JSES Reviews, Reports, and Techniques 1 (2021) 224–228

Contents lists available at ScienceDirect

JSES Reviews, Reports, and Techniques

journal homepage: www.jsesreviewsreportstech.org

Pedicled-lesser tuberosity osteotomy for glenohumeral joint exposure: a technical note and case report highlighting its use in allograft reconstruction of a large engaging reverse Hill-Sachs lesion after posterior shoulder dislocation

Andrew M. Ker, FRCSOrth(Ed)[a,b,*], Egbert J.D. Veen, MD[a,b], Jashint C. Maharaj, MPHTM[c], Marine M. Launay, MEng[c], Kenneth Cutbush, FRACS[b], Ashish Gupta, FRACS[a,c]

[a]Greenslopes Private Hospital, Brisbane, QLD, Australia
[b]Brisbane Private Hospital, Brisbane, QLD, Australia
[c]Shoulder Surgery QLD Research Institute (SSQRI), Brisbane, QLD, Australia

ARTICLE INFO

Keywords:
Lesser tuberosity osteotomy
subscapularis
humeral head exposure
shoulder instability
reverse Hill-Sachs lesion
allograft

Level of evidence: Level V; Case Report

Exposure of the humeral articular surface through an anterior approach to the shoulder for grafting humeral bone defects requires partial or complete detachment of the subscapularis tendon and traditionally is achieved through a subscapularis tenotomy, peel tuberosity osteotomy, or lesser tuberosity osteotomy. This case report presents a technique of performing a pedicled-lesser tuberosity osteotomy to allow adequate access for allograft reconstruction of a large reverse Hill-Sachs lesion after a traumatic posterior dislocation, to restore humeral head sphericity and prevent recurrent glenohumeral joint instability. The inferior subscapularis insertion is left intact leaving a periosteal sleeve and preserving the blood supply to the lesser tuberosity and humeral head, with the aim of improving healing of the osteotomy and preventing graft-related complications, such as resorption. Successful union of the pedicled-lesser tuberosity osteotomy and allograft was seen on a 6-month follow-upcomputed tomography scan, with adequate restoration of subscapularis function.

Articular exposure for treatment of humeral head defects or glenoid fracture often involves an extensile approach to the shoulder. An anterior approach to the shoulder requires a subscapularis split or a partial or complete detachment of the subscapularis tendon, depending on the extent of exposure required. In a young individual, preservation of subscapularis muscle tendon function is of paramount importance for a good long-term outcome. For total shoulder arthroplasty, traditionally a subscapularis tenotomy medial to the tendon insertion onto the humerus has been performed; however, some studies have reported high failure rates after this technique.[7,9] Subsequently, a subscapularis peel and lesser tuberosity osteotomy (LTO) have been described with the aim of improving postoperative repair integrity.[1,5]

For patients with large bony defects of the humeral head after acute or recurrent episodes of shoulder instability, open anatomic reconstruction using osteochondral allografts to restore the sphericity of the humeral head and reduce the risk of further instability has been reported.[2-4,8,10,12] Most published case series favor a limited or complete subscapularis tenotomy or peel technique if anterior access to the humeral head is performed.[2-4,8]

Both the anterior humeral circumflex artery (AHCA) and the posterior humeral circumflex artery and their branches perfuse the humeral head.[6] In particular, the AHCA and one of its terminal branches, the ascending arcuate vessel which branches lateral to the bicipital groove, have been shown to be the predominant blood supply to the medial portion of the humeral head and lesser tuberosity.[6,11]

Injury to the AHCA as it passes within the connective tissue over the inferior muscular attachment of the subscapularis, or to the ascending arcuate vessel, may occur when performing a subscapularis tenotomy, peel or LTO, for access to the humeral head, thus affecting the potential for healing. Furthermore, preservation of this blood supply may be important in preventing allograft-

The Ramsay Health Care QLD Human Research Ethics Committee approved this study (RHC QLD HREC; Protocol 19/41).

* Corresponding author: Andrew M. Ker, FRCSOrth(Ed), Greenslopes Private Hospital, Newdegate Street, Greenslopes, QLD 4120, Australia.

E-mail address: andrewker84@gmail.com (A.M. Ker).

https://doi.org/10.1016/j.xrrt.2021.04.010

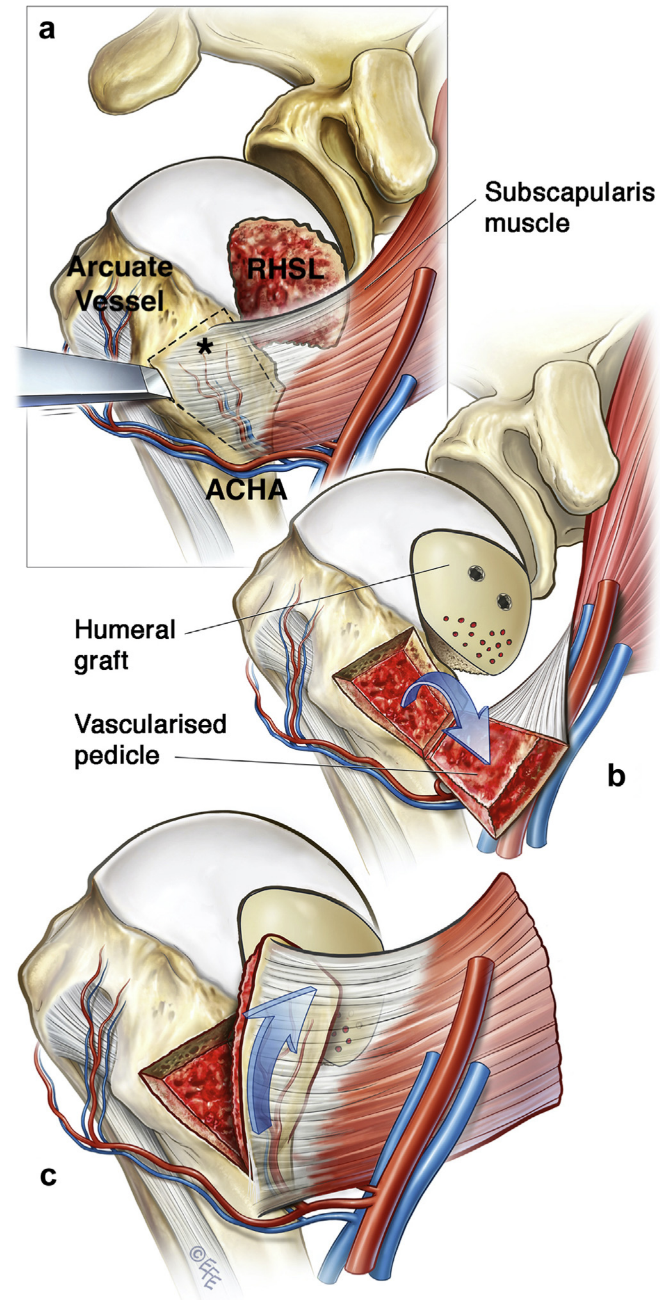

Figure 1 Illustration demonstrating P-LTO preparation. (**a**) Osteotome used to make medial, superior, and lateral champher cuts. Inferior periosteal sleeve left intact. (**b**) P-LTO rotated inferomedially to expose vascular bed and allow exposure of humeral articular surface. (**c**) P-LTO rotated back before fixation. ACHA, anterior circumflex humeral artery; P-LTO, pedicled-lesser tuberosity osteotomy; RHSL, reverse Hill-Sachs lesion.

related complications, such as nonunion or graft resorption, which remains a concern in case series reporting the use of allografts to reconstruct large bony defects of the humeral head.[10,12]

We propose our technique of performing an open pedicled-LTO (P-LTO) to allow adequate exposure of the humeral head. This technique can be used to gain access to the humeral articular surface in the setting of a large humeral defect (Hill-Sachs or reverse Hill-Sachs), while preserving the AHCA and its supply to the lesser tuberosity and humeral head, to ensure union of the tuberosity postoperatively and satisfactory subscapularis function.

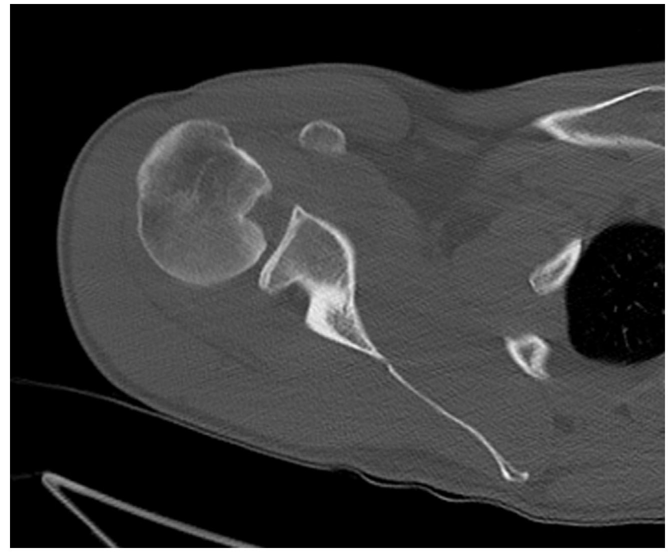

Figure 2 Axial CT scan with RHSL involving approximately 20% of humeral head articular surface. CT, computed tomography; P-LTO, pedicled-lesser tuberosity osteotomy; RHSL, reverse Hill-Sachs lesion.

We illustrate this technique in a case report of a large reverse Hill-Sachs lesion (RHSL) after a traumatic posterior glenohumeral dislocation that underwent humeral head reconstruction using a size-matched humeral head allograft.

Materials and methods

P-LTO surgical technique

Setup

After general anesthetic and interscalene block, the patient is positioned in the beach-chair position, with the operative arm in a pneumatic arm holder (Spider 2, Smith and Nephew, Watford, UK).

P-LTO preparation

A deltopectoral approach is performed. The superior and inferior margins of the subscapularis tendon, as well as the AHCA and 2 corresponding veins inferior to the subscapularis, are identified.

The P-LTO is started just medial to the bicipital groove. The long head of biceps tendon, as well as the ascending arcuate artery immediately lateral in the groove, is preserved. Care is taken to preserve the inferior subscapularis insertion leaving a muscular periosteal sleeve pedicle. Superior, medial, and lateral champher cuts are performed using a small osteotome to create a trapezoidal osteotomy (Fig. 1, *a*). The thickness of the osteotomy should be approximately 5 mm, with a width of approximately 4 cm to include the entire insertion of the subscapularis tendon, to maximize bony surface area for healing. The inferior cortex is left in situ, preserving the inferior subscapularis insertion and the vascular pedicle to the lesser tuberosity from the AHCA. The P-LTO is then gently opened with an osteotome ensuring vascular back bleeding through the osteotomy (Figs. 1, *b* and 4).

Medial and inferior reflection of the P-LTO on its pedicle allows for complete exposure of the humeral and glenoid articular surface. The surgical intervention is carried out as required.

P-LTO reattachment/fixation

The shoulder is placed in 45 degrees of external rotation, and the P-LTO flap is rotated back into its bleeding cancellous bed on the humerus (Figs. 1, *c* and 5, *a*). The P-LTO is fixed with two 4.0-mm

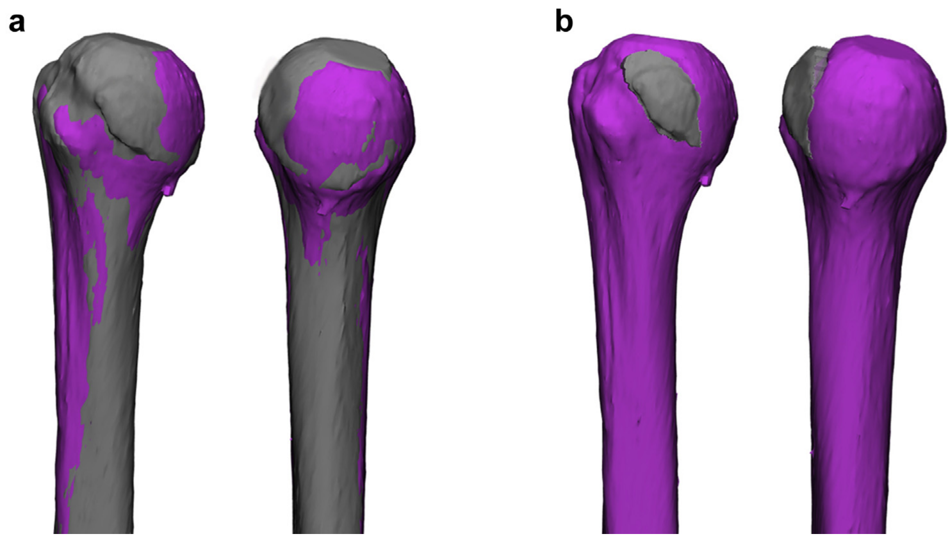

Figure 3 Preoperative planning using 3D segmented models in coronal and sagittal views. (**a**) Overlay of the right pathologic (purple) and left mirrored (gray) humeri and (**b**) right pathologic humerus (purple) and personalized humeral graft (gray) computed from the left mirrored humerus. 3D, 3-dimensional.

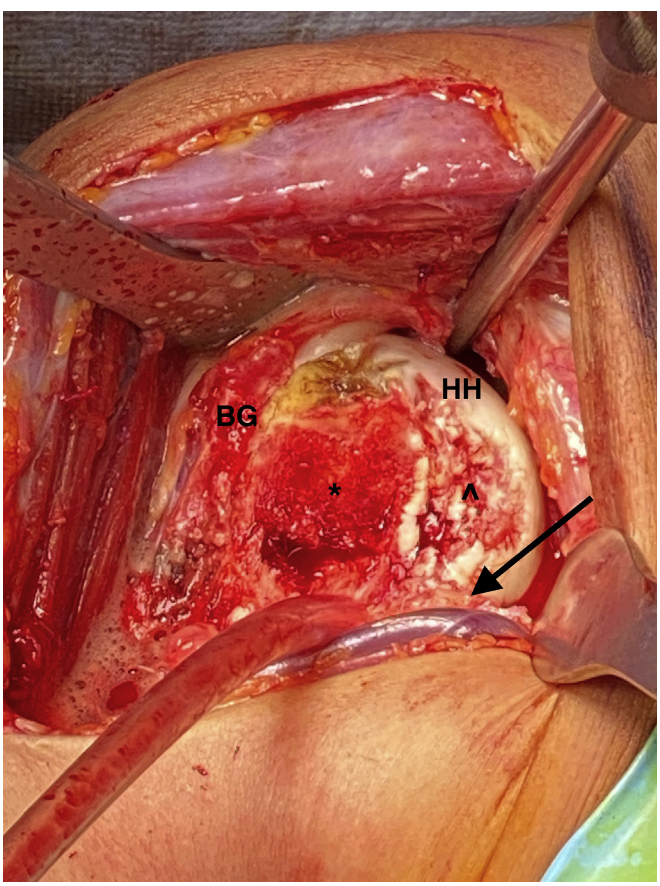

Figure 4 The P-LTO has been created and rotated on its pedicle (currently rotated under the anteroinferior soft tissues largely out of view, as indicated by the arrow) to give excellent access to the large RHSL of the humeral head. The highly vascular bed of the P-LTO is also demonstrated. BG, bicipital groove containing long head of biceps; HH, humeral head; P-LTO, pedicled-lesser tuberosity osteotomy; RHSL, reverse Hill-Sachs lesion; *, vascularized bed of P-LTO; ^, RHSL.

cannulated screws, as well as a suture bridge construct using two medial row anchors in the medial osteochondral bed of the P-LTO, which are passed through the subscapularis tendon to one lateral row anchor (Quattro Link, Zimmer Biomet, Warsaw, IN, USA) (Fig. 5, *b*). The patient is positioned in a sling and the repair is protected for 6 weeks.

Results

Case report

A 32-year-old, right hand–dominant man sustained a first-time acute posterior right shoulder dislocation while lifting a 100-kg steel mesh with work colleagues. His shoulder remained unstable with more than 10 further dislocations noted by him that he was able to self-reduce. He remained severely restricted in activities of daily living. He was a nonsmoker, had no significant past medical history, and lived an active lifestyle, in particular he was a keen surfer. Clinical examination found his shoulder to be unstable posteriorly with internal rotation.

An axial 2-dimensional computerized tomography (CT) scan confirmed a large RHSL of the humeral head, involving approximately 30% of the humeral articular surface area (Fig. 2). Three-dimensional CT models of both humeri were created using the image segmentation software Mimics 21.0 (Materialise, Leuven, Belgium). The left humerus was mirrored to match the pathologic right side and the humeral bone defect was found to be 17% of the articular surface, using this 3-dimensional method (Fig. 3, *a*). Size-matched patient-specific humeral allograft reconstruction of the defect was planned (Fig. 3, *b*).

A standard deltopectoral approach to the shoulder was performed and access to the humeral head was achieved by performing a P-LTO as previously described. Rotating the P-LTO inferiorly on its intact periosteal sleeve allowed excellent exposure to evaluate the RHSL (Fig. 4).

The edges of the RHSL were freshened. The fresh frozen humeral head allograft was then shaped using a saw and keyed into the

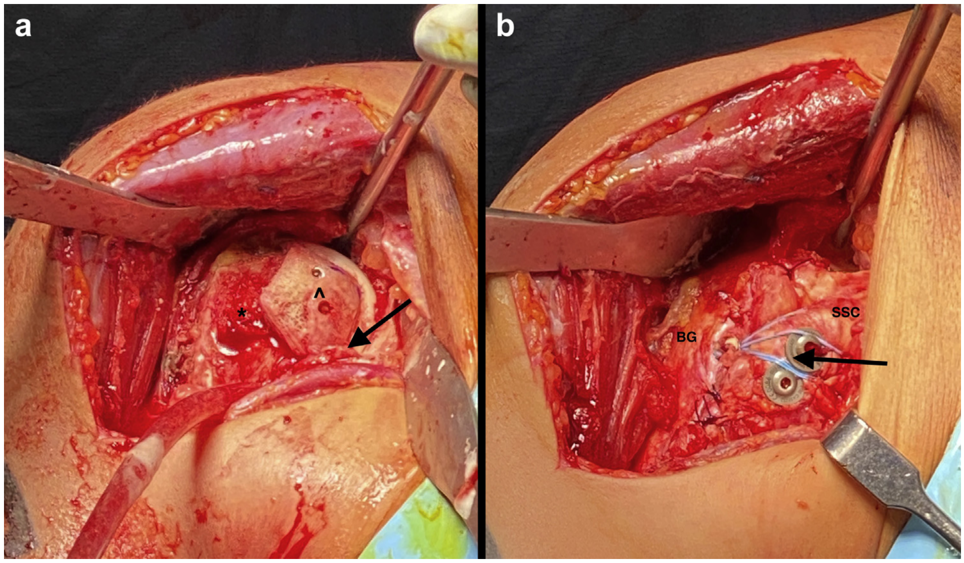

Figure 5 (**a**) Size-matched humeral head allograft fixed with 2 headless cannulated screws. The P-LTO is visualized before being rotated on its periosteal sleeve back into its vascularized bed. (**b**) The P-LTO has been rotated back and fixed with 2 cancellous screws with washers as well as a double-row suture fixation from 2 medial anchors passed through the subscapularis tendon to a single lateral row anchor. arrow, P-LTO; BG, bicipital groove; P-LTO, pedicled-lesser tuberosity osteotomy; SSC, subscapularis tendon; *, bed of osteotomy; ^, allograft humeral head.

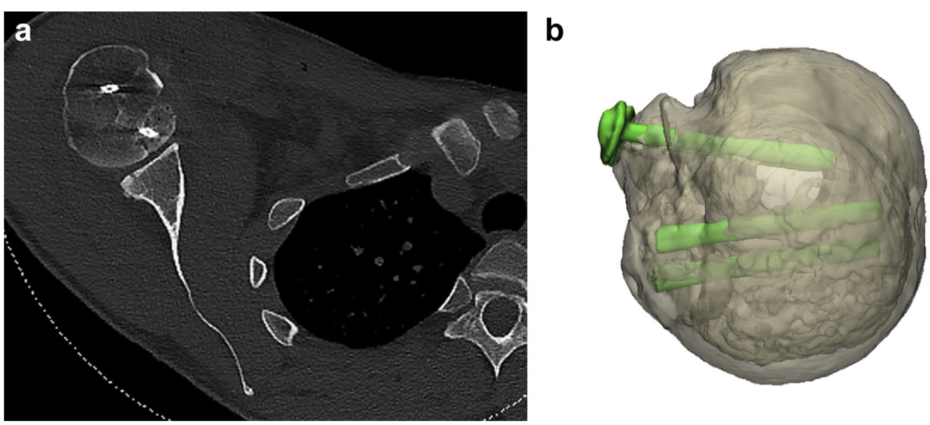

Figure 6 (**a**) Postoperative axial CT and (**b**) 3D model (superior axial view) demonstrates restoration of humeral head sphericity and union of the allograft and P-LTO. CT, computed tomography; P-LTO, pedicled-lesser tuberosity osteotomy; 3D, 3-dimensional.

defect, with good restoration of the humeral head sphericity and a flush articular surface. Provisional fixation with two temporary 1.4-mm Kirshner wires, followed by definitive fixation with 2 cannulated variable pitch 4.0-mm headless screws (Zimmer Biomet, Warsaw,IN, USA) was performed (Fig. 5, *a*).

The shoulder was then placed in 45-degree external rotation and P-LTO flap was rotated back and slightly medialized over the graft with minimal tension. The allograft cortical surface was perforated with K wires and the medial overlap of the PLTO was performed to provide vascularity to the allograft from the bleeding P-LTO. The P-LTO was fixed as outlined previously (Fig. 5, *b*).

Postoperative protocol

He was placed in a 60-degree abduction brace (Ottobock, Duderstadt, Germany) in neutral rotation for four weeks. Supervised active-assisted range of motion was commenced at 2 weeks, with full active range of motion starting after 6 weeks.

A postoperative CT scan performed at 6 months demonstrated graft and lesser tuberosity osteotomy union and good restoration of humeral head sphericity (Fig. 6, *a*). CT scan segmentation was performed to evaluate graft and screw positioning (Fig. 6, *b*).

Table I
Potential benefits of the P-LTO for performing humeral head allograft reconstruction

- Vascularized osteotomy bed promoting bone to bone healing of the osteotomy
- Improved blood supply to the osteochondral graft improving union rates
- Reduced rate of graft resorption or collapse
- Improved blood supply to the humeral head reducing the risk of later avascular necrosis

P-LTO, pedicled-lesser tuberosity osteotomy.

Subscapularis strength was noted to be equal to the uninjured side on hand-held dynamometry testing.

Discussion

Generally, a partial or complete subscapularis tenotomy or peel technique has been performed in the small number of case series and case reports using an anterior approach to the glenohumeral joint for allograft reconstruction of the humeral head.[2–4,8] However, there is not enough evidence to suggest an increased risk of repair failure with either technique for this indication. Furthermore, based on the literature comparing subscapularis tenotomy, peel, and LTO for total shoulder arthroplasty, a recently published multicenter trial showed no benefit of one technique over the other on clinical outcome scores or subscapularis integrity postoperatively.[1]

Graft-related complications remain a concern in the small number of studies reporting outcomes after allograft reconstruction of the humeral head.[2–4,8,10,12] A recent systematic review included 12 studies (8 case reports and 4 cases series) with a total study group of 35 patients and reported allograft necrosis in 8.7% and allograft resorption in 36% of cases.[10] Zhou et al[12] reviewed 19 patients who underwent osteochondral allograft reconstruction of large Hill-Sachs lesions with femoral head allograft at the 2-year follow-up and reported graft resorption in 43% of patients. The clinical significance of graft collapse and resorption was questioned in this study as patient satisfaction was high; however, longer-term studies have shown graft collapse to be associated with the development of symptomatic glenohumeral osteoarthritis.[3,8]

Avascular necrosis of the humeral head is a late complication that has also been reported after allograft reconstruction of RHSLs in small cases series. Diklic et al[2] followed up 13 patients for a mean of 54 months after allograft reconstruction following a posterior dislocation, with one patient developing osteonecrosis resulting in a poor clinical outcome and one of four patients in another small case series developed osteonecrosis.[4] In both studies, avascular necrosis developed in patients with large defects of the humeral head, which may have been significant in contributing to this. However, both cases series describe a complete subscapularis tenotomy 1 cm from the tendon insertion that was performed for access, without specifically describing preservation of the AHCA and its branches, which may also have been a contributing factor in the development of late avascular necrosis of the humeral head.

Our technique of P-LTO allows access to the glenohumeral articulation, while carefully preserving the AHCA and ascending arcuate artery. This provides a vascularized bleeding bed for repair and allows bone-to-bone healing, potentially promoting faster