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Sports Medicine

Arthroscopic Distal Clavicle Glenoid Augmentation: An Ideal Graft Option

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Recent work has demonstrated the importance of addressing bone loss in the surgical management of anterior shoulder instability. Multiple options exist for reconstituting the glenoid articular surface to include anatomic vs nonanatomic techniques, and utilizing autograft vs allograft material. An ideal approach would provide an autograft source of osteochondral material that is well matched to the defect, readily available, cost effective, and with minimal comorbidity. The distal clavicle autograft provides such an option. The graft has a cortical and cancellous side for direct fixation, and is amenable to arthroscopic techniques. Recent work has demonstrated the utility of this graft noting that the distal clavicle graft provides an anatomic restoration of the glenoid radius with an articular cartilage cap comparable in thickness to that of the native glenoid. Along with a summary of the pertinent literature, this review article outlines the rationale, indications, and technical notes for this procedure.

KEYWORDS Bone loss, instability

Introduction

Bone loss has emerged as a critical issue in the treatment of glenohumeral instability. Its presence has been reported in up to 72% of instability cases and is known to influence the outcome of surgical intervention.[9,24]

Traditionally, bone loss greater than 20% has been shown to adversely affect biomechanical stability and clinical results.[23] Utilizing Lo and Burkhart's "inverted pear" concept of glenoid bone loss morphology, a defect as small as 6-8 mm can result in recurrent instability following soft tissue stabilization.[6] Even in the absence of recurrence, subcritical bone loss of 13.5% can be detrimental to clinical outcomes. The recognition and treatment of bone loss are critical factors to ensure the successful management of anterior shoulder instability. There are multiple approaches to addressing bone loss in the shoulder. Each approach has advantages and disadvantages unique to its application.

The distal clavicle represents an intriguing option for addressing this problem. As an autograft, it is generally readily available, at very low cost, and has zero risk of transmittable disease. It offers the advantage of providing a true osteochondral graft, which may provide advantages over traditional bone transfers. It is harvested from an established technique that has been practiced for generations, as the Mumford procedure, which has demonstrated very little donor site morbidity.[1]

Surgical Treatment Options

There are number of options described to treat bone loss in shoulder instability. These include coracoid transfers such as the Latarjet and Bristow procedures, iliac crest graft bone grafting, and osteochondral allografts. Factors such as graft size, the presence or absence of articular cartilage, availability, immunocompatibility, and cost are all considerations in graft selection, and are compared in Table 1. In addition to restoring the bone and cartilage loss seen in erosive glenoid bone loss, the ideal graft should also be readily available, free, and sourced without donor site morbidity.

Coracoid Bone Autograft

Since its original description in 1954, coracoid transfer is still considered the gold standard technique for glenoid bone loss treatment. In addition to restoring a significant amount of glenoid bone, this technique offers the advantage of a capsular reconstruction and an inferior subscapularis myodesis via the conjoined tendon in abduction, external rotation, which

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Table 1 Comparison of the Various Approaches for Bone Loss in the Shoulder

Graft Choice Characteristic	Distal Clavicle Autograft	Latarjet	Distal Tibial Allograft	Iliac Crest Bone Graft
Availability	+	+	-	+
Cartilage source	+	-	+	-
Cost	+	+	-	+
Donor site morbidity	+	+	+	-
Rejection/infection	+	+	-	+
Sling effect	-	+	-	-

has become known as the "triple blocking effect." Biomechanical studies demonstrate that this procedure is effective in restoring shoulder stability, and clinical outcomes studies have demonstrated low recurrence rates and excellent patient-reported outcomes.[2-5]

The technique is limited by a complication rate approaching 30%,[20] and the potential for up to 60% of the graft may undergo osteolysis.[6,7] In addition, the transferred graft lacks articular cartilage. This drawback has been cited as a potential reason for osteoarthritis development after Latarjet surgery, which has been reported in up to 62% of cases.[8]

