Technical Note

Talar Allograft Preparation for Treatment of Reverse Hill-Sachs Defect in Recurrent Posterior Shoulder Instability

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Abstract: Reverse Hill-Sachs lesions (rHSLs) after chronic posterior shoulder instability are important to recognize and treat appropriately. Treatment options for posterior instability with rHSL in the current literature are primarily based on percentage of humeral bone loss. In cases of moderate (25% to 50%) anterolateral humeral head bone loss, fresh osteochondral allografts are preferred. Recent literature has indicated that the talus serves as a robust grafting alternative site for the humeral head, as the talar dome shows high congruency and offers variable sizes. The purpose of this Technical Note is, therefore, to describe our technique for talus allograft preparation for the treatment of a large rHSL that highlights precise cutting anatomy, sizing options, and use of orthobiologics to ensure excellent talus union to the native humeral head surface.

Introduction

Stability of the glenohumeral joint is dependent on the articulation of the scapular glenoid and humeral head. In the case of an instability event, the humeral head is forced out of the glenoid in an anterior- or posterior-inferior direction. Traumatic episodes such as this can cause compression of the postero- or anterolateral region of the humeral head, known as a Hill-Sachs lesion (HSL) or reverse HSL (rHSL), respectively. While incidence of HSLs have been reported as a high as 100% in patients with recurrent anterior shoulder dislocations,[1] rHSLs are detected in roughly 39% of dislocations posteriorly.[2]

At present, algorithms for posterior instability intervention reflect many of the same principles as anterior instability: consideration of the arc of rotation of the humeral head with respect to the glenoid surface. Therefore, surgical strategies include either optimizing the surface arc of rotation (and, therefore, total arc of stability) by restoration of the humeral head (e.g., osteochondral graft), or restriction of the arc of rotation by constraining the motion of the humeral head relative to the glenoid (e.g., reverse-remplissage).[3] Treatment options for posterior instability with rHSL in the current literature are primarily based on the percentage of humeral bone loss: posterior capsulolabral repairs or plications for <25% bone loss, and iliac crest structural bone grafting or distal tibial allografting, reverse remplissage, balloon humeroplasty,[4] hemiarthroplasty,[5] or a talar osteochondral allograft wedge[6] for patients with 25% to 50% humeral head bone loss. Resurfacing and replacement options should be reserved for the

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The authors report the following potential conflicts of interest or sources of funding: M.T.P. reports personal fees from Arthrex, the Joint Surface Foundation, SLACK, Inc., Arthrosurface, during the conduct of the study; he is an editorial or governing board member of Arthroscopy, Knee, Orthopedics, and SLACK, Inc.; and is a board or committee member of AANA, AAOS, AOSSM, ASES, ISAKOS, the San Diego Shoulder Institute, and the Society of Military Orthopedic Surgeons. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received March 24, 2022; accepted May 19, 2022.

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2212-6287/22408
https://doi.org/10.1016/j.eats.2022.05.009

older patients who are less active or have severe arthritis in which >50% of the humeral head articular surface is affected.[1]

In cases of moderate (25% to 50%) anterolateral humeral head bone loss, fresh osteochondral allografts are preferred. Recent literature has illustrated that osteo- and osseocartilaginous intervention both maximizes anatomic restoration of the humeral head, while minimizing disruption of healthy native bone. Allografting for humeral head defects have also reported lower resorption rates than other intervention options.[7,8] While use of fresh humeral head allografts has shown success in repairing humeral head lesions, concerns over donor availability and risk of graft harvest contamination have justified the search for alternative allograft sites.[9] Recent literature has indicated that the talus serves as a robust grafting alternative site for the humeral head, as the talar dome shows high congruency and offers a maximum size of 30 × 10 mm for a single graft.[6,10-12] Moreover, anthropometric properties of talus are similar to the native humeral head and the radius of curvature (ROC) of the glenoid.[11]

Although techniques using talus allograft for humeral head reconstruction have been described in the previous literature, it is essential to provide an outlined preparatory allograft procedure that optimizes bone union. The purpose of this Technical Note is, therefore, to describe our technique for talus allograft preparation for the treatment of a large rHSL that highlights precise cutting anatomy, sizing options, and use of orthobiologics to ensure excellent talus union to the native humeral head surface.

