Technical Note

Arthroscopic Distal Clavicle Bone Block Technique for Anteroinferior Instability With Critical Bone Loss

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Abstract: Arthroscopic distal clavicle autograft represents a locally available source of autograft for bone block augmentation in patients with anterior shoulder instability with glenoid bone loss. Anatomic and biomechanical studies have supported distal clavicle autograft use as comparable to coracoid graft with regard to restoration of glenoid articular surface, with the theoretical advantage of minimizing complications associated with coracoid transfer procedures, such as neurologic injury and coracoid fracture. The current technique describes a modification of those previously described, including a mini-open approach for distal clavicle autograft harvest, orientation of the distal clavicle with the medial clavicle graft against the glenoid (congruent arc), an all-arthroscopic technique of graft passage, and graft placement and fixation using specialized drill guides and four suture buttons to reproducibly place and secure the graft with final capsulolabral advancement over the graft to render it extra-articular.

Introduction

Glenoid bone loss contributes significantly to anterior shoulder instability. Historically, critical glenoid defects greater than 20% were considered an indication for osseous augmentation;[1–3] however, with the growing appreciation of functional glenoid bone loss related to the glenoid track concept,[4,5] there is growing interest in glenoid augmentation techniques to address glenoid bone loss. Although coracoid transfer (i.e., Latarjet, Bristow) has historically been the most common technique used, high and significant complication rates, including coracoid fractures, neurologic injuries, glenohumeral osteoarthritis, and hardware complications, have led to growing interest in alternative methods to restore glenoid congruency.[6–9] An alternative to coracoid transfer involves bone-block augmentation using either iliac crest autograft[10–13] or distal tibia osteochondral allografts.[14,15]

Recently, distal clavicle autograft has been recognized as particularly appealing because of its safety, accessibility, and minimal donor site morbidity. Additionally, Kwapisz et al. found that distal clavicle autograft can restore significantly greater glenoid bone deficit than the Latarjet procedure and that the articular cartilage thickness of the distal clavicle is within 1.4 mm of the native glenoid.[16] Furthermore, biomechanical analysis by Petersen et al. demonstrated that an articular distal clavicle bone graft is comparable in glenohumeral contact area and pressures to an optimally placed coracoid bone graft.[17]

The technique of using a distal clavicle autograft has previously been described by Tokish et al.[18] and Boileau et al.[19] The current technique details a modification of those previously described, including a mini-open approach for distal clavicle autograft harvest, orientation of the distal clavicle with the medial clavicle graft against the glenoid (congruent arc), an all-arthroscopic technique of graft passage, and graft placement and fixation using specialized drill guides and two sets of paired suture buttons to reproducibly place and secure the graft followed by advancement of the capsule over the graft, rendering the graft extra-articular. The study

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Surgical Technique

Preoperative Considerations

Patients being evaluated for shoulder instability undergo shoulder radiographs and magnetic resonance imaging to evaluate for osseous and soft tissue pathology. If there is concern for a bony Bankart lesion or glenoid bone loss, a computed tomography (CT) scan is obtained with three-dimensional reconstruction to further characterize the location and degree of bone loss. With either 1) greater than 13.5% (subcritical) glenoid bone loss or 2) an off-track lesion,[5,20] the patient is indicated for bone block augmentation (Fig 1). The distal clavicle (DC) can be used in 3 different orientations: 1) distal clavicle attached by its posterior surface (DCP), 2) inferior surface (DCI), and 3) resected end (DCR). Preoperative CT scan measurements can aid in deciding which is the best option. Because all orientations can provide at least 1 cm in the anterior-posterior and medial to lateral planes, we prioritize the orientation that can simultaneously fill the length of the defect, while minimizing the amount of distal clavicle resection to prevent AC joint instability. In this case, as is most common, we attached the resected end (DCR, congruent arc) to the glenoid. The lack of articular cartilage is addressed by repairing the capsulolabral complex over the graft, making it extra-articular.

Patient Positioning

The patient is positioned in the lateral decubitus position using a beanbag positioner. The operative shoulder and arm are prepped and draped in a sterile fashion. A mobile arm holder (SPIDER2 Limb Positioner; Smith & Nephew, Andover, MA) is used, including a lateral jack beneath the brachium to provide glenohumeral joint distraction.