Iliac Crest Bone Autograft

In 2006, Warner et al reported autogenous tricortical iliac crest bone graft to be effective in treatment of recurrent instability in setting of glenoid bone loss.[9] They reported excellent short-term results with a low complication rate. The technique is readily available, nearly free, and is an autograft source of bone,[9] but is nonarticular, and may lead to secondary osteoarthritis which has been reported after this procedure.[10,11] An additional drawback is the potential for donor site morbidity, described in up to 100% of cases. Other complications such as local infection (14%) and anterior superior spine fracture (3%) incidences have been reported.[9,12,13]

Distal Tibia Allograft

Distal tibial allograft provides an osteochondral source for glenoid bone loss. It performs biomechanically similar to the iliac crest bone graft, and the technique has been shown to produce a better articular pressure profile than that of the Latarjet. Furthermore, authors have reported that glenoid arc articular conformity can be reproduced with this graft source.[14,15] Promising clinical outcomes have been published with equivalence to the Latarjet technique.[16]

This technique, however, has some limitations. Decker et al reported that the chance of a random pairing of a distal tibial allograft matching the radius of curvature of a recipient glenoid is low.[17] The possibility of graft resorption due to immunologic response has not been investigated, but this concern has plagued allograft usage in other transplant settings.[18-21]

The largest limitation to this method is its logistic application. The cost of a fresh osteochondral allograft can exceed tens of thousands of dollars, and there can be a significant wait time which can exceed 6 months. Fresh allograft preparation requires a minimum of 14 days for infectious disease screening, and chondrocyte viability has been shown to significantly drop after 28 days postmortem. This requires surgeons to perform transplantation in roughly a 2-week window, which can be difficult for both patient and surgeon in many facilities.[6]

Justification for the Distal Clavicle Osteochondral Autograft

Recently, Tokish et al described a technique of employing the distal clavicle as a fresh, osteochondral autograft in the treatment of glenoid bone loss. The distal clavicular autograft (DCA) is the first reported option that provides an autograft source of bone and cartilage to replace similar tissue loss on the glenoid. It has the advantage of being readily available and sourced with minimal cost. It can also be placed arthroscopically as well as utilized in both anterior and posterior cases of bone loss (Table 2). While donor site morbidity has not been reported with this specific technique, graft harvest is similar to the Mumford technique which has reported to give excellent or good outcomes in up to 85% of treated patients. Researchers have previously suggested excising 5-10 mm of distal clavicle to optimize results, which is similar to our technique.[22]

Recent work has shown that the DCA can, on average, reproduce up to 44% of the glenoid radius, which compares favorably to the 31% restoration achieved with the traditional coracoid transfer.[23] Moreover, the distal clavicle graft is capped with articular cartilage which is within 1 mm of native glenoid cartilage thickness. It is a fresh, unprocessed tissue source that is immediately transplanted, so concerns about chondrocyte viability, immunorejection, or infection are minimized. Petersen et al examined contact pressure differences between the clavicular

Table 2 Advantages of the Distal Clavicle for Use in Glenoid Bone Loss

Characteristic	Advantage
Autograft	No risk of disease transmission or graft vs host issues
Osteochondral	Cartilage source immediately available, and similar to the thickness of the native glenoid
Cost	Free
Availability	No wait time for tissue banks, serologic testing or processing
Versatility	Can be used for anterior or posterior bone loss in the glenoid

grafting and congruent arc coracoid transfer techniques and determined a more favorable profile for the DCA.[24]

Preoperative Preparation

DCA augmentation is indicated in patients with recurrent instability above subcritical thresholds, ideally when glenoid bone loss is the primary contributor to failure. Patients with significant collagen loss such as cases where there is poor capsular tissue, Ehlers-Danlos syndrome, or significant humeral bone loss are relative contraindications to this technique. All patients will undergo a standard history and physical examination, as well as preoperative advanced imaging such as CT or MRI. Glenoid bone loss is calculated in every patient, and this calculation aids in determining the operative approach to the patient according to the "on-track, off-track" concept.

Positioning and Portal Placement

After the induction of general anesthesia, examination under anesthesia is performed to confirm the preoperative diagnosis. The patient is positioned in the lateral decubitus position on a beanbag with a padded axillary roll. A padded arm sleeve (STAR sleeve; Arthrex, Naples, FL) with balanced suspension is employed for limb positioning.

