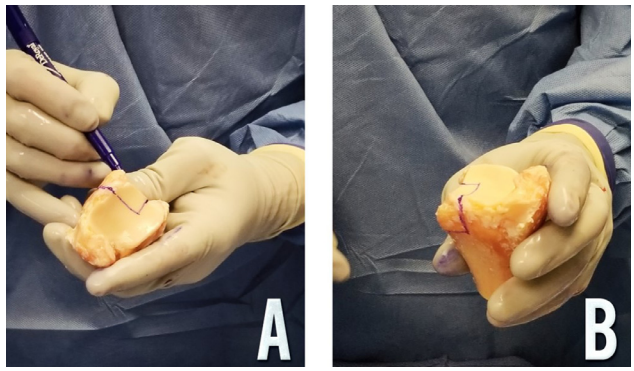

Figure 4 Preparation of bone graft: (A) before marking, (B) after marking.

of 3000 mm^3. The graft size should be tailored to the size of the bone defect based on preoperative imaging and intraoperative measurement.

If an iliac crest autograft is being used, we harvest a tricortical block of bone from the ipsilateral iliac crest. We would use a size similar to the distal tibia autograft, and once again adjust the size based on the defect. Either the inner table or the outer table of the graft can be placed laterally, adjacent to the glenoid articular surface, based on anatomic fit.

Graft Fixation

Our preferred fixation technique is the arthroscopic anatomic glenoid reconstruction with distal tibial allograft and without a subscapularis split, first described by Wong and Urquhart.[24] This is usually done in lateral decubitus position. This technique is performed using the standard 3 shoulder portals with 1 additional Halifax portal, created by an inside-out technique to introduce the graft into the shoulder, passing it lateral to the conjoin tendon, through the rotator interval, and above the subscapularis. A double-barrel cannula is used to control the graft which is passed through the Halifax portal using 2 slotted cannulas to keep the muscle fires from sticking to the graft. The position of the graft is initially fixed using K-wires. We prefer to use a switching stick from the posterior portal to assess the position of the graft: graft angle to native glenoid, medial to lateral positioning compared to glenoid face, and superior to inferior positioning relative to the inferior glenoid rim (Fig. 5A). Inferior to superior positioning is adjusted first as this requires both K-wires to be repositioned. Graft angle and medial to lateral positioning can be made by repositioning each K-wire individually and rotating or angling the graft. Once proper position of the graft is confirmed (graft angle, flush with inferior glenoid, and flush with glenoid face), then the graft can be fixed with cannulated screws. We prefer to use top hat washers on the graft to prevent hoop stresses and allow us to compress the graft against the glenoid. Screws can be tightened in alternating fashion under direct visualization to ensure there is no gap between the graft and glenoid. (Fig. 5B) This technique not only recreates the normal anatomy of the glenoid surface but also ensures preservation of the coracoid and subscapularis tendon and repair of the capsulolabral complex.

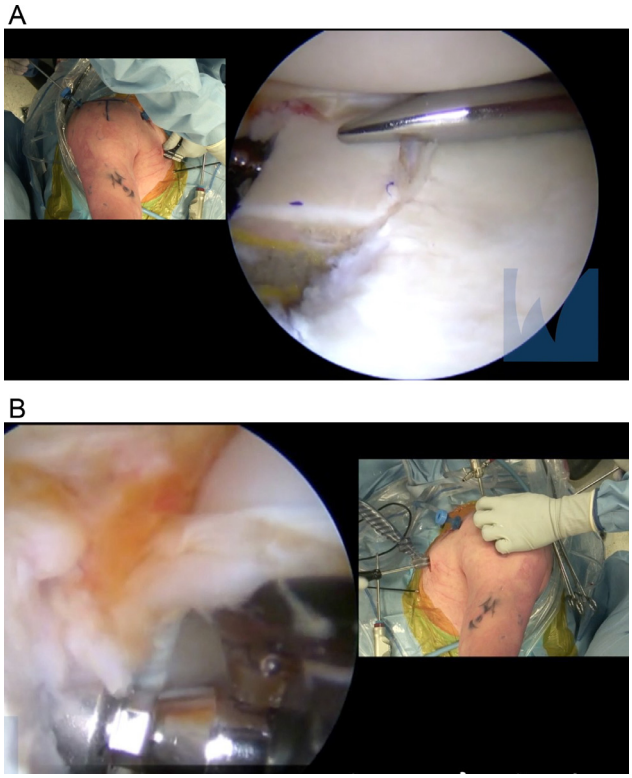

Figure 5 (A) Switching stick is used to assess the graft position. (B) Insertion of compression screw.