Surgical Technique

A detailed video with demonstration of the surgical technique described in the following may be reviewed (Video 1). The pearls and pitfalls associated with the talus allograft preparation technique are listed in Table 1. Advantages, risks, and limitations of this surgical preparation are also listed in Table 2.

Lesion Sizing

A comprehensive preoperative evaluation is conducted to accurately evaluate the presence, volume, and orientation of the rHSL. While radiographs may be used to identify the rHSL, supplemental imaging, including computed tomography (CT) scans and magnetic resonance imaging should also be used to provide better 3-dimensional evaluation and quantification of the compression fracture.[6]

The shoulder is placed in an abducted, externally rotated position to ensure proper evaluation of the rHSL. Once appropriately visible, the lesion is outlined and an oscillating saw with a 1.3-cm-wide blade is used for further bony excision of the lesion to form a pie-shaped defect. This will produce a lesion that is shape-fit with the subsequently prepared talus allograft. Once preparation of the proximal humerus defect is complete, lesion length, depth, and width are measured.

Table 1. Pearls and Pitfalls of Talus Allograft Preparation for Anatomic Head Reconstruction

Pearls	Pitfalls
Preoperative planning with advanced imaging (CT-scan with 3D reconstruction) is crucial	Inaccurate measurement of the defect preoperatively may result in inadequate allograft size.
It is essential that the allograft is kept cool and is copiously irrigated to avoid risk of thermal necrosis of the cartilage and the underlying subchondral bone.	High learning curve
All cut outline should be 2–5 mm larger than the desired graft length to compensate for an error of measurement and the kerf of the saw blade.	Potential of saw blade injury
The orange slice configuration must be kept in mind during shaping of the allograft for an optimal fitting.	
A biologic treatment such as autologous conditioned plasma and platelet-rich-plasma is encouraged	

Graft Preparation: Width and Length Sizing

Talar dome from a donor source (JRF Ortho, Centennial, CO) is obtained on the back table. The talar dome should be matched with the humeral defect. First, the cartilage margin at the medial and lateral aspect of the allograft is marked. This will match the preoperatively templated width of the proximal humerus defect

Table 2. Advantages, Risks and Limitations of Talus Allograft Preparation for Anatomic Head Reconstruction

Advantages	Risks and Limitations
The fresh talus allograft is identical to the radius of curvature of the humeral head	Improper graft sizing and positioning that fails to restore the anatomic glenohumeral arc of motion
Restoration of humeral head sphericity and its arc of rotation against the glenoid surface	Risk of nonunion
Offers a dense, weight-bearing cartilaginous surface to create a more profound articular contact with the glenoid, and stable fixation	Availability of talus allograft
Precise cutting anatomy, sizing options, and orthobiologics ensure excellent talus union to the native humeral head surface	Learning curve

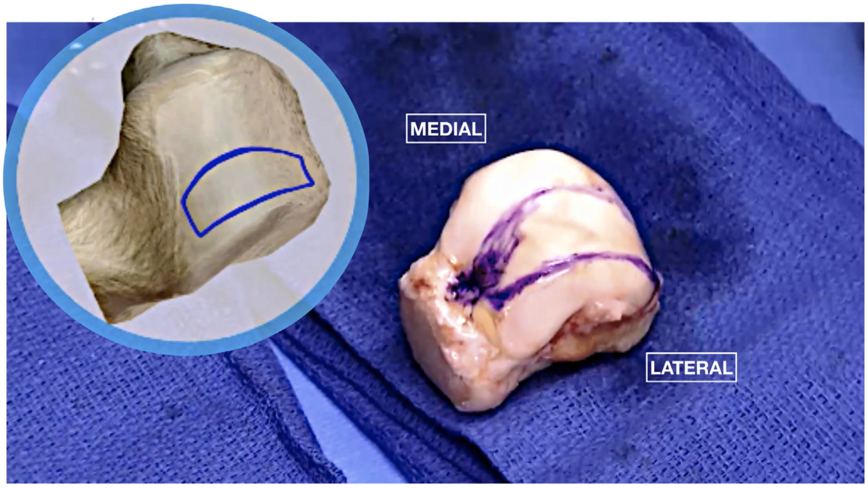

Fig 1. The talus allograft (right) on the preparation table. The cartilage margin is marked at the medial and lateral aspect of the talus allograft (medial talar dome), matching the preoperative template width of the proximal humerus defect (graft width and length sizing).