A standard 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. To allow efficient switching of the camera and instruments throughout the case, 8.25-mm cannulas are routinely used, or a flexible 12 × 4 mm Passport cannula (Arthrex, Naples, FL) for graft passage. If screw fixation is to be employed, a percutaneous "Portal of Halifax" is used. We do not use this for graft passage, but just for screw fixation.[25]

Diagnostic Arthroscopy and Biologic Preparation

Viewing from the posterior portal, the arthroscope is switched to the anterosuperior portal and a 3 mm graduated probe is placed to confirm our preoperative measurements for glenoid bone loss. Biologic preparation includes a wide release of the glenoid labrum to ensure its mobility for accurate reduction over and around the transplanted graft. Tissue is mobilized with arthroscopic liberators and ablators. The glenoid is also biologically prepared with either an arthroscopic rasp or high-speed cylindrical burr, with the goal to create a healthy bed of bleeding cancellous bone, as well as to create a flat surface perpendicular to the glenoid margin to ensure a flush fit during graft placement. Often, an osteotome is used to provide a clean and perpendicular cut, which aids in the matching of the recipient glenoid to the clavicle bone graft (Fig. 1).

Graft Harvest

A 3 cm horizontal incision is made over the subcutaneous border of the acromioclavicular joint, along the midline of the clavicular longitudinal axis. The skin and subcutaneous tissues are divided, and full-thickness periosteal flaps are raised to expose the joint. A 1 cm wide saw blade is used to remove the distal 1 cm of clavicle, and soft tissue is cleaned from around the bone. The graft is placed on the back table, and the harvest site flaps are 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.

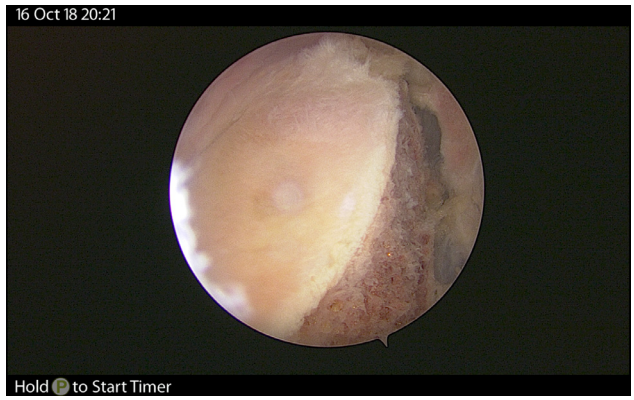

Figure 1 An osteotome is used to prepare the native graft to ensure that a flush surface is provided on the recipient glenoid to ensure excellent fit. (View of a left shoulder viewing from an anterosuperior portal.)

Graft Preparation

The distal clavicle provides a versatile osteochondral graft, with a variable amount of version and an articular surface that is generally 19 mm long and 13 mm wide[23] (Fig. 2). The graft is evaluated based on its best fit and cut perpendicular to its articular surface to a width that matches the recipient glenoid defect. Seven 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. We have used both suture anchor and screw fixation. For larger grafts in harder bone, screw fixation is generally chosen. In these cases, a single drill hole is made in the center of the graft 5 mm from the articular surface. Additional 1 mm drill holes can be used to pass sutures from adjacent suture anchors placed in the native glenoid. If suture anchor fixation is chosen, two 1 mm drill

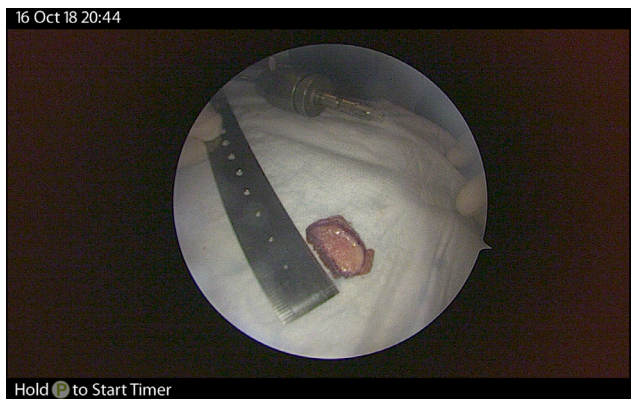

Figure 2 The distal clavicle autograft is harvested, sized, and prepared.

