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Glenoid Reconstruction With Distal Tibia Allograft for Recurrent Anterior Shoulder Instability

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Abstract: Anterior glenoid bone loss is present in nearly all cases of recurrent anterior glenohumeral instability. Treating glenoid bone loss in the setting of recurrent instability is challenging, and often, soft tissue stabilization procedures in isolation are inadequate. The nonanatomic, incongruous joint resulting from most bony augmentation procedures has motivated investigators to find an alternative solution. Recently, the use of fresh distal tibia allograft has been reported as an anatomic, osteoarticular reconstructive option for restoring the glenoid arc and maintaining glenohumeral congruency. This article describes the surgical technique for glenoid reconstruction with distal tibia allograft for recurrent anterior shoulder instability. [*Orthopedics.* 2017; 40(1):e199-e205.]

Recurrent anterior shoulder instability results from a variety of factors, including young age (<22 years), male sex, increased number of preoperative dislocations, patient positioning at the time of surgery, and the use of fewer than 3 anchors for repair.[1] Importantly, humeral head loss, glenoid bone loss, or both have been implicated in 90% to 100% of cases of recurrent instability following soft tissue stabilization.[1-6] Anterior glenoid bone deficiency disrupts the articular congruency of the glenohumeral joint,[7-12] resulting in an overall loss of resistance to shear stress.[2,13-15] With repetitive loads on the shoulder during athletic activities or just activities of daily living, even small degrees of bone loss can become problematic, ultimately resulting in increased attritional bone loss. As the volume of glenoid bone loss increases beyond 15% to 20% of the anterior glenoid surface, the biomechanical stability of the joint becomes increasingly compromised, leading to further instability.[8,16]

Historically, structural reconstruction of the glenoid has been recommended for defects larger than 20% of the glenoid surface.[6] The volume and morphology of bone loss is typically assessed via en face sagittal computed tomography scans of the glenoid with the humeral head subtracted. Available options for glenoid reconstruction include autograft with either coracoid transfer (Bristow, Latarjet)[17,18] or iliac crest bone graft, as well as allograft reconstruction. Although long-term outcomes following coracoid transfer are encouraging regarding maintaining stability, the nonanatomic, noncartilaginous nature of the reconstruction and its resulting nonanatomic reconstitution of the glenoid arc is concerning regarding the early development of glenohumeral arthritis. Given the young patient population in which these procedures are typically performed, operative strategies aimed at joint preservation in addition to joint stability are certainly preferred.

The use of fresh distal tibia allograft for reconstruction of glenoid bone defects in the setting of shoulder instability has recently been described.[4,19-21] Early cadaveric studies have identified a nearly identical

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Figure 1: Incision for distal tibia allograft reconstruction. Note that this incision is more medial than for a standard deltopectoral approach to the shoulder.

radius of curvature among the distal tibia and the glenoid, even among cadaveric specimens that are unmatched. Similarly, the distal tibia conforms nicely to the humeral head throughout a full range of motion, again among both matched and unmatched cadaveric specimens. Early biomechanical work has revealed meaningful improvement in glenoid contact pressure, contact area, and peak force when reconstructing both anterior and posterior glenoid defects with distal tibia allograft.[4,22,23] Importantly, and different from other glenoid grafting options such as the Latarjet transfer, distal tibia allograft contains a thick, robust cartilaginous surface. Thus, it provides not only a static restraint to shoulder instability following reconstruction, but also potentially a biologic solution for anatomic joint preservation. Although distal tibia allograft reconstruction for anterior glenoid bone defects is a relatively novel surgical technique, early case reports from multiple centers are encouraging, as are 4-year outcomes from the authors' institution. The authors describe their preferred technique for fresh distal tibia allograft reconstruction.

Surgical Technique

Patient Positioning

Following the induction of anesthesia (regional with or without general), the patient is placed in the beach-chair position with the head elevated to 40°. A bump is then placed behind the medial border of the scapula, which improves the ability of the surgeon to access the anterior aspect of the glenoid. The authors prefer to leave the arm free with the use of a padded Mayo stand; however, a commercially available arm holder may also be used.