(Fig 1). An additional line is drawn from medial to lateral along the anterior aspect of the allograft, which will mark the desired graft length. While the assistant and surgeon hold the allograft firmly in place with a Kocher clamp, a sagittal saw is used to remove the preoperatively templated portion of the medial talar dome as the initial medial sagittal cut (Fig 2). With the allograft kept in the same position, a second cut is made along the lateral talar dome as the initial lateral sagittal cut. The excess lateral portion of the talar dome is removed (Fig 3). During this time, it is essential that the allograft is kept cool and is copiously irrigated to avoid risk of thermal necrosis of the cartilage and the underlying subchondral bone. The final cut outline should be 2−5 mm larger than the desired graft length to compensate for the kerf of the saw blade and potential erroneous measurement and allow for better overall customization of the graft to the defect. After the initial medial and lateral sagittal cuts are completed, the talus allograft is rotated. The longitudinal cut is made in line to the axis of the talus to remove the excess portion of the predefined graft (Fig 4).

Graft Preparation: The Cut Graft Contour and Depth Sizing

Attention is turned back to the exposed medial portion of the talar dome. The cut graft contour should be rechecked with the humeral defect (Fig 5). The preoperatively templated maximum depth is then marked. The final cut will form an "orange wedge," which is similar to the shape of the previously prepared humeral defect. The anatomical landmarks for the final cut are as follows: the junction of the articular surface of the talar dome and the talar neck for the anterior anatomical landmark; and the posterior margin of the talar articular cartilage for the posterior anatomical landmark (Fig 6).

Graft Drilling and Final Adjustments for Implantation

A parallel guide with a finger projection is angled toward the anterior portion of the allograft. A 2.4-mm Kirschner wire (K-wire) is inserted into the graft. Next, the graft is inserted into the humeral defect and marked with a marker pen, ensuring that an area of error for fitting the graft of the defect is included. The graft is then brought back to the table and finally

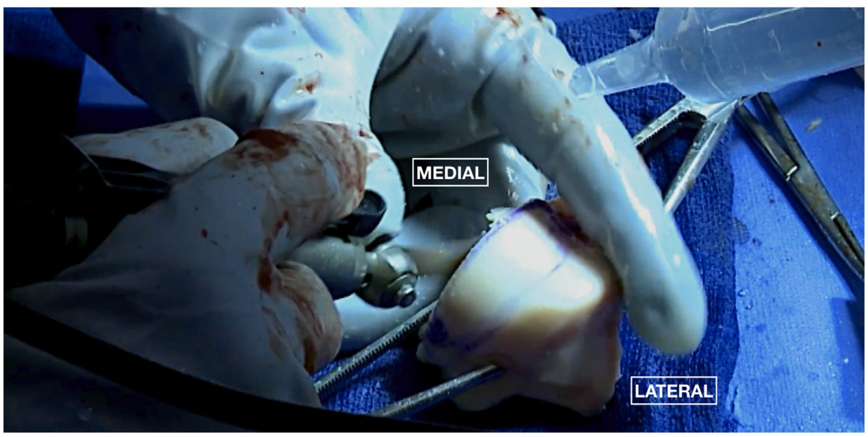

Fig 2. The talus allograft (right) on the preparation table. Using Kocher clamps to firmly hold the allograft in place, an initial medial sagittal cut is made on the medial talar dome (Initial medial sagittal cut).