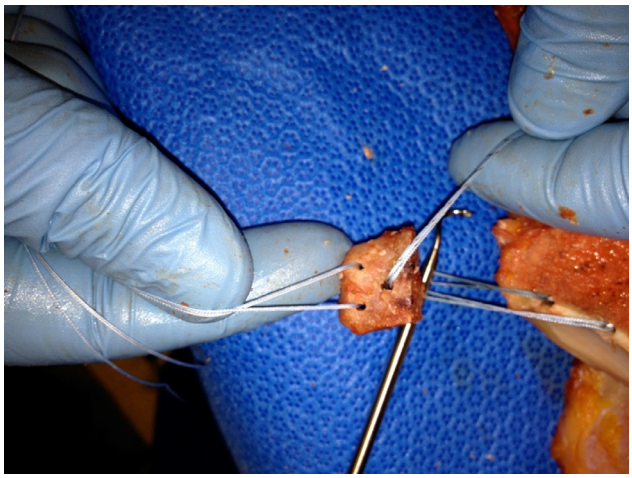

Figure 3 In the suture anchor technique for fixation, 3 holes are drilled to allow the graft to be secured rotationally stable.

holes are positioned 3-4 mm away from the articular surface at the superior and inferior borders of the graft, which correspond to the planned offset position of the suture anchors or screws on the glenoid defect surface. For larger grafts, a third drill hole may be placed further from the articular surface to create an inverted triangle configuration which provides additional rotational stability in the sagittal plane (Fig. 3).

Delivery and Fixation of Graft

If screw fixation is to be used, the graft is passed freely into the joint through the rotator interval/anterosuperior portal (Fig. 4). The advantage of this pass is that the graft may fit down a standard cannula (Arthrex 12 × 3 mm Passport, Naples, FL) portal and held in place with a clamp aligning the articular surface of the graft with that of the native glenoid. Once in place, we have adopted creating a far medial, so-called "Halifax portal" that allows placement of a small drill guide through the pectoralis major muscle, above the conjoined tendon and parallel to the glenoid.[25] This portal has been shown to be a safe distance from the axillary and musculocutaneous nerves, and avoids the need to do a subscapularis split approach. From posteriorly, a switching stick is placed parallel to the glenoid. It is passed across the joint and just superior to the subscapularis tendon. The switching stick is advanced anterior to the conjoined tendon until it can be visualized under the skin, typically in the region of the pectoralis muscle. The skin is incised similarly to an arthroscopy portal, and the switching stick is advanced through the skin. A small cannulated drill guide is advanced over the switching stick, and brought back into the joint. The switching stick is then removed from posteriorly, and the drill guide is placed against the distal clavicle graft and positioned such that the graft is held in a reduced position (Fig. 5). A kwire is then advanced through the drill guide, the graft, and the glenoid (Fig. 6). A measurement is taken of the length, and the wire is overdrilled with a cannulated drill. A single 3.5 cannulated screw is then passed over the kwire and tightened to compress the graft against the native glenoid (Fig. 7). The previously passed sutures are then tied down to

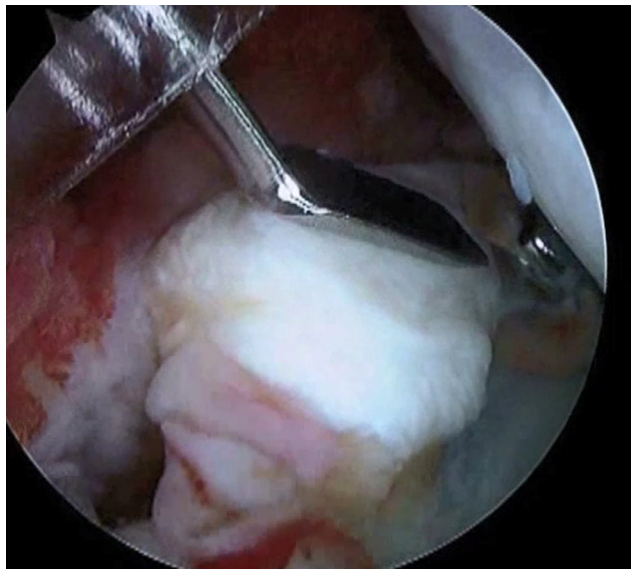

Figure 4 The distal clavicle autograft is passed through the anterosuperior portal and maneuvered into position using an elevator from the front and back.

