Technical Note

Anatomic Osteochondral Glenoid Reconstruction for Recurrent Glenohumeral Instability With Glenoid Deficiency Using a Distal Tibia Allograft


Abstract: The treatment of glenoid bone loss in the setting of recurrent shoulder instability remains a challenge. This is because of the nonanatomic nature and resultant incongruous joint resulting from most bony augmentation procedures. We present a novel technique for the management of glenoid bone deficiency by using a fresh osteochondral distal tibial allograft. We have found that the distal tibia has excellent articular conformity to unmatched humeral heads, fits nearly anatomically on the distal two thirds of the glenoid, is composed of dense weight-bearing cortical and metaphyseal distal tibia bone, and provides for a cartilaginous surface for which the humeral head to articulate. This article describes the technique, initial results, and postoperative findings with the use of a distal tibia allograft (the lateral portion of the distal tibia) for the treatment of glenoid bone deficiency (mean loss of 30%) in a series of 3 patients. Key Words: Glenoid bone loss—Shoulder instability—Inverted-pear glenoid—Shoulder bone defects—Bone deficiency—Allograft—Osteoarticular—Osteochondral.

The diagnosis and treatment of glenohumeral instability in the setting of glenoid bone loss remain a challenge. This is because of the loss of bony articular conformity of the joint\(^1\)\(^-\)\(^6\) and loss of a resistance to shear stress.\(^7\)\(^-\)\(^10\) Glenoid bone loss most commonly occurs in a clinical setting along a line parallel to the long axis of the glenoid,\(^4\)\(^,\)\(^11\)\(^-\)\(^16\) and as the amount of glenoid bone loss approaches 15% to 20% of the anterior glenoid surface, alterations in biomechanical stability of the glenohumeral joint are noted.\(^3\)

The recognition of glenoid bone loss as a potential mechanism of failure in glenohumeral instability surgery has been recently highlighted with multiple studies calling attention to this often underappreciated problem.\(^1\)\(^-\)\(^4\),\(^7\)\(^-\)\(^17\)\(^-\)\(^21\) Both arthroscopic techniques\(^6\),\(^7\),\(^16\),\(^20\),\(^22\)-\(^27\) and open techniques\(^1\)\(^,\)\(^2\) have been described to treat glenoid bone loss. Although the amount of glenoid bone loss that requires surgical reconstruction remains an issue of debate, there is a growing body of evidence to suggest that the status of the glenoid remains paramount to obtain a stable shoulder after a glenohumeral instability procedure.\(^3\),\(^7\),\(^18\),\(^28\)-\(^30\)
Although controversial, bony reconstruction of the glenoid is usually recommended if there is significant bone loss (usually >20% to 25%), in primary instability surgery, and in revision situations. The current techniques for bony reconstruction of the glenoid include several variations of the coracoid transfer, iliac crest autograft, and allograft glenoid tissue. The concerns regarding coracoid transfer include a nonanatomic repair of the glenoid defect, poor reconstitution of the glenoid arc, an extra-articular nonanatomic repair of the capsulolabral tissues, and no reconstitution of the chondral surface. Fresh glenoid osteochondral allograft reconstruction of the glenoid has also been described; however, concerns over graft availability, donor contamination, expense, and fresh glenoid graft harvest techniques have made this a challenging prospect.

We describe a novel technique of an osteochondral allograft procedure for bony defects of the glenoid using a fresh distal tibia. Initial data have shown the curvature and concavity of the lateral aspect of the distal tibia to be highly congruent with the area of glenoid bone loss. In addition, the fresh distal tibia allograft contains dense weight-bearing corticocancellous bone with a robust cartilaginous surface that nearly matches the native curvature of the glenoid, allowing for excellent screw fixation and host-graft incorporation. In this article we describe the rationale, surgical technique, and early outcomes of 3 patients with mean glenoid loss of 30% treated with fresh osteochondral allograft transplant for glenoid bone deficiency.