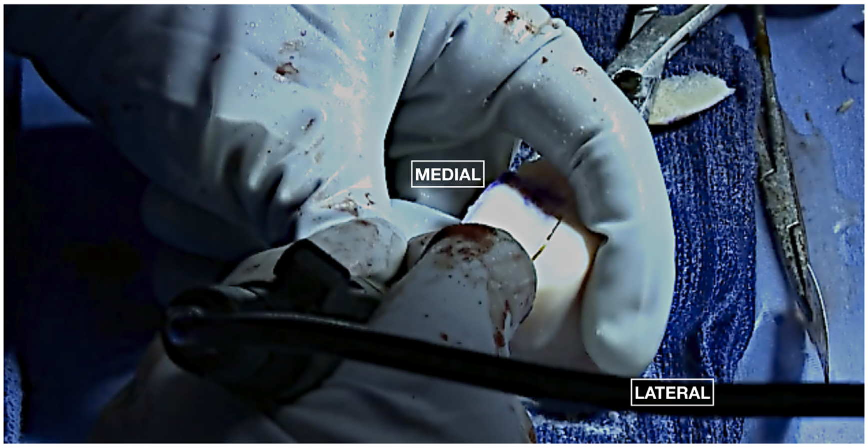

Fig 3. The talus allograft (right) on the preparation table. With the allograft in the same position, a second cut is made along the lateral aspect of the medial talar dome (initial lateral sagittal cut).

adjusted for implantation. For optimal fitting of the allograft into the humeral head, the orange wedge configuration must be kept in mind during allograft shaping. The humeral head defect can be prepared using a rasp to ensure perfect graft fit. The allograft fit should be tight enough to stand in place without manual impaction (Fig 7).

Irrigation and Insertion

A pulse lavage can be used on the allograft for at least 10 minutes to remove remnant bone marrow and mitigate the risk for cross-reactivity and inflammatory responses following transplantation. The graft is then soaked in a combination of autologous conditioned plasma and platelet-rich-plasma using a double syringe system (Greyledge Technologies, Vail, CO) (Fig 8). Prior to graft insertion, 2 or 3 2.4 -mm K-wires are drilled through the center portion of the graft, aiming directly toward the center of the humeral head. Once the graft is positioned appropriately, the K-wires are advanced to provisionally fix the graft into the proximal humerus. A cannulated drill is used over the K-wires, and three separate 3.0-mm Acutrak headless compression titanium screws (Acumed, Hillsboro, OR) are placed in a unicortical fashion to definitively fix the graft into the defect. Care should be taken to confirm that the screws are not violating the articular surface.

Discussion

This Technical Note outlines our technique for talus allograft preparation for treatment of a large rHSL. Advantages of this preparatory technique include precise cutting anatomy, sizing pearls, and use of orthobiologics to ensure excellent talus union to the native humeral head surface.

Notable treatment options for rHSLs include humeral head reconstruction, tissue filling (reverse-remplissage type procedure), disimpaction, and prosthesis replacement. To establish an appropriate treatment algorithm for humeral head bone loss in the setting of posterior glenohumeral instability; however, appropriate lesion sizing is imperative. In their multicenter case series of 102 posterior instability patients, Moroder et al.[13] distinguished posterior shoulder instability into three severity subgroups: dislocation, locked dislocation, and chronic locked dislocation. The authors determined that rHSL size, depth, and medialization significantly

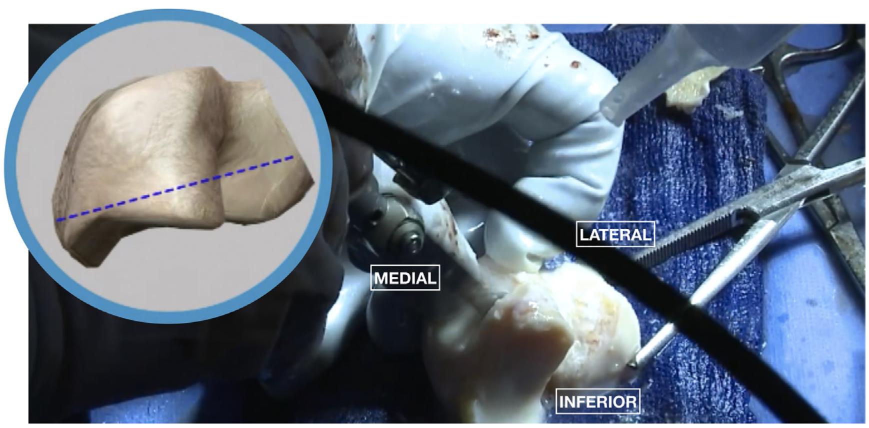

Fig 4. The talus allograft (right) rotated 90° on the preparation table. After the initial medial and lateral cuts are made, the allograft is rotated and a longitudinal cut is made in line to the axis of the talus to remove the excess portion of the predefined graft.

