Arthroscopic Distal Clavicular Autograft for Treating Shoulder Instability With Glenoid Bone Loss

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Abstract: Glenoid bone loss is a significant risk factor for failure after arthroscopic shoulder stabilization. Multiple options are available to reconstruct this bone loss, including coracoid transfer, iliac crest bone graft, and osteoarticular allograft. Each technique has strengths and weaknesses. Coracoid grafts are limited to anterior augmentation and, along with iliac crest, do not provide an osteochondral reconstruction. Osteochondral allografts do provide a cartilage source but are challenged by the potential for graft rejection, infection, cost, and availability. We describe the use of a distal clavicular osteochondral autograft for bony augmentation in cases of glenohumeral instability with significant bone loss. This graft has the advantages of being readily available and cost-effective, it provides an autologous osteochondral transplant with minimal donor-site morbidity, and it can be used in both anterior and posterior bone loss cases. The rationale and technical aspects of arthroscopic performance will be discussed. Clinical studies are warranted to determine the outcomes of the use of the distal clavicle as a graft in shoulder instability.

Glennon bone loss has emerged as 1 of the most significant risk factors for recurrence after arthroscopic treatment of glenohumeral instability.1-4 Although the amount of bone loss that requires restoration remains controversial, when it exceeds 20% to 25%, glenohumeral stability is biomechanically compromised.5,6 As a result, many authors have recommended that glenoid bone defects exceeding 25% should be reconstructed.5,7,8 Given that the diameter of the inferior glenoid is usually between 24 and 26 mm,9 6 to 8 mm of glenoid loss should be considered for reconstruction, and this qualitatively corresponds to the “inverted-pear” glenoid described by Lo et al.8 Posterior instability, though less common than its anterior counterpart, can be a painful and debilitating condition in an active patient. Bone loss can occur in this condition as well and, when severe, should be addressed similarly to anterior instability.

Many techniques have been described to reconstruct glenoid bone loss. These approaches include the Bristow10 and Latarjet11 coracoid transfers, iliac crest bone grafting,12,13 and osteochondral allograft transfer.12,14 Coracoid transfers have become very popular but are a nonanatomic approach to this condition. They may have an underappreciated complication rate15 and possibly complicate future revision surgery. Iliac crest grafts can be customized to match the contour of the glenoid, a variant of the Eden-Hybbinette procedure,16 but lack any articular cartilage, and concerns for longer-term osteoarthritis persist. Osteochondral allograft transfers provide a source of articular cartilage, but cost, availability, and questionable allograft incorporation remain issues of concern. We have investigated the use of patients’ own distal clavicle as an autograft alternative for bony augmentation in shoulder instability with glenoid bone loss (Fig 1). The distal clavicle has several potential advantages over other described techniques.

We describe an innovative technique using osteochondral distal clavicular autograft for reconstruction of glenoid bone loss. The purpose of this report is to describe the rationale and technical considerations in the arthroscopic placement of this graft for glenoid bone loss in shoulder instability.
Surgical Technique

Step 1: Preoperative Workup

Patients who present with glenohumeral instability to our institution undergo a standard history and physical examination, as well as preoperative magnetic resonance imaging. The imaging is carefully evaluated to ensure that it correlates with the history and physical examination findings, and both soft-tissue pathology and bony pathology are noted. Glenoid bone loss is calculated in every patient, and this calculation aids in determining the operative approach to the patient. Relative indications for bony augmentation of either anterior or posterior instability include bone loss of greater than 20% of the glenoid diameter or the existence of significant retroversion in the presence of posterior instability (Fig 2).

Step 2: Positioning and Portal Establishment

The patient is brought to the operating room, and after the induction of general anesthesia, the patient is examined under anesthesia to confirm the preoperative diagnosis. The patient is positioned in the lateral decubitus position on a beanbag, with the use of a padded arm sleeve (STAR sleeve; Arthrex, Naples, FL), distal traction, and a lateral distractor (Arthrex positioner).

A posterior portal is established approximately 1 cm medial and 2 cm distal to the posterolateral acromial border. The arthroscope is introduced and additional portals are established using an outside-in technique under direct visualization with the use of a switching stick. The anterosuperior portal is established first, approximately 1 cm inferior to the clavicle and lateral to the coracoid. The mid-glenoid portal is created just superior to the superior border of the subscapularis. In cases of posterior augmentation, a 7-o’clock portal is created approximately 4 cm off of the posterolateral corner of the acromion under direct visualization. To allow efficient switching of the camera and instruments throughout the case, 8.25-mm cannulas (Arthrex) are liberally used.