**BIOMECHANICAL PILOT DATA**

Initial data in 2 fresh-frozen shoulder and distal tibia specimens (non–size-matched specimens, randomly selected from 4 different donors) have shown that excellent conformity to the humeral head was achieved in all cases (Fig 1). The degree of conformity was noted throughout a full arc of motion in multiple unmatched humeral head and distal tibia specimens. The conformity of the distal tibia to the glenoid is profound, with a nearly identical radius of curvature across multiple nonmatched specimens (Fig 2). In addition, with pilot data from distal tibia–grafted cadaveric specimens with a simulated 30% clinical defect, we have shown that the articular conformity was restored to nearly the intact state.

**FIGURE 1.** Cadaveric specimens of (A) distal tibia viewed from the lateral aspect showing concavity and radius of curvature similar to that of (B) native glenoid.
Patient Setup and Operative Approach

After induction of adequate anesthesia (regional block when possible with or without general anesthesia), the patient is placed in the beach-chair position with the head elevated approximately 40°. Two blue towels are placed behind the medial border of the scapula between the patient and the bed to ensure that the glenoid and scapula do not rotate anteriorly. This ensures an optimal trajectory for working on the anterior aspect of the glenoid and allows for an easy trajectory of screw fixation placement for the glenoid allograft. The operative arm may be placed in a commercially available arm holder or left free and controlled on an adjustable operating room tray.

A deltopectoral approach is used with an instability-type incision, which starts near the tip of the coracoid process and extends directly inferiorly to the superior axillary fold for a distance of approximately 7 cm.
Once the deltopectoral interval is identified, the cephalic vein is retracted laterally, and the fascia overlying the conjoined tendon is identified and incised with Metzenbaum scissors. The subfascial plane of the deltoid is also mobilized. The lateral aspect of the conjoined tendon is identified and incised just lateral to the muscle belly of the short head of the biceps. A retractor is placed underneath the lateral aspect of the conjoined tendon as well as underneath the deltoid, with care taken to avoid excessive medial retraction and protect the musculocutaneous nerve.

The subscapularis (SSc) tendon is easily identified and then incised in line with the fibers longitudinally in the middle portion to perform an SSc tendon-splitting approach. A pointed retractor is placed within the SSc split to allow access to the capsule. Care is taken to identify the capsule of the glenohumeral joint and tease the structure medially where it is more easily separated from the SSc tendon. In the revision situation, this may prove more difficult, and if unable to be easily identified and separated, the SSc is incised along with the capsule to expose the glenohumeral joint.

If the capsule is identified, it is elevated as far medially off the glenoid neck in a subperiosteal fashion and then tagged. It is also separated from the SSc tendon medially and also extended laterally; however, this becomes more difficult as the dissection proceeds in the lateral direction because of the close adherence of the capsule to the SSc. The capsule is tagged with No. 2 nonabsorbable suture, and the glenohumeral joint is identified. Glenohumeral rotation, as well as gentle lateral traction by an assistant, may be necessary to facilitate exposure of the joint. Alternatively, instead of an SSc-splitting approach as described here, anywhere from the superior two thirds to the entire SSc may be taken off the humerus to expose the glenohumeral joint. We have found the SSc-splitting approach to be adequate to obtain sufficient exposure to the glenoid neck. Caution is warranted to avoid splitting the SSc medial to the coracoid because iatrogenic injury to the nerve supply to the SSc may result.

Once the anterior glenoid is identified, the amount of glenoid bone loss is confirmed from a preoperative 3-dimensional CT scan. If there is 25% to 30% loss, this generally indicates that around 8 to 9 mm of anterior glenoid bone will need to be augmented. The anterior glenoid is then prepared. Any labral tissue is elevated and dissected medially, with care taken to protect the axillary nerve, because the labrum will be repaired to the anterior aspect of the allograft. Occasion-
distal tibia is marked, and cuts are made with a thin 0.5-inch sagittal saw while an assistant holds the graft in place with 2 towel clamps (Fig 4). Irrigation is used to keep the allograft cool while making the cuts. To accommodate any slope changes of the glenoid, the allograft may be cut at various angles. For our 3 patients, between 8 and 11 mm of tibial bone was used (measured on the articular surface). The superior-most and inferior-most aspects of the distal tibial allograft are rounded to the shape of a glenoid by use of a small sagittal saw. Two 1.6-mm K-wires are placed in the allograft bone at a 45° angle to the articular surface to facilitate placement and positioning within the joint (Fig 5). The allograft is then transferred to the native glenoid to assess fit, conformity, and angle relative to the articular surface. If necessary, additional cuts can be made to improve graft conformity. Once graft fit is confirmed, two small 1.6-mm K-wires are placed (not in the location of screw placement) to temporarily hold the graft.