Diagnostic Arthroscopy

For all cases, the authors perform a diagnostic glenohumeral arthroscopy prior to beginning the open portion of the procedure using standard posterior viewing and anterior mid-glenoid working portals. This allows them to document and potentially treat any symptomatic concomitant pathologies. They do not routinely employ the arthroscopic remplissage technique to treat concomitant Hill-Sachs lesions of the humeral head because they find that Hill-Sachs lesions rarely track medial to the glenoid rim following glenoid rim reconstruction.

Incision and Approach

Bony landmarks, including the coracoid process, are palpated to allow for appropriate incision placement. The anticipated incision is then drawn from the tip of the coracoid process, extending inferiorly along the axillary fold for approximately 7 cm (**Figure 1**). This incision will allow for a modified deltopectoral approach to the joint, being slightly more medial than the skin incision used for a standard deltopectoral approach. A No. 10 scalpel is used through the skin, and a combination of Metzenbaum scissors and Bovie electrocautery is used to dissect through the subcutaneous tissue until the fascia of the deltoid and pectoralis major is identified. The cephalic vein is located in the interval between the deltoid and the pectoralis major, often identified via a strip of fat, and is retracted out of the field bluntly; most often, the vein is retracted laterally with the deltoid. The interval between the deltoid and the pectoralis major is bluntly mobilized, and retractors (Gelpi or Weitlaner) are placed to expose the fascia overlying the conjoined tendon, which is subsequently incised with Metzenbaum scissors. The lateral aspect of the conjoined tendon is visualized and retracted medially as the deltoid continues to be retracted laterally. At this stage, the Kolbel retractor, placed over the top of the coracobrachialis, helps to retract the deltoid laterally. In order to avoid traction injuries to the musculocutaneous nerve, care is taken to avoid excessive medial retraction.

Deep Exposure

At this point, the subscapularis is visualized crossing the operative field, impeding access to the joint. Several options are available regarding gaining joint exposure deep to the subscapularis. The authors prefer to perform a subscapularis split at the junction of the superior and middle thirds as popularized by Burkhart and De Beer. Gentle external rotation of the arm puts the subscapularis on stretch, and the superior and inferior borders of the muscle can be easily identified. The planned incision for the subscapularis split is then drawn out with a marking pen at the junction of the superior and middle thirds. The authors next split the muscle sharply, in line with its fibers, using a No. 15 scalpel. This exposes the underlying anterior glenohumeral joint capsule. Care is taken to avoid cutting the subscapularis medial to the coracoid process because iatrogenic injury to the nerve supply to the subscapularis can occur at this location. Alternatively, a subscapularis takedown from the lesser tuberosity can be used to gain exposure to the joint.

Blunt finger dissection and often an elevator (Freer or Cobb) are then used to mobilize the subscapularis fibers off of the joint capsule both medially and laterally. Typically, there are more adhesions