Step 3: Diagnostic Arthroscopy and Biologic Preparation

A diagnostic arthroscopy is performed with particular attention to the pathology consistent with the direction and severity of instability, including labral pathology and glenoid bone loss. The arthroscope is switched to the anterosuperior portal, and a 3-mm graduated probe is placed to confirm our preoperative measurements of glenoid bone loss and, if this loss exceeds 20%, to estimate the shape of the augmenting graft. Biologic preparation includes a wide release of the glenoid labrum to ensure its mobility for accurate reduction, especially once the bone block reconstitutes the glenoid shape. This is performed with arthroscopic liberators and ablaters (Arthrex). The glenoid is also biologically prepared with either an arthroscopic rasp or high-speed cylindrical burr (Arthrex), with the goal to create a healthy bed of bleeding cancellous bone, as well as to create a flat surface perpendicular to the glenoid surface to ensure a flush fit with graft placement.
Step 4: Graft Harvest
A single 3-cm horizontal incision is made over the subcutaneous border of the acromioclavicular joint, along the midline of the clavicular axis. The skin and subcutaneous tissues are divided, and a single, thick periosteal flap is raised to expose the joint and distal 6 to 8 mm of the clavicle. A 1-cm-wide saw blade is used to remove the distal 6 to 8 mm of clavicle, and soft tissue is cleaned from around the bone. The graft is placed on the back table, and the periosteal flap is closed with nonabsorbable No. 2 interrupted stitches. The remainder of the soft tissue is closed in 2 layers, and the wound is dressed at the completion of the case (Fig 3).

Step 5: Graft Preparation
The distal clavicle is a versatile graft, with a variable amount of version and an articular surface that is generally 20 mm long × 11 mm wide (Fig 4) (J.M.T., unpublished data, August 2012). We evaluate the graft based on its best fit and cut the graft perpendicular to its articular surface to a width that matches the measurement of bone loss that was determined preoperatively and confirmed arthroscopically. In most cases, 7 to 8 mm of augmentation is normally sufficient to reconstruct up to 30% bone loss, and the graft is fashioned to anatomically fit and replace the loss. At this point, the method of fixation for the graft is chosen. If we decide on screw fixation, the graft is generally not predrilled. Alternatively, we often use suture anchors to secure the graft; in these cases, three 1-mm holes are drilled in a triangular formation, with 2 drill holes, 3 to 4 mm off of the articular surface, at the superior and inferior borders of the graft. The third hole is drilled medial with respect to the graft’s final position on the glenoid (Fig 5).

Step 6: Delivery and Fixation of Graft
Screw Fixation. If the graft is to be fixed with screw fixation, it can be passed either freely into the joint or along a K-wire guide predrilled in the glenoid. The advantage of a free pass is that the graft may fit down a standard mid-glenoid cannula and, once inserted, can be flipped 90° and advanced through the rotator interval inferiorly to match its resting position at the anterior-inferior glenoid, where it can be held in place with a liberator introduced from the posterior portal for anterior bone augmentation. Trying to pass the graft down a K-wire will require a wider exposure through the subscapularis to obtain a proper position. Likewise, the graft can be introduced through a posterior cannula and held in place with a liberator from the mid-glenoid portal. Once in place, a K-wire is drilled as perpendicular as possible to the glenoid articular surface through the graft and across the glenoid. This is usually not difficult for posterior grafts, but with anterior screw placement, the standard mid-glenoid portal may not be sufficient to achieve the appropriate angle. In such situations, an additional 5-o’clock portal is established.
through the subscapularis to ensure the correct trajectory. Extreme care is taken to protect the axillary nerve, and if any doubt exists, it is dissected arthroscopically, visualized, and protected. Once the graft is secured to the glenoid in the appropriate position with the K-wire, it is over-drilled to be fixed by a lag technique with a cannulated, titanium 3.75-mm screw (Arthrex) (Video 1). If the graft is too large to easily be delivered, the cannula can be removed, the portal expanded, and the graft delivered directly. If the proper trajectory cannot be achieved with wire provisional fixation, then one can consider using a suture anchor as an alternative or conversion to an open approach.