Another proposed technique is nonrigid fixation with transglenoid sutures and Endobuttons, as first described by Taverna et al[27] In this technique, the graft is prepared first by drilling 2 parallel holes through the graft and passing a suture with an Endobutton through each hole.

The glenoid is prepared by drilling 2 tunnels using a targeted guide from the posterior to anterior glenoid, exiting at the site of bone loss. The aiming arm of the guide is passed through the standard posterior portal and across the face of the glenoid to hook onto the center of the bone defect (Fig. 6A,B). A second portal is created medial to the standard posterior portal. This medial posterior portal allows the passage of 2 drill guides, which will rest on the posterior glenoid, for transglenoid tunnel placement using a cannulated drill guide. Bankart anchors must be drilled prior to removing the cannulated drill guides to avoid damaging the suspensory fixation of the graft. Two anchors are placed at 5:30 and 3:30 positions on the glenoid for the capsular shift and suture are shuttled out the posterior portal.

The anterior to inferior portal is then finger dilated to allow passage of the graft. Suture shuttles are passed through both cannulated drills from posterior to anterior and taken out the anterior inferior portal. Corresponding sutures from the Endobuttons on the graft are shuttled through the cannulated drills and out posteriorly. The graft is guided through the anterior to inferior portal using a large grasper and slotted cannulas to the anterior glenoid rim (Fig. 7A). A switching stick is then passed through the portal to manipulate as assist in positioning of the graft. Another switching stick should be passed through the posterior portal and placed along the face of the glenoid (Fig. 7B). This will help to ensure that the graft is not lateralized. When the graft is appropriately positioned, posterior buttons are placed onto the sutures and a tensioning device is used to compress the graft to the prepared native glenoid. It is secured with a combination of sliding and locking knots.

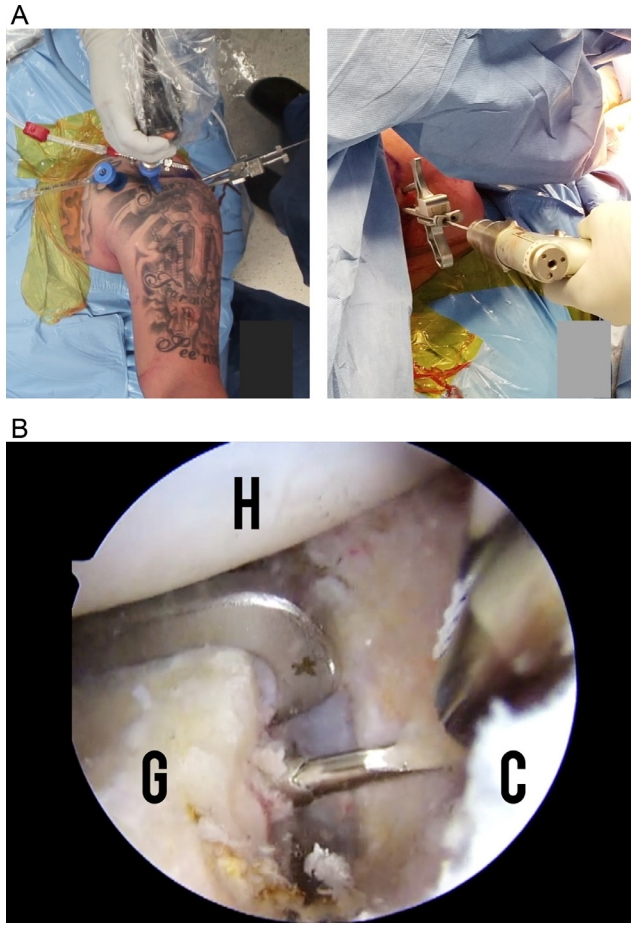

Figure 6 (A) Bullet drill guide posteriorly. (B) Bullet drill guide as viewed from anterior superior portal (H, humerus, G, glenoid, C, capsule).