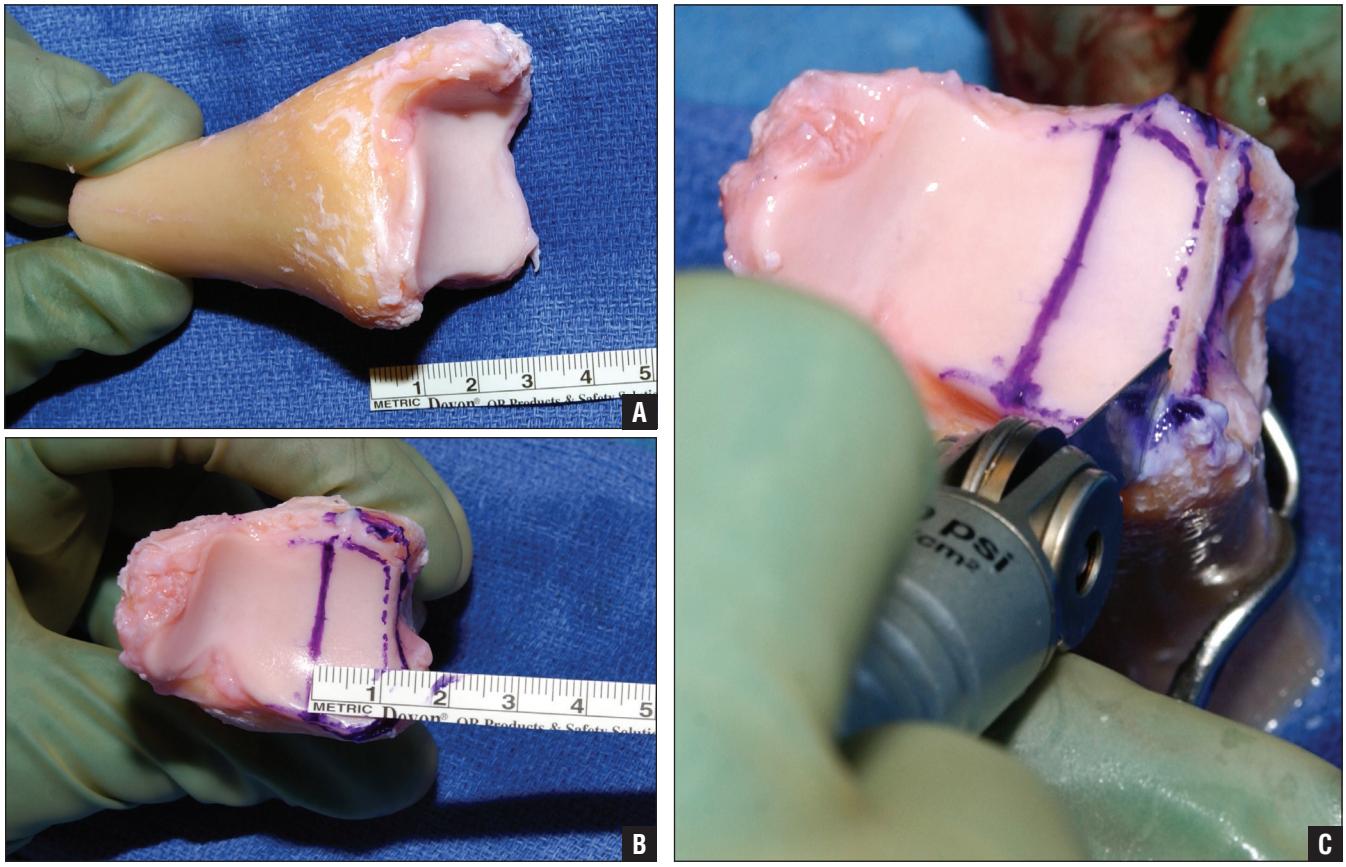

Figure 2: Distal tibia allograft preparation, including the entire fresh graft prior to harvest (A), measurement of the graft to fit the glenoid defect (B), and cutting of the graft with a thin 0.5-inch sagittal saw (C).

between the subscapularis and the joint capsule laterally, and care must be exercised while separating the tissue planes. A medial-based T capsulotomy is then performed in line with the subscapularis split, beginning approximately 1 cm medial to the glenoid rim, and the capsule is tagged with a heavy No. 2 nonabsorbable suture to aid in later repair. The capsule is then gently elevated off of the glenoid neck medially in a subperiosteal fashion using a No. 15 scalpel.

Glenoid Visualization and Preparation

A Fukuda retractor is placed along the humeral head, and an anterior glenoid retractor is used medially to provide visualization of the glenohumeral joint. In addition, a blunt-tipped 90° Gelpi retractor can be used to improve exposure. Attention is then turned to the anterior aspect of the glenoid rim. Any remaining anterior-inferior labral tissue is mobilized and debrided, although this is typically fragmented and nonviable due to multiple previous recurrent instability episodes. It is especially important to remove any soft tissue medially on the glenoid that may interfere with allograft placement. Of note, care should be taken to protect the axillary nerve with medial and inferior dissection. This is especially pertinent if the patient has undergone prior open surgery, such as a prior Latarjet reconstruction, as scar tissue is likely to disrupt the normal anatomy. The anterior glenoid bone defect is then fully visualized and its surface is prepared down to a bleeding surface with a high-speed burr. The surgeon should attempt to create a uniform surface with the burr so that the allograft can fit the defect congruently. After defect site preparation, a ruler is used to confirm the size of the defect to assist with final allograft preparation.