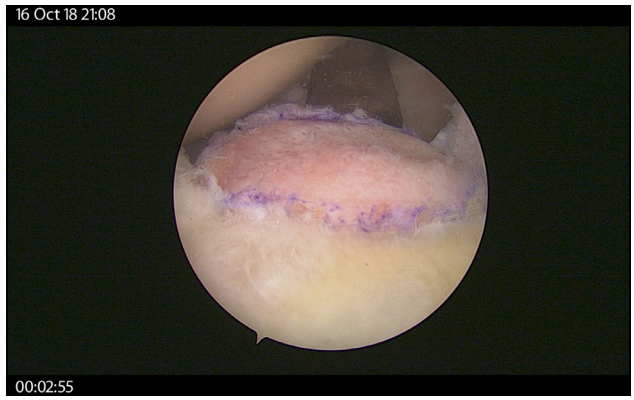

Figure 5 A drill guide is passed percutaneously through the Halifax portal to hold the distal clavicle graft in place.

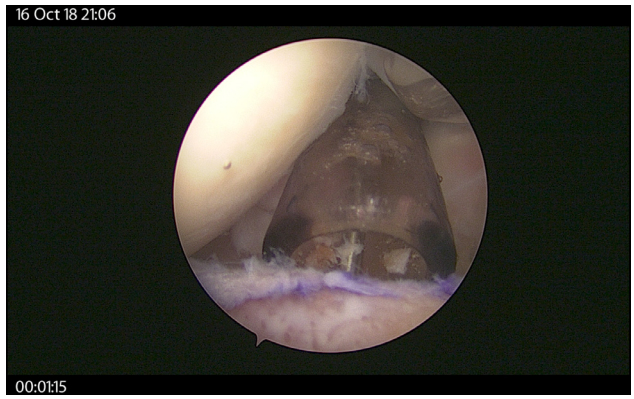

Figure 6 A kwire has been passed through the Halifax portal providing a guide for placement of the screw.

the native labrum to provide additional rotational fixation and reestablish the native capsule/labrum connection to the glenoid.

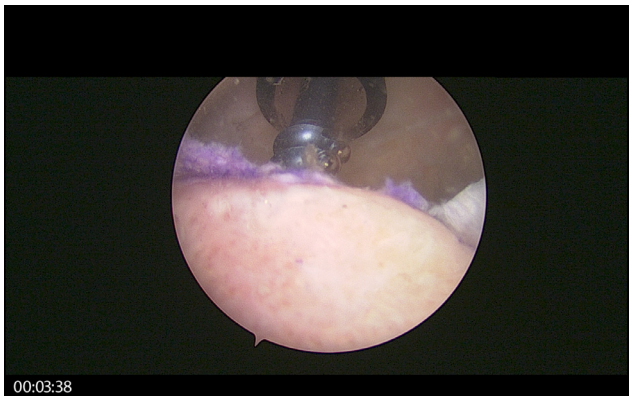

Figure 7 The finished distal clavicle graft is visualized compressed with a 3.5 cannulated screw.

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, Naples, FL) 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, mid-glenoid portal, and shuttled through the corresponding holes in the graft. The graft is then manually introduced into the joint with a hemostat or small Alis clamp through either a flexible Passport cannula (Arthrex, Naples, FL), half-slotted metal cannula employed as a sled, or freely through a cleared soft tissue portal. The graft is manipulated, positioned over the glenoid bone defect, and held securely in place with a liberator or probe from the posterior portal. One limb from each anchor is then tied to the other outside the mid-glenoid cannula for "double-pulley" delivery and fixation. The remaining free suture limbs from each anchor are then pulled to advance the pretied knot down the cannula and over the prepositioned bone graft. Once the slack is pulled out of the anchor system, an arthroscopic square-knot is tied over the intervening bone bridge with 3 stacked half-hitches on alternating posts. Care is taken to ensure the graft remains in anatomic position while knots are tied (Fig. 8).