Suture Anchor Fixation. If suture anchor fixation is selected, the previously drilled holes in the graft are noted by their measurements from the articular surface and from each other. From these measurements, two 3.0 mm BioComposite SutureTaks (Arthrex) are placed at the superior and inferior borders of the bone defect at the corresponding distances from the articular surface and each other, respectively. All limbs are delivered out of the working portal. One limb from each suture anchor is passed through the medial “conjoined” drill hole. The other 2 sutures are passed, 1 each, through the superior and inferior articular drill holes. These latter sutures are tied in a square-knot fashion over the intervening bone bridge with 3 stacked half-hitches. The excess suture is not cut. Graft delivery is then accomplished through the cannula by a “double-pulley” technique whereby the free limbs are pulled, which brings the graft to the suture anchor eyelets because of the knotted ends of the opposite limbs of suture. Either the graft can be assisted with a switching stick through a cannula or, if the graft is too large, the portal can be enlarged slightly and the graft can be introduced with the assistance of a curved hemostat (Fig 6). Once the slack is pulled out of the anchor system, an arthroscopic knot with 3 additional half-hitches is tied and the graft is secured to the native glenoid across 2 bone bridges in a “double-row” fashion (Fig 7).

Step 7: Incorporation of Native Labrum to Graft

The remaining tails are passed through the native labrum to bring it up to the neo-articular surface with the aid of SutureLassos (Arthrex) and tied down with secondary similar knots (Video 2). If screw fixation has been used, supplemental suture anchors can be placed either through grafts of larger size or at the superior and inferior borders of the graft if there is concern about there being enough accommodating space.
graft. All arthroscopic instrumentation is removed, and the skin is closed and dressed steriley.

**Step 8: Postoperative Rehabilitation**

The patient is placed in a neutral rotation sling for 6 weeks. Pendulums are allowed immediately, and passive motion is started at 3 weeks, with a goal to obtain full range of motion by 8 weeks. At 8 weeks’ follow-up, imaging is obtained, and if the graft looks incorporated, active motion is begun. Strengthening is added at 4 months postoperatively, and return to full activity is assessed at 6 months. Final radiographs are obtained at this point to ensure graft incorporation. Videos 1 and 2 demonstrate both forms of fixation (screw fixation from anterior and suture anchor fixation from posterior).

**Discussion**

The distal clavicle provides a readily available, safe, and free source of osteochondral autograft for the treatment of glenoid bone loss in patients with glenohumeral instability. The anatomy of a distal clavicular graft has several favorable characteristics as a replacement for glenoid bone. In most cases the normal articular cartilage thickness of the distal clavicle is comparable with the thickness of the recipient glenoid cartilage. The distal clavicle is also a corticocancellous graft, which provides a broad healing surface and allows for secure fixation against the native glenoid with either a screw or suture anchor construct.

Currently, the gold standard in augmenting the glenoid is a Latarjet transfer. Although we do not compare the 2 techniques in this report, there are several points worthy of mention. The obvious advantage of the distal clavicle is that it supplies replacement of autograft articular cartilage, which the coracoid does not provide. Furthermore, the graft can be placed either anterior or posterior, whereas coracoid transfers are limited to the anterior side of the bone. The current technique does not provide the subscapularis sling effect that is provided in a coracoid transfer, which has been shown to be an important part of the stabilizing mechanism of a Latarjet transfer.17

Other techniques have been described to address glenoid bone loss, and although we did not directly compare the distal clavicular autograft with them, there are potential strengths and weaknesses of this technique in comparison with others (Table 1). Iliac crest autograft has shown excellent clinical outcomes in the treatment of even large glenoid bone loss.13 In the previous series, Warner et al.13 reconstructed defects up to 35 mm in length, which is longer than what the distal clavicle can provide. Thus there may be limits to the size of glenoid defect that the distal clavicle can reconstruct. The distal clavicle does provide the potential advantage of articular cartilage to the glenoid restoration. However, in their series, Warner et al. saw no joint space narrowing or evidence of osteoarthritis at 6 months’ follow-up. It is unclear whether longer follow-up would have resulted in significant arthritis from contact between the humeral articular cartilage and iliac crest bone graft. Both techniques have the potential for donor-site morbidity, but this seems to be relatively minor in either setting.13,18

A host of osteochondral allografts have been used to reconstruct the glenoid.12,14,19 These techniques offer articular cartilage replacement without donor-site morbidity, and concerns about graft resorption20 have not yet been shown in the glenoid. The main advantages of the distal clavicular autograft over these techniques include lack of antigenicity, decreased infection risk, lower cost, and greater availability. The costs of fresh osteochondral allografts can run in the tens of thousands of dollars, and wait times can exceed 6 to 9 months. The distal clavicle offers an immediately available alternative that has no associated graft charge. The acromioclavicular joint should be evaluated for osteoarthritis, which may make it less attractive in comparison with osteochondral allograft options, but should always be favorable in this regard compared with the coracoid.