Distal Tibia Allograft Preparation

At any point during the case, the allograft can be prepared on the back table. In the setting of anterior glenoid bone deficiency of approximately 25% to 30%, approximately 8 to 9 mm of anterior glenoid bone augmentation is necessary.[12] Preoperative planning with computed tomography scans as well as intraoperative findings via arthroscopy and direct defect visualization should guide allograft sizing. An entire fresh distal tibia is provided, and the authors harvest the lateral one-third of the articular portion of the graft for anterior glenoid reconstruction (**Figure 2**). The

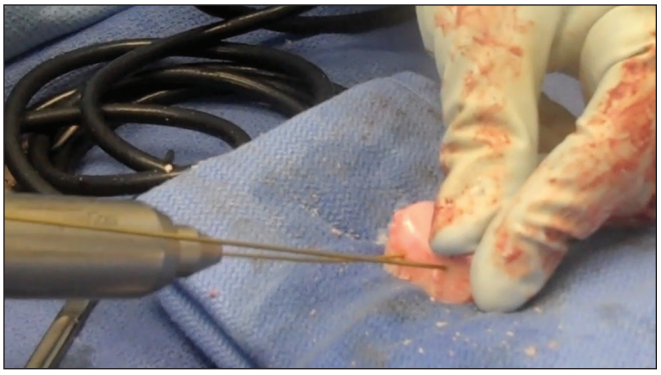

Figure 3: Placement of 2 K-wires to act as joysticks for graft placement into the glenoid defect.

fresh distal tibia allograft is obtained from the donor within 24 hours after donor death and then processed and maintained fresh at 4°C (never frozen) until the time of implantation. No blood group matching or tissue typing is used. A marking pen is used to delineate the anticipated cuts, and the graft is secured in a steady position prior to making the cuts. The authors prefer to use 2 towel clamps on either end of the graft held securely by an assistant. The medial aspect of the harvested graft (again harvested from the lateral aspect of the distal tibia) is the surface of the graft that will contact the glenoid rim, while the lateral-most aspect of the harvested distal tibia will become the anterior-most aspect of the glenoid rim. A 0.5-inch sagittal saw is used to make the cuts as cool irrigation fluid is continuously applied. The graft should be cut at a slight angle, typically between 10° and 20°, to match the concavity of the glenoid. For most patients, the final graft size will be approximately 25 to 30 mm from superior to inferior, 6 to 10 mm from anterior to posterior, and 10 mm deep (medial down to glenoid neck). Per surgeon preference, the superior and inferior-most aspects of the graft can be contoured with a rongeur and/or the saw to match the recipient site on the glenoid. After confirming that the graft is the appropriate size and shape, which often requires several back-and-forth trials with intervening microadjustments to the graft and/or recipient site surfaces, pulsatile lavage should be used to wash the graft to remove any marrow elements.[24,25] Next, 2 smooth 1.6-mm K-wires are placed in the allograft at a 20° angle to the articular surface, but away from the anticipated location of the final fixation screws. The K-wires can be used as joysticks to allow for easier graft placement into the glenoid defect (**Figure 3**). The authors then assess the appearance of the allograft along the anterior glenoid rim one final time to confirm satisfactory graft fit, conformity, and angle relative to the articular surface.

Graft Fixation

Holding the graft flush to the glenoid in the desired location, the authors again assess graft position from multiple angles. Final adjustments to the graft size or shape to ensure the best fit possible on the glenoid can still be made at this point if needed. Once the graft anatomy and anticipated position on the glenoid are satisfactory, the graft is secured to the glenoid. Several different fixation techniques can be employed, including the use of cannulated screws and the use of cortical screws.