Soft Tissue Repair

Once the graft has been secured, we then proceed with a Bankart repair. We routinely use 3 suture anchors either single or double loaded for fixation. With rigid graft fixation, these anchors are inserted after fixation of the graft being careful not to drill into the screws. The traction suture is helpful to maximize the inferior to superior capsular shift as each of the sutures is passed around the labrum using a curved retrograde suture passer. These sutures are tied prior to insertion of the following anchor. The traction suture is used to complete the soft tissue repair by using a knotless suture anchor to the superior pole of the glenoid. Then the final view is assessed (Fig. 8).

When using suspensory fixation, a similar technique is performed, but the first 2 suture anchors are already in position prior to passing the graft. Inferior to superior capsular shift is also done utilizing the traction stitch and completed with a knotless anchor.

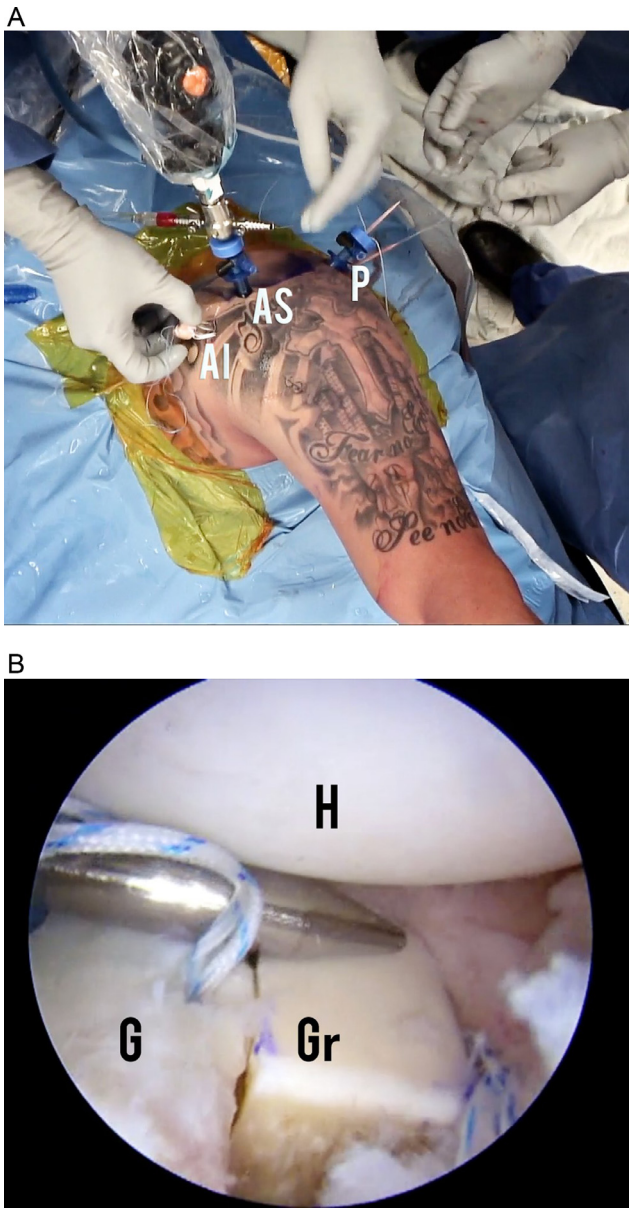

Figure 7 (A) Passing the graft as viewed from above (AI, anterior inferior portal; AS, anterior superior portal; P, posterior portal). (B) Switching stick is from posterior portal as viewed from anterior superior portal (H, humerus; G, glenoid, Gr, graft).