We present the use of a distal clavicular autograft for the reconstruction of glenoid defects in the setting of glenohumeral instability (Table 2). This graft choice provides an immediately available and low-cost method for anatomic reconstruction of glenoid bone loss. The graft both restores the articular contour of the native glenoid and matches its native cartilage thickness. It compares favorably with the coracoid in terms of thickness and bulk, providing a corticocancellous buttress for both healing and mechanical strength. We have used this graft successfully in a pilot cohort of 8 clinical cases and consider it a promising option in the treatment of glenohumeral instability with glenoid

**Table 1. Comparison of Graft Types for Treatment of Glenoid Bone Loss in Shoulder Instability**

| Cartilage source | Distal Clavicular Autograft | Coracoid Transfer | Iliac Crest Transfer | Allograft |
|------------------|-----------------------------|-------------------|----------------------|----------|
| Versatility      | Patient’s own               | None              | Anterior or posterior| Anterior or posterior |
| Graft rejection  | None                        | None              | Anterior or posterior| Potentially |
| Cost             | Free                        | Free              | Free                 | Expensive |
| Availability     | Readily                     | Readily           | Readily              | 6-9 mo   |
| Sling effect     | None                        | Subscapularis     | None                 | None     |
### Table 2. Pearls, Pitfalls, and Solutions for Each Surgical Step

| Operative Step                  | Pearl                                                                 | Pitfall                                                                                           | Solution                                                                 |
|--------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Step 1: Preoperative workup    | Ensure an en face view of the glenoid is available: MRI or CT.         | 2-Dimensional CT can be formatted to give misleading levels of bone loss.                          | Obtain 3-dimensional CT with humeral subtraction or MRI with standardized technique. |
| Step 2: Positioning and portals | Use a lateral position; optimize the space between portals on the same side. | The patient is oriented too anterior, creating difficult anterior access; wire too vertical for screw fixation. | “Airplane” the bed to ensure that the body is perpendicular to the floor; use a 5-o’clock portal for more accurate screw placement. |
| Step 3: Diagnostic arthroscopy and biologic preparation | Wide liberation of the labrum is critical for incorporation of the graft and subsequent labral repair. | Failure to be aggressive with the burr to ensure a flush perpendicular glenoid edge can result in a poor graft match. | Ensure a flush cut with an arthroscopic biter, a burr, or even a small osteotome to obtain a clean cartilage perpendicular edge. |
| Step 4: Graft harvest          | Tailor the size of the graft to the previously measured defect to minimize the length of the graft. | The articular surface of the distal clavicle is variable—if one fails to appreciate its orientation, the graft can be compromised. | Visualize the articular surface, and use a saw to cut perpendicular to this. |
| Step 5: Graft preparation      | Precise measurement of the drill holes from the articular surface helps ensure a flush fit when reduced with anchors. | The version of the articular surface is variable; ensure that the cut is perpendicular to this—it may be different than the long axis of the clavicle. | If the version is significantly off-axis, consider inverting the graft because it will reverse the version. |
| Step 6: Graft delivery and fixation | Do not hesitate to remove the cannula and pass the graft freely through the soft tissues through a split in the muscle. | If the K-wire is too vertical, graft mismatch or fracture is possible. | Convert to the suture anchor technique if the insertion angle of the screw cannot be safely fixed; conversion to an open procedure is always an option to be kept in mind. |
| Step 7: Native labrum incorporation | Use standard suture-passing techniques; use accessory portals for suture management. | Improper tissue release can impede labral reduction on the new glenoid edge. | If suture is not easily passed, additional anchors in the native glenoid above and below the graft can be used to bolster the labral reconstruction. |
| Step 8: Postoperative rehabilitation | Go slow: you are dependent on fracture healing; the first 8 wk is critical. | Prolonged immobilization leads to atrophy and dyskinesia. | Proper balance between protection and mobilization is a must; rely on the therapist or athletic trainer to take a team approach to recovery. |

CT, computed tomography; MRI, magnetic resonance imaging.
bone loss. Larger studies with longer-term follow-up are warranted to evaluate this technique.

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