Distal Clavicle Graft Harvest

A transverse, 3-4-cm incision is made overlying the acromio-clavicular (AC) joint. Dissection is carried down through the subcutaneous tissue, directly to the surface of the AC joint, which is identified by direct palpation. A hypodermic needle can be used to confirm AC joint identification. Full-thickness periosteal flaps are raised with electrocautery, exposing the bony surface of the distal clavicle. A ruler is used to measure 15 mm from the lateral end of the clavicle and marked with a surgical pen. Up to 15 millimeters of resection can be performed, with concern for biomechanical AC joint instability with greater resection. Small blunt Hohmann retractors are placed beneath the site of the planned cut to protect the underlying neurovascular structures. A half inch oscillating saw blade is then used to osteotomize the clavicle, transversely at the marked site. The posterior AC ligament is preserved, and the distal clavicle bone block is removed from the wound and passed to the back table for preparation. The AC joint capsule and fascia are then closed securely with a braided nonabsorbable suture in interrupted, figure-of-eight fashion.

Graft Preparation

The autograft bone block is then prepared on the back table. The graft is sized with a ruler and trimmed with a quarter-inch oscillating saw blade to a size of 20 mm (anteroposterior) × 10 mm (superoinferior) × 10 mm (mediolateral). Before proceeding, verify on the back table that the graft is capable of passage through the 15-mm cannula. The medial surface of the graft is freshened up with a saw blade to prepare for placement against the glenoid. The lateral edge of the graft is lightly decorticated and flattened with a sawblade to

Fig 1. Three-dimensional computed tomography (CT) reconstruction (left) of the glenoid demonstrating 20.8% anterior glenoid bone loss. Glenoid track = 0.83 × 29 mm. Glenoid bone loss = 5.99 mm. Axial slice of shoulder CT (right), with Hill-Sachs interval measuring 18.8 mm, which is greater than (0.83 × 29 mm) − 5.99 mm = 18.1 mm, representing an off-track lesion.

allow the buttons to sit flush against the bone. The graft is locked into the Graft Preparation Tool (Glenoid Bone Loss System, Smith & Nephew, Andover, MA), and a 2.8-mm drill bit is used to drill two holes, 10 mm apart and 5 mm from each edge. Two Endobuttons (Smith & Nephew, Andover MA) are then loaded through the graft using a looped guide wire to pass the sutures through the superior and inferior holes in the graft. It is ensured that the buttons sit flush to the bony surface of the graft and do not overlap. The planned intra-articular, superior edge of the graft and the superior sutures are marked with a surgical pen to aid graft orientation during implantation (Fig 2).

Arthroscopy and Glenoid Preparation

A posterior arthroscopic portal is made 1 cm more medial than the standard posterior portal, in order to ensure that the instrumentation is inserted parallel to the glenoid face. Next, anterosuperior (AS) and anteroinferior (AI) portals are created using an outside-in technique. A diagnostic arthroscopy is performed. Remaining capsulolabral tissue is elevated from the glenoid defect using an elevator, and a suture lasso is used to pass 2 labral tapes (Smith & Nephew, Andover MA) through the labrum for retraction. It is imperative that a complete and wide release of the capsulolabral complex is performed to allow the graft to be shuttled against the glenoid without soft tissue interposition. The glenoid defect is prepared using a 4.0-mm burr and arthroscopic shaver, first while viewing from the posterior portal and working from the anterosuperior portal, and next while viewing from the anterosuperior portal and working from the anteroinferior portal. All soft tissue is then removed from the anterior glenoid neck with a shaver and radio frequency ablation, and the bony surface is contoured with a burr to create a flat, bleeding surface for acceptance of the graft (Fig 3). A pilot hole for a knotless FiberTak anchor (Arthrex, Naples, FL) is drilled along the face of the glenoid adjacent to the defect for later capsulolabral imbrication over the graft, therefore, creating extra-articular graft placement (Fig 4). Drilling the pilot hole before graft placement minimizes the chance of damaging the graft with the drill.