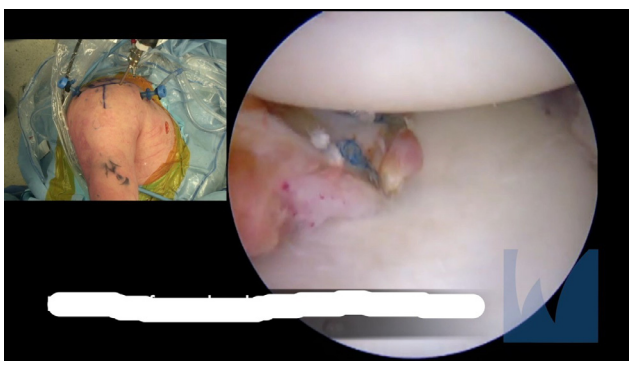

Figure 8 Final view after repair.

Post-OP Rehab

The patient is placed in a shoulder sling in neutral position at the end of the operation. On postoperative day 5, the patient will have his or her first physiotherapy visit. Range of motion exercises for the wrist and elbow are started, as well as passive ROM of the shoulder up to neutral rotation. Between weeks 2 and 6, the patient will progress with active assisted ROM and active ROM for the shoulder. At 6 weeks, the sling is discontinued, and light strengthening is started. This usually progresses over the next 6 weeks. The patient usually will be ready to return to sport between 6 and 12 months, depending on clinical and radiographic assessment, as well as the nature of the sport/activity.

Outcomes

Arthroscopic anatomic glenoid reconstruction is a successful procedure. The largest study published to date reports patient satisfaction of 92.3%.[24] Several studies have assessed functional outcomes using various scores, including Rowe, Walch-Duplay, Constant, Subjective Shoulder Value, Western Ontario Shoulder Index, and Visual Analog Scale.[25-27] We have recently published a study including 42 patients who underwent arthroscopic anatomic glenoid reconstruction using distal tibial allograft for the treatment recurrent anterior shoulder instability with glenoid bone loss. There was no report of intraoperative or postoperative complications including neurovascular injuries, bleeding, infections, and recurrent instability.[26] These have shown statistically significant increases in all of these scores postoperatively.

Radiographic assessment has shown very high union rates,[28,30-32] and only a single case where there was radiographic evidence of arthritis progression.[29] Perhaps most importantly, there is only a single case reported in the literature of recurrent dislocation after an arthroscopic anatomic glenoid reconstruction.[28] We have recently published a study of radiological comparison between arthroscopic coracoid autograft and tibial allograft for the treatment anterior shoulder instability with glenoid bone loss. Graft union was seen in 94% of the patients with tibial allograft while 75% coracoid autograft patients had union ($P = 0.08$).[33]

Discussion

Techniques for arthroscopic anatomic glenoid reconstruction have been described using either autograft or allograft. Autograft is more frequently described. The most common source of autograft is iliac crest,[6,27,29,31,32,34-37] but distal clavicle autograft has also been described.[38] Sources of allograft that have been described include iliac crest,[28] glenoid,[39] proximal tibia,[40] and distal tibia.[24]

Allograft does present some advantages over autograft. Donor site pain, infection, hematoma, nerve injury, and fracture at the donor site are all complications reported from harvest of autograft.[41-44] In addition to the elimination of donor

site morbidity, allograft can allow the opportunity for larger graft size, and also the ability to make a "trial" graft if deemed necessary.[24] Disadvantages of allograft include cost, potential unavailability, and infection.[26,45]

Union rates for arthroscopic anatomic glenoid reconstruction are very high, regardless of whether autograft or allograft is used. While one study with autograft found a union rate of 67%,[29] all others have found union rates of 100%.[30-32] A recently published study involving 42 patients underwent anatomic glenoid reconstruction with distal tibial allograft showed 100% union rate.[26]

Graft resorption of between 10% and 32% has been reported in all studies that have performed radiographic assessment of bone stock on serial postoperative CT.[28,30,31] Wong et al reported that graft resorption was seen for 71% of the tibial allograft patients and 42% of coracoid autograft (Latarjet) patients. However, there was no statistically significant difference between the 2 groups regarding anteroposterior diameter of final graft size ($P = 0.81$).[33] As a result, we feel that this should be considered an expected outcome of the procedure, rather than a complication. Work by Kraus et al demonstrated a final glenoid index approaching 1.0, which may suggest that the graft will remodel to the native size of the glenoid.[31] However, the study by Anderl et al would contradict this.[30] They found a final glenoid area of 89.5% compared to the contralateral side. With current available evidence, it is impossible to predict the extent of graft resorption and longer term studies are required to know the full extent of graft resorption through bone remodeling.