The graft is then fixed with two 3.5-mm fully threaded cortical screws (between 32 and 38 mm in length) by use of a lag technique (Fig 6). If the capsule and labrum are available for repair, they are then stitched back down to the screw heads (with or without washers) before final tightening. The SSc is then closed with standard techniques (approximation with No. 2 nonabsorbable suture) and remaining closure completed. We have not used a drain if the deep wound remained dry. The patient’s extremity is placed in an abduction sling.

Postoperatively, the patient undergoes pendulum exercises and passive range of motion in the scapular plane for the first 2 weeks, followed by progressive

![Figure 5.](image1.png)

**Figure 5.** Two K-wires (1.6 mm) are placed in the tibial allograft at a 45° angle to the glenoid surface to facilitate positioning in the glenoid defect.

![Figure 6.](image2.png)

**Figure 6.** (A) Intraoperative image showing glenoid defect. (B) Image obtained after the distal tibia allograft has been affixed in place with two 3.5-mm cortical screws.
ing on successful graft incorporation (Fig 7), functional range of motion, and strength recovery.

DISCUSSION

We have performed distal tibia osteochondral bony augmentation for glenoid deficiency in 3 patients with excellent success. The merits of this procedure are the potential prevention of morbidity after coracoid transfer and nonanatomic placement of the conjoined tendon. In addition, there is the potential added benefit of restoration of the articular surface of the glenoid, with the ability to provide for an anatomic fit by customizing the graft size for the defect.

The distal tibia allograft provides several advantages over a glenoid allograft. Tibial allografts are much more readily available than fresh glenoid allografts because of greater graft contamination issues with centrally harvested structures (the glenoid is close to the central portion of the body, where higher rates of contamination occur after graft harvest because of the close location to the gastrointestinal tract and lungs); the dense weight-bearing bone of the distal tibia can easily accommodate drill holes as well as offer the potential for improved bony incorporation because of the dense nature of the trabecular matrix. Finally, the distal tibial allograft has been shown by us to have excellent conformity to the native glenoid and can be customized to fit the defect in a nearly exact fashion. In addition, the cartilage that is placed in the defect is believed to be robust weight-bearing cartilage, and there is no donor-site morbidity associated with the procedure.

The current techniques for coracoid transfer (Latarjet procedure) have described using the lateral aspect of the coracoid as the glenoid surface or the inferior surface. Both techniques offer bony reconstruction options for glenoid deficiency but lack the ability to conform to the glenoid and are limited by the amount of bone available for grafting.

There are potential concerns regarding allograft bone incorporation to the glenoid because of the uncontained nature of the bone graft technique; however, the iliac crest and other bone procedures for the shoulder joint have shown reliable healing. In addition, we have shown that a frozen fibula allograft has incorporated well in patients treated for bone loss, which we used before the advent of the tibial allograft procedure. In all 3 of our patients, we have shown CT scan–proven bony incorporation and remodeling without resorption.

CONCLUSIONS

We have presented a small series of patients treated for recurrent shoulder instability and glenoid bone loss with a fresh distal tibial osteochondral allograft. The advantages of the fresh distal tibia osteochondral allograft are improved graft availability (over fresh glenoid specimens), the ability to have a cartilaginous interface between the humerus and glenoid allograft, and excellent glenoid arc articular conformity shown by initial pressure-mapping studies. In addition, there is no need to obtain sizing films, and unmatched distal tibias have been shown to fit well among this small group of patients. Additional work is needed to assess the long-term efficacy of this novel allograft technique; however, early results and biomechanical studies are promising.

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REFERENCES

2. Burkhart SS, De Beer JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: Significance of the inverted-pear glenoid and the