Incorporation of Native Labrum to Graft

The tied suture limbs are then passed through the native labrum in horizontal mattress fashion to bring it up to the neoarticular surface with the aid of retrograde suture lassos, and tied down with secondary stacked knots (Fig. 9). At conclusion, all arthroscopic instrumentation is removed, and the skin is closed and dressed sterilely.

Postoperative Rehabilitation

The patient is placed in a neutral rotation sling for 6 weeks. Pendulums are allowed immediately, and passive motion is started at 6 weeks, with a goal to obtain full range of motion by 10 weeks. At 12 weeks' follow-up, imaging is obtained, and if graft healing is noted, 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 complete graft incorporation.

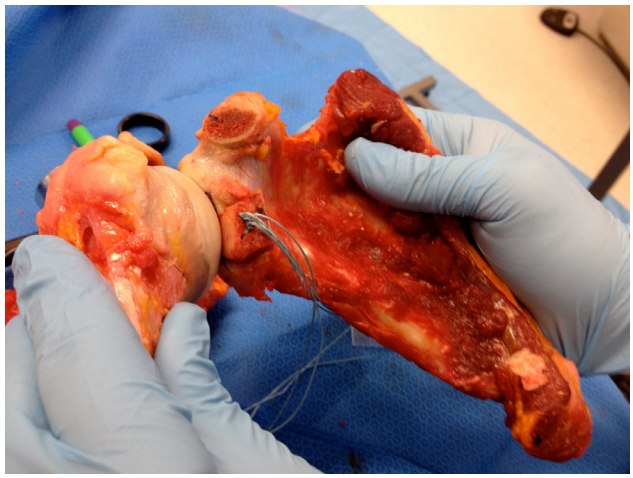

Figure 8 A cadaveric demonstration of the distal clavicle autograft fixed with suture anchor construct.

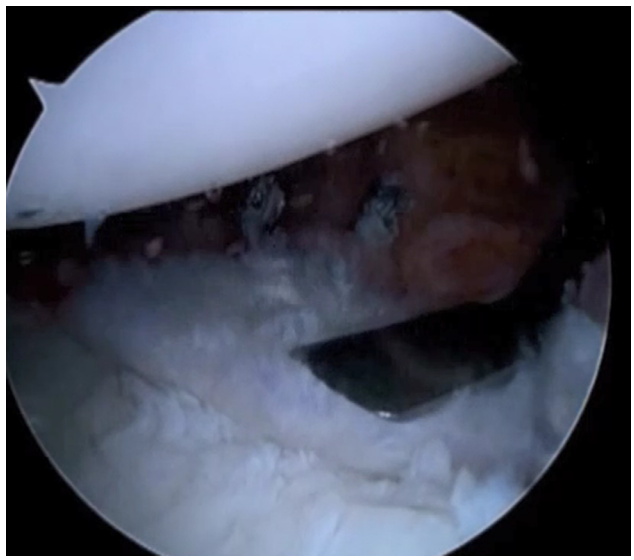

Figure 9 The distal clavicle autograft is secured and the sutures are repassed through the labrum for a double-row fixation.

Conclusion

Glenoid bone loss in the setting of anterior shoulder instability can be addressed using a variety of techniques, each with unique advantages and limitations. We have found the distal clavicle autograft to be an intriguing choice for glenoid bone loss. This autograft provides a readily available and almost no-cost method for osteochondral reconstruction of glenoid bone loss. The graft restores both the radius of the native glenoid and offers articular cartilage comparable in thickness to that of the native glenoid. It also compares favorably to the coracoid in terms of arc of restoration, providing a corticocancellous buttress for glenoid restoration. Further study is needed to ensure that clinical results perform to their expected level.

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