Traditionally, glenoid bone grafts have been secured with rigid fixation with screws, and this is what has been described in most studies of arthroscopic anatomic glenoid reconstruction.[6,24,29,31,32,35,36,38-40] Nonrigid fixation has also been described, including suture anchors,[28] transglenoid TightRope device,[34] and transglenoid sutures with Endobuttons.[27] Finally, there is a single technique that has been described where the graft is impacted into a trough in the native glenoid, without fixation.[37] However, the long-term follow-up of these techniques is yet to be established.

In one study where the graft was secured with screws, 33% of patients required a second surgery for screw removal for symptomatic hardware.[29] Our experience 10% of patients have symptomatic hardware without instability and proceed for screw removal. This finding is not unique to arthroscopic anatomic glenoid reconstruction. Revision surgery for symptomatic hardware has been widely reported for the Latarjet procedure,[46-52] with rates as high as 73%.[51]

Moreover, a recent cadaveric study showed that bone graft can be used for the treatment of recurrent anterior shoulder instability safely by using the Halifax Portal technique, without damage to the subscapularis tendon and keeping the major neurovascular structures at a safe distance. This portal can be created quickly and reproducibly using an inside-out technique that keeps the portal at least 4 cm away from any major neurovascular structure (axillary nerve, musculocutaneous nerve, cephalic vein).[25] Another study involving total 54 patients (Anatomic glenoid reconstruction = 27, arthroscopic Latarjet = 27) revealed that arthroscopic anatomic glenoid reconstruction using distal tibial allograft is faster to learn and perform than arthroscopic Latarjet. This study also found higher rates of desired graft positioning (lower one third of the anterior glenoid surface) for arthroscopic anatomic glenoid reconstruction clusters.[53]

In light of complications that have been reported with traditional screw fixation techniques, some authors have advocated for the use of bioabsorbable screws for graft fixation during arthroscopic anatomic glenoid reconstruction.[31,32] Another proposed advantage of bioabsorbable screw fixation is reduced artifact on postoperative CT and magnetic resonance imaging.[49] However, the use of bioabsorbable material has been shown to cause surrounding osteolysis when used for other orthopaedic indications.[54,55] In one study, osteolysis was also observed when bioabsorbable screws were used to secure the coracoid in the Latarjet procedure.[49]

When rigid fixation is used, the approach to the subscapularis must be considered. Traditionally, the 2 options are subscapularis tenotomy or subscapularis split. When compared to a subscapularis split, a Latarjet performed with an L-shaped tenotomy has been shown to result in decreased strength, decreased endurance, lower functional scores, and higher rates of fatty infiltration.[20-22] The technique developed by Wong and Urquhart reduces risk to musculocutaneous nerve and axillary nerve by leaving the conjoint and subscapularis intact and passing the graft lateral to conjoin tendon and superior to subscapularis through the rotator interval.

The subscapularis split is not without its own shortcomings. When a Latarjet has been performed through a subscapularis split, the operative side has been shown to have a significant decrease in strength and endurance when compared to the nonoperative side.[23] In a cadaveric anatomic study, the musculocutaneous nerve was found to be within the subscapularis split 66% of the time, and the axillary nerve 50% of the time.[56] Given these results, we recommend a subscapularis-sparring technique when using rigid fixation.

Conclusion

Arthroscopic anatomic glenoid reconstruction is a safe, effective, and reproducible procedure for managing anterior shoulder instability with bone loss. We advocate for the use of distal tibia allograft using rigid fixation and the Halifax portal for preservation of the subscapularis muscle and soft tissue repair with inferior to superior capsular shift. We are intrigued with suspensory fixation of the graft to decrease the need for hardware removal. Longer term follow-up will determine if there is an advantage to 1 fixation method over another.

Acknowledgment

Authors would acknowledge the help of Swagata Ghosh for summarizing information, overall formatting, and submission.

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