Drill Guide Placement

Viewing from the anterosuperior portal, the glenoid guide is introduced through the posterior portal, and the guide hook is centered on the anterior glenoid defect (Fig 5). The glenoid guide is ensured to be parallel and flush to the glenoid surface. A 2-cm incision is made at the location where the drill guide contacts the skin. The two drill guide "bullets" are advanced by ratcheting through the guide via this incision until they firmly contact the posterior glenoid. These drill guides are spaced 10 mm apart to match the prepared holes in the graft and should be placed roughly 5 mm from the superior cortical edge of the glenoid. A 2.8-mm sleeved drill is placed through each drill guide and advanced by power until exiting the anterior glenoid defect (Fig 6). The inner drill bits are removed, while keeping the outer sleeves in place in order to facilitate suture passage. The glenoid guide is then removed while turning the hook of the guide parallel to the glenoid to minimize risk of articular injury.

Rotator Interval Dilation and Graft Placement

Viewing from the posterior portal, the anterosuperior portal incision is extended, and the rotator interval is dilated to allow for placement of a 15-mm cannula. A nitinol loop is passed through the drill sleeves from posterior to anterior to retrieve the anterior Endobutton sutures via the 15-mm cannula. Using this technique, the surgeon shuttles the sutures from the anterior Endobutton and graft anterior to the posterior through the glenoid to exit the posterior glenoid and the posterior medial incision previously used for glenoid drilling. The suture limbs are tensioned, superior first to ensure that the superior portion of the graft enters the cannula first, and then sutures are sequentially tightened, shuttling the graft into the joint until flush with the anterior glenoid defect (Fig 7, Video 1). Care is taken to ensure that the graft is clearly below the equator at the inferior aspect of the defect. An

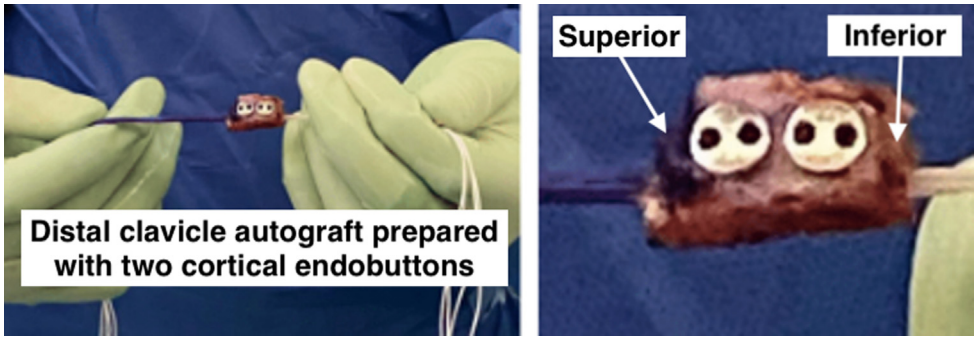

Fig 2. Intraoperative photograph of the prepared distal clavicle autograft. Note the superior aspect of the graft and corresponding sutures are marked with a surgical pen for orientation.

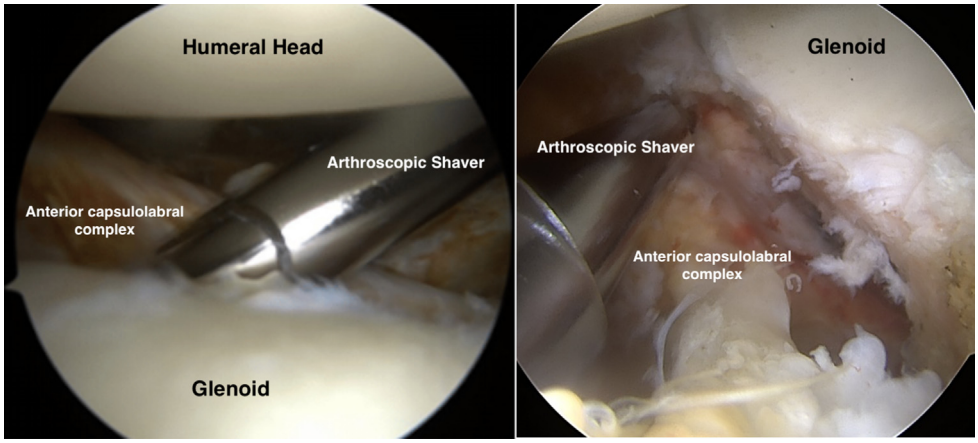

Fig 3. Arthroscopic image showing glenoid defect preparation using an arthroscopic shaver from the anteroinferior portal and viewing from posterior portal (left). Completed preparation of the anterior glenoid defect using an arthroscopic shaver from the anteroinferior portal and viewing from anterosuperior portal (right).

arthroscopic bone grasper can be used to reposition the graft as needed.