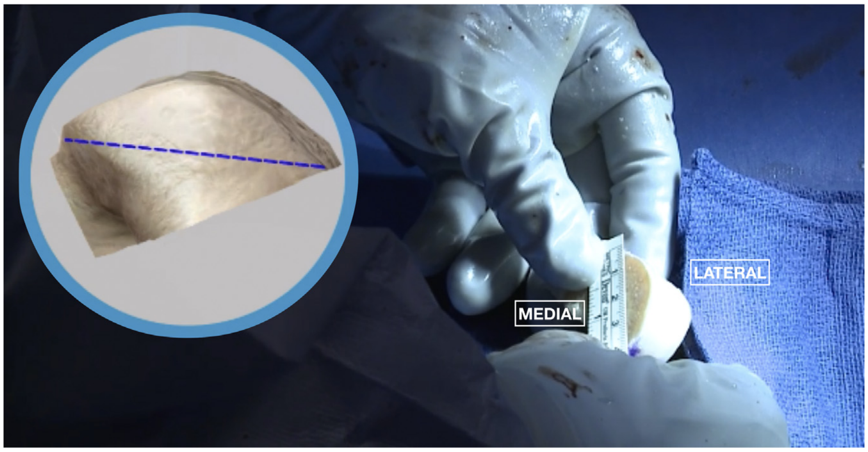

Fig 5. The talus allograft (right) on the preparation table. The cut graft contour is rechecked with the humeral defect and the preoperatively templated maximum depth is marked.

increased with chronicity. These findings were supplemented by Gheuring et al.[3] in their retrospective case series of 17 patients that underwent management for rHSLs, in which the authors found that defect sizes <25% of the humeral articular cartilage could be treated conservatively if stable, while patients with 25-40% and >40% defects were successfully managed with bony augmentation and arthroplasty procedures, respectively. Such findings emphasize the importance of rHSL parameters, including superficial size, depth, and medialization, which should be considered to guide treatment decision making and optimize outcomes in the setting of posterior glenohumeral instability.

Osteochondral allograft transplantation remains the treatment of choice for reconstruction the humeral head.[8,14,15] To date, there exist a wide variety of allograft options, including fresh or fresh-frozen femoral head, humeral head, allograft plug or the talus allograft.[6,8,11,12,14,15] In their retrospective case series, Zhu et al. demonstrated a high union rate and significantly improved subjective and functional outcomes at a mid-term follow-up period (mean 27.8 months) following reconstruction of large HSLs using a fresh-frozen humeral head allograft.[14] However, the authors also reported a high graft resorption rate (43.1%).[14] Saltzman et al.[8] found similar complications in their systematic review, including 35 patients who underwent humeral head reconstruction with osteochondral allograft, of which 36.2% experienced graft resorption, and glenohumeral arthritic changes in 35.7% of patients.

The fresh talus allograft has recently been proposed as an excellent alternative graft choice for reconstruction the humeral head.[11] The talus allograft offers several advantages. First, the anthropometric measurements of the talus are almost identical to the radius of curvature (ROC) of the humeral head, optimizing restoration of the humeral head sphericity and its arc of rotation with respect to the glenoid surface.[10,11] Additionally, the dense, weight-bearing cartilaginous surface of the talus creates a more profound articular contact with the glenoid and allows for