Cannulated Technique. Prior to securing the graft to the glenoid, a coracoid drill guide is secured around the allograft and a 4.0-mm drill is used to create 2 parallel holes through the coracoid process. The holes should be centered on the graft and perpendicular to the prepared surface. The graft is then placed flush to the glenoid and the parallel drill guide is used for placement of 2 nonthreaded 1.6-mm K-wires through the guide, through the holes in the coracoid, and into the glenoid to the posterior glenoid cortex. The drill guide is then removed. The 2.75-mm drill is placed over the guidewire, through the previously drilled hole in the graft, and penetrated through the anterior (near) cortex of the glenoid. This process is done for both K-wires. Two 3.75-mm cannulated screws are then placed over the guidewires and secured in place by hand.

Noncannulated Technique. The previously placed K-wires are driven into the glenoid to hold the graft in the desired orientation. No drill guide is used, with the drill holes being made freehand instead. A 3.5-mm drill is used to penetrate the graft in the location of the anticipated screws, which should be approximately 3 to 4 mm apart. A 2.5-mm drill is then placed through the previously drilled hole in the graft and penetrated through the anterior (near) cortex of the glenoid. This process is done for both. Next, two 3.5-mm fully threaded noncannulated interference screws are placed bicortically across the glenoid in lag technique, permitting graft compression against the anterior glenoid. The inferior screw is placed first. These screws are placed approximately 3 to 4 mm apart, essentially equally spaced from the superior and inferior aspects of the graft (**Figure 4**).

Regardless of technique, the screws are typically between 32 and 36 mm long and can be secured in place with small washers that do not extend beyond the graft surface. In the setting of a large graft (greater than 12 mm long), 3 screws may be used (**Figure 5**). If available, any remaining labral tissue is repaired down to the screw heads with a heavy nonabsorbable No. 2 suture prior to final screw tightening. The capsulotomy is then repaired with interrupted figure-of-8 stitches using the previously placed tag suture (No. 2 FiberWire; Arthrex Inc) as a guide for reapproximation.

Closure

After capsulolabral repair (when tissue is available), the

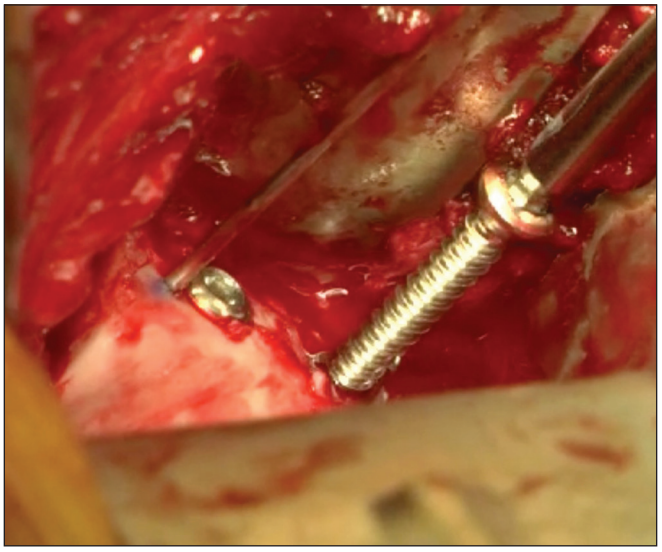

Figure 4: Allograft insertion with two 3.5-mm bicortical screws (right shoulder).

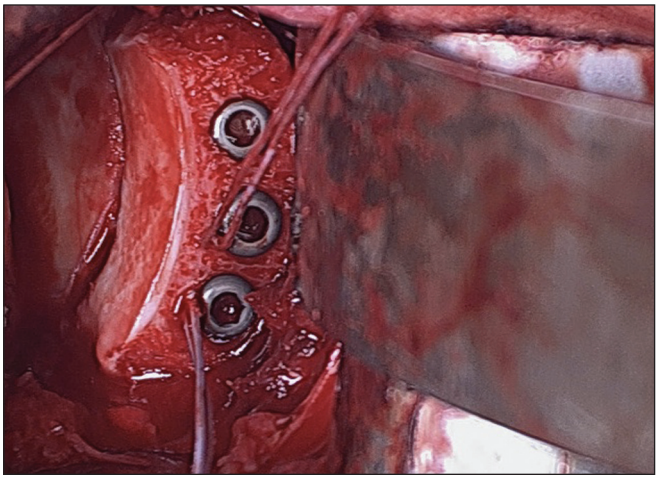

Figure 5: Final construct. In this case, 3 screws were used (right shoulder).

subscapularis split is closed with a heavy nonabsorbable No. 2 suture with interrupted figure-of-8 stitches. The remaining soft tissues and skin are closed in standard fashion. The authors do not typically place a drain, but one can certainly be used if preferred by the surgeon. A standard abduction sling is used, and the authors allow most patients to be discharged the same day as surgery. The authors' rehabilitation and postoperative clinic visit protocol is outlined in **Table 1**.

Pearls, Pitfalls, and Complications

Table 2 contains technical pearls and pitfalls to assist with performing distal tibia allograft reconstruction for anterior glenoid instability with anterior glenoid bone loss. Complications are listed in **Table 3**; however, given that this procedure is relatively new and few clinical outcome studies are available, the potential for complications other than those listed remains. At a minimum, several of the albeit rare complications associated with other arthroscopic and open techniques for shoulder stabilization (ie, Latarjet) are likely to also be associated with distal tibia allograft reconstruction.

Conclusion

Anterior glenoid reconstruction with distal tibia allograft is a viable alternative solution for patients with symptomatic, recurrent anterior glenohumeral instability with significant glenoid bone loss. Similar to the Latarjet procedure, glenoid reconstruction with distal tibia allograft provides a stable final construct; in contrast, however, it may prevent the morbidity associated with coracoid transfer. The potential long-term biologic benefits of the osteoarticular allograft regarding joint preservation are promising, but long-term clinical and imaging studies are needed to determine the efficacy and safety of this novel allograft technique.

Table 1

Rehabilitation Protocol After Distal Tibia Allograft Reconstruction for Recurrent Anterior Instability

Weeks	Rehabilitation Protocol
0-2	Abduction sling at all times
	Pendulum exercises
	Passive range of motion in scapular plane
	Radiographs at first postoperative visit to assess graft position
2-4	Abduction sling at all times
	Pendulum exercises
	Progression to passive range of motion out of scapular plane
4-6	Abduction sling at all times
	Active-assist range of motion, progression to active range of motion
6-8	Discontinue sling
	Gentle strengthening
	Radiographs by week 8 to assess graft position
8-16	Continued strengthening
16+	Sport-specific exercises
	Return to sport/work by 6 months
	Radiographs prior to return to sport/work to ensure successful graft incorporation

Table 2

Pearls and Pitfalls of Distal Tibia Allograft Reconstruction for Recurrent Anterior Instability

Make incision slightly more medial (in the axillary fold) than the standard deltopectoral incision
Avoid excess medial retraction on the conjoined tendon —> protect the musculocutaneous nerve
If unable to bluntly separate the subscapularis from the capsule, incise the subscapularis along with the capsule to expose the joint
Do not split the subscapularis medial to the coracoid —> protect the nerve to the subscapularis
Be cautious with inferior dissection on the glenoid —> protect the axillary nerve
Be meticulous with exposing the capsule and make every attempt to preserve sufficient tissue to allow for repair after the distal tibia allograft is secured in place —> the capsular tissue will ultimately be repaired to the distal tibia allograft via the screws/washers
For capsular repair, suture anchors may also be used —> place these in the native glenoid bone superior and inferior to the graft, as opposed to in the distal tibia allograft itself
Ensure flush and congruent distal tibia allograft placement on the anterior glenoid such that there is sufficient bone-to-bone contact to allow for graft incorporation and healing
Be meticulous with repairing the subscapularis split —> use nonabsorbable suture

Table 3

Potential Complications of Distal Tibia Allograft Reconstruction for Recurrent Anterior Instability

Neurologic injuries —> traction related
Vascular injuries —> cephalic vein during dissection
Infection —> if concerned, obtain comprehensive laboratory workup, including serum complete blood count with differential, erythrocyte sedimentation rate, C-reactive protein, and intra-articular aspirate with synovial complete blood count with differential and culture
Be sure to hold cultures in the laboratory for at least 10 days to assess for *Propionibacterium acnes*
Arthrofibrosis
Painful hardware
Recurrent instability
Allograft rejection
Allograft failure to incorporate
Systemic disease transmission from allograft

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