Bone Graft Fixation via Suture Button Tensioning

Once the bone block sits flush on the anterior neck of the glenoid, each suture loop is cut to separate the 2 ends of the loop. Each pair of suture limbs are then placed through a posterior Endobutton using a suture retriever, for a total of 2 posterior Endobuttons corresponding to the superior and inferior anterior Endobuttons. A Nice knot is created and used to advance the buttons through posterior portal to the posterior surface of the glenoid. Both limbs are tensioned using a tensioning device, first to 50 N. The graft is then viewed arthroscopically to ensure it is still correctly positioned, and any further adjustments to position can be made with an arthroscopic grasper. The sutures are then tensioned to 100 N, and a knot pusher is used to secure the posterior Endobutton devices with 5 half hitches and an alternating post. We recommend using 2 tensioning devices to maintain tension while tensioning the alternative button. The suture limbs are cut. Using the pilot hole, the surgeon places a FiberTak knotless labral anchor, and the labral tape is used to shuttle the repair suture around the labrum. Using a second anchor superiorly, the capsulolabral complex is sequentially tensioned over the graft restoring IGHL tension, while rendering the graft extra-articular (Fig 8).

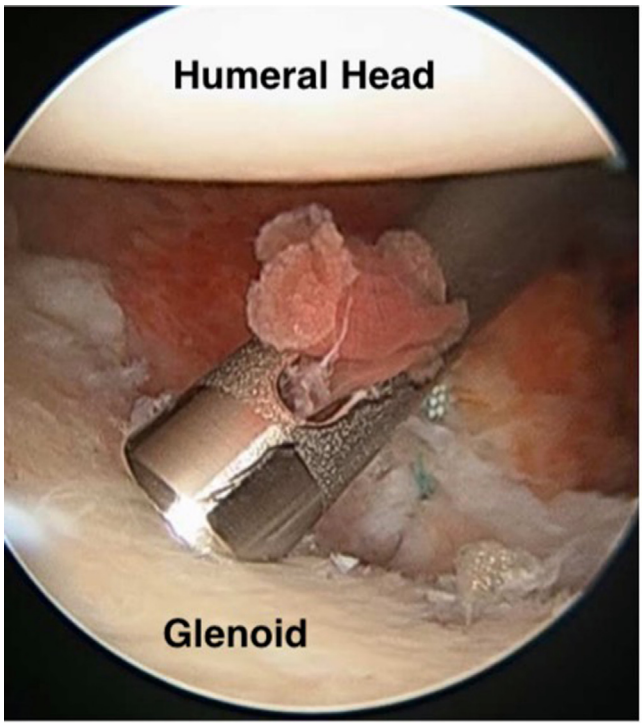

Fig 4. Arthroscopic image showing an anchor pilot hole drilled prior to graft insertion in preparation for later capsulolabral imbrication.

The shoulder is abducted and externally rotated to visualize arthroscopically that the Hill-Sachs defect does not engage. The incisions are closed with interrupted nylon sutures, and sterile dressings are placed. Postoperative fluoroscopic images are taken to confirm satisfactory graft placement and a concentric glenohumeral joint (Fig 9). Pearls and pitfalls of this technique are summarized in Table 1.

Postoperative Protocol

Postoperatively, the patient is immobilized in a sling with an abduction pillow and the shoulder in neutral position. Sling wear is continued for 6 weeks. Pendulum exercises are initiated immediately. A postoperative follow-up visit occurs 2 weeks after surgery, at which time sutures are removed, and passive ROM is begun under the supervision of an outpatient physical therapist. Passive motion is progressed to full by the 8-week follow-up visit. A radiograph is obtained on this visit to ensure that there has been no graft migration. Active range of motion is initiated at the 8-week visit, with progression to strengthening by 4 months and return to full activity by 6 months.

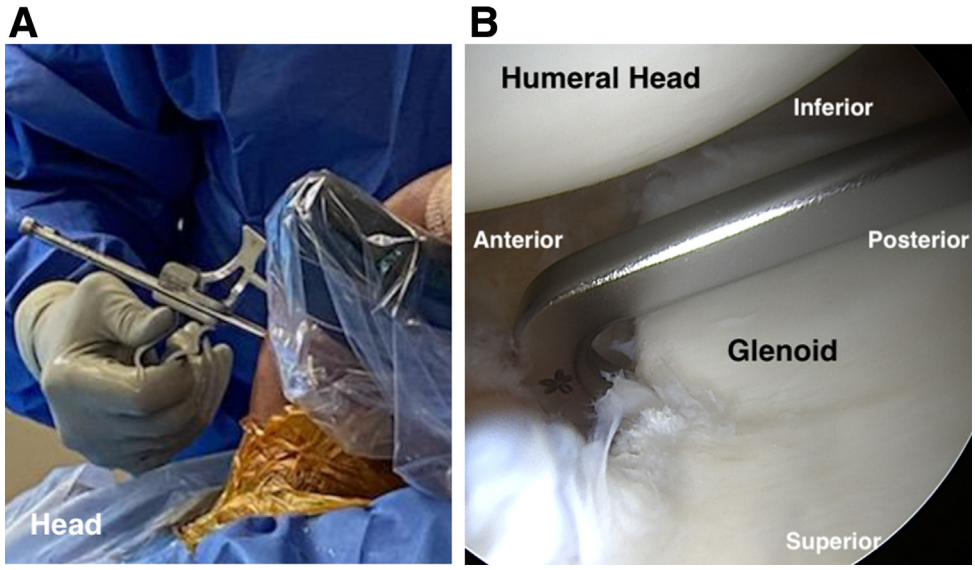

Fig 5. (A) Intraoperative photo of patient in lateral decubitus positioning with distraction pad placed under upper brachium of right arm, demonstrating insertion of the glenoid drill guide from posteriorly. (B) Arthroscopic image viewing from the anterosuperior portal showing the guide hook placed via the posterior portal and centered on the anterior glenoid defect.

Discussion

The importance of glenoid bone loss has been increasingly recognized as a critical factor contributing to recurrent anterior shoulder instability.[1–5] Although coracoid transfer historically represented the standard of care for addressing recurrent anterior instability with anterior glenoid bone deficiency, the high rate of complications associated with this procedure has fueled interest in alternative options for managing this complex problem.[6–8] The distal clavicle autograft bone block procedure described in this technique article represents a reproducible and minimally invasive technique to performing bone block augmentation for anterior instability with anterior glenoid bone loss.

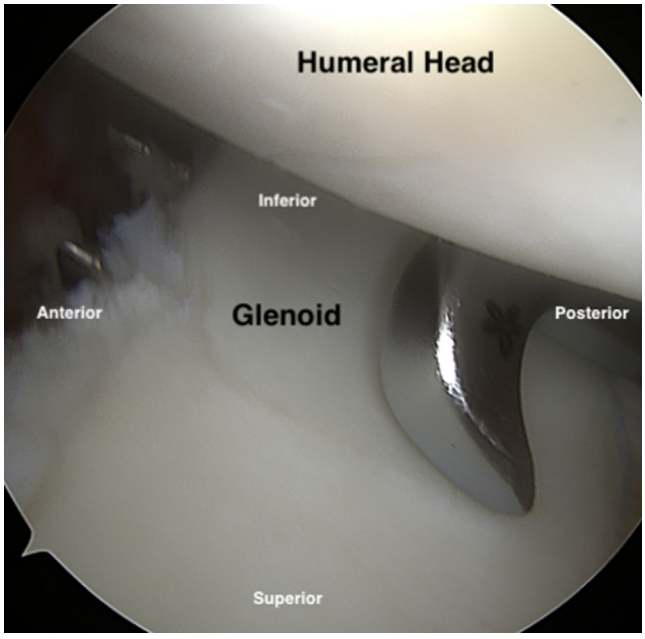

Fig 6. Arthroscopic image viewing from the anterosuperior portal showing the 2 drill sleeves in place, as the bone block guide is withdrawn from the posterior portal, with the hook parallel to the articular surface to prevent articular injury.

The distal clavicle represents a locally available source of osteochondral autograft that is easy and safe to harvest with previous anatomic studies supporting its use for reconstituting glenoid bone loss. Larouche et al.[21] performed an anatomic and cadaveric study investigating dimensions and morphology of the distal clavicle autograft and found that distal clavicle graft can reconstruct 22% of the glenoid articular surface. Additionally, Kwapisz et al.[16] performed a cadaveric study comparing distal clavicle to coracoid graft and found the distal clavicle graft provided greater radius of glenoid restoration, and an ability to restore larger glenoid defects (44% vs 33%; $P < .001$). Furthermore, Rodriguez et al. performed a radiologic and cadaveric assessment comparing coracoid, distal clavicle, and scapular spine autografts and found that glenoid bone loss greater than 20% was adequately addressed by either the coracoid or the distal clavicle, while scapular spine autograft only reliably addressed subcritical bone loss (13.5% to 20%). Anatomically the distal clavicle graft appears suitable and comparable to coracoid graft for restoration of glenoid articular surface, and it can be used in alternate orientations, according to the deformity and surgeon preference. When using a non-cartilaginous surface to articulate with the humeral head, we recommend repairing the capsule over the graft to minimize risk of arthritis.

The technique for distal clavicle bone block augmentation of the glenoid has previously been

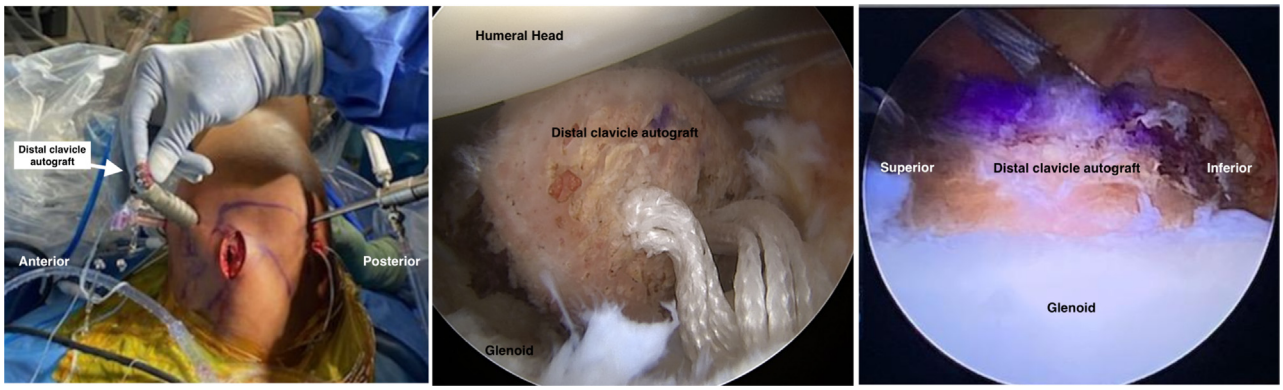

Fig 7. Intraoperative photo of patient in left lateral decubitus position with right arm in traction and the graft being shuttled through the anterosuperior 15-mm cannula (left). Arthroscopic image viewing from posterior portal of the graft being shuttled into the joint (center). Arthroscopic image viewing from posterior portal of the graft seated flush against the glenoid defect (right).

described by Tokish et al.[18] and Boileau et al.[19] In terms of the technique used by Tokish et al., the glenoid articular cartilage was repristinated via the lateral distal clavicle articular cartilage. Tokish et al. described both screw fixation and suture anchor fixation techniques, with suture anchor used if the insertion angle of the screw cannot be safely fixed. Boileau et al. described a different approach to distal clavicle autograft harvest, which was performed arthroscopically, while the current technique article describes a mini-open approach. Additionally, Boileau et al. described securing the graft with one set of Endobuttons, as opposed to two sets. In terms of graft orientation, they described a similar technique to ours: placing the undersurface of the distal clavicle laterally about the glenoid in an attempt to restore the congruent arc of the glenoid. Screw fixation has been associated with hardware complications that can be avoided using an Endobutton technique, including the advantage of smaller drill holes required for suture button fixation and lower risk of fracture, and high rates of graft incorporation.[22,23,24] In addition, we believe that suture Endobutton fixation allows for more flexibility, especially while avoiding the subscapularis arthroscopically, than screw fixation. This may allow for more consistent graft positioning. In terms of graft orientation, further research is needed to determine the optimal graft orientation and to evaluate clinical outcomes following distal clavicle autograft

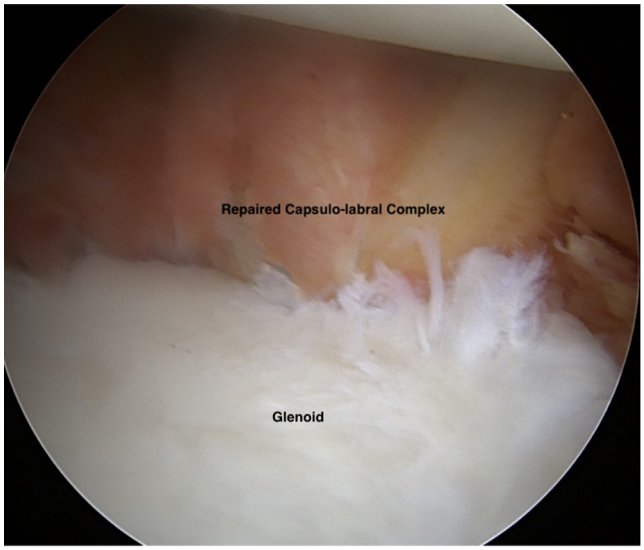

Fig 8. Arthroscopic image viewing from posterior portal, demonstrating imbrication of the capsulolabral complex over the secured graft, rendering the graft extracapsular.

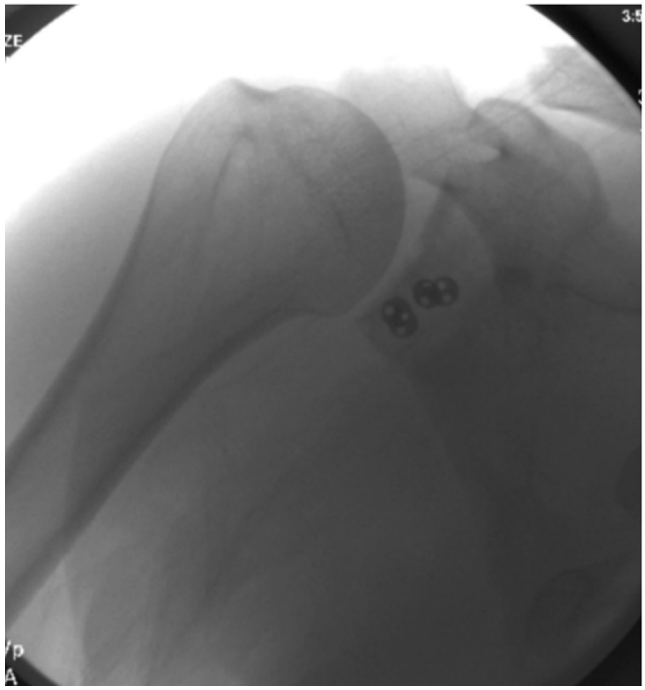

Fig 9. Postoperative fluoroscopic image demonstrating satisfactory implant positioning and restoration of a concentric glenohumeral joint.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Make standard posterior viewing portal approximately 1 cm more medial than standard portal to allow for placement of guide parallel to glenoid articular surface	Resecting greater than 15 mm of the distal clavicle can result in disruption of the coraco-clavicular ligaments and cause iatrogenic AC instability
Drill holes for soft tissue repair while metal sleeves are in place traversing the glenoid to ensure soft tissue repair anchors do not converge with path of Endobutton suture fixation	Tensioning graft with soft tissue interposed between glenoid and graft can result in inadequate compression of graft.
Mark soft tissue drill holes with ablation initially, or use nitinol wire to probe anchor holes to allow identification of path for anchor placement when performing final soft tissue repair	
Use arthroscope to visualize the shuttle sutures within the metal cannula being used for graft passage. Ensure sutures are not twisted to ensure correct graft orientation during passage. Buttons on graft should point toward inferior glenoid when loading graft into cannula.	

AC, acromioclavicular.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Smaller drill holes in graft and glenoid when compared to screw fixation	Potential morbidity of over-resection of distal clavicle
Use of cortical buttons eliminates risk of screw breakage	
Simple open harvest of distal clavicle graft	
Arthroscopic graft placement and fixation technique can similarly be used with allograft	
No subscapularis detachment or split performed	

compared to Latarjet and iliac crest bone graft procedures. Limitations of this technique include the potential morbidity related to sacrifice of an anatomic structure, the distal clavicle, with potential for acromioclavicular (AC) instability with overresection. However, distal clavicle excision is a common treatment for AC joint arthritis, and prior studies report minimal morbidity associated with the procedure.[25,26] Advantages and disadvantages of this technique are summarized in Table 2.

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