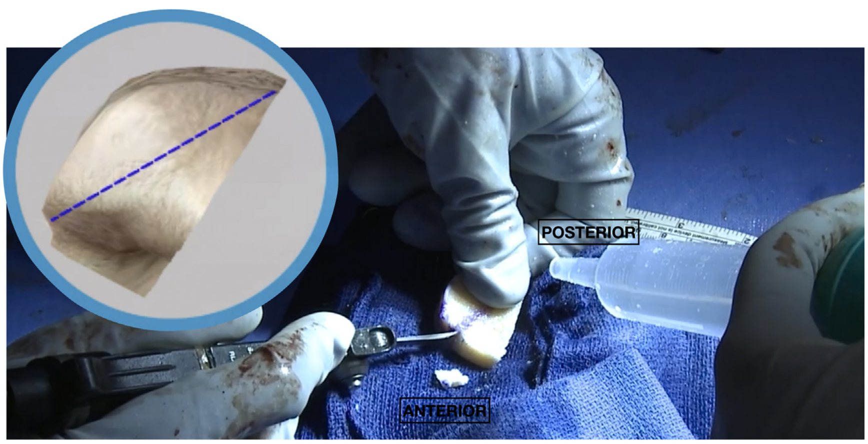

Fig 6. The talus allograft (right) on the preparation table. The anatomic landmarks for the final cut (depth) are the junction of the articular surface of the talar dome and the talar neck for the anterior anatomic landmark (seen above) and the posterior margin of the talar articular cartilage for the posterior anatomical landmark.

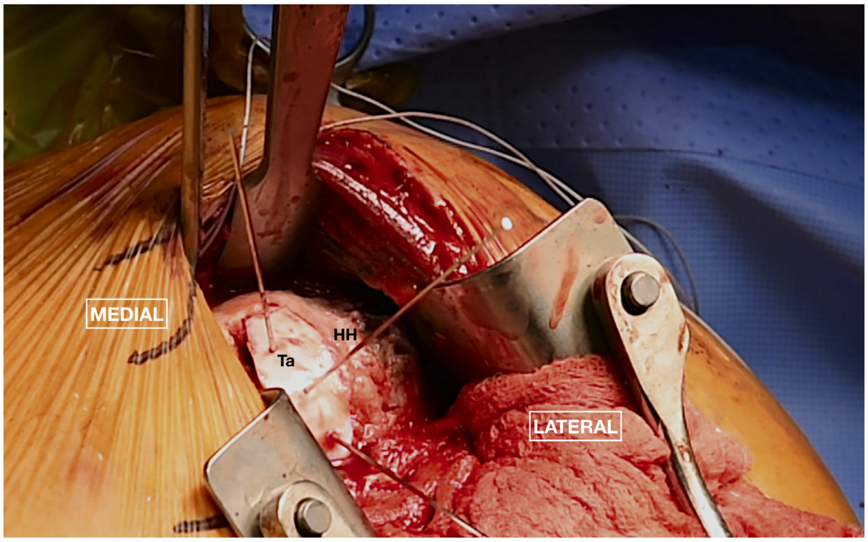

Fig 7. The operative photograph of the left shoulder. The graft is inserted into the humeral defect and marked to show an area of error. The graft is adjusted, and a rasp is used to ensure perfect graft fit. The allograft should be tight enough to stand in place without manual impaction. H, humeral head; Ta, talus allograft.

more stability.[6] The dense, weight-bearing talus allows for a stable graft fixation.[6] These morphological advantages have recently been described by Griswold et al.[11] in their retrospective review of 82 patient's tali using magnetic resonance images (MRIs). The authors reported that the talus head ROC was extremely compatible to humeral heads, specifically in males (mean: +2.86 mm; males: +1.36 mm), and maximum vertical height of the talus was 23.54 ± 2.87 mm, ensuring ample thickness to provide a suitable humeral head graft. Such findings reinforce the characteristics that make the talus a viable allograft candidate for humeral head reconstruction in the setting of a large rHSL.

However, the use of the talus allograft comes with notable disadvantages inherent to all grafting procedures; such pitfalls can include improper graft sizing that fails to restore the anatomic glenohumeral arc of motion, or risk of nonunion between the native humeral head and talus allograft. Steps to ensure accurate sizing, positioning, and subsequent union of the talus allograft must, therefore, be taken to reduce these risks. This Technical Note outlines our technique and notable pearls for talus allograft preparation for

Fig 8. The talus allograft (right) on the preparation table. The allograft is pulse lavaged for 10 minutes to remove remnant bone marrow and then soaked in platelet-rich plasma.

the treatment of a large rHSL that highlights precise cutting anatomy, sizing options, and use of orthobiologics to ensure excellent talus union to the native humeral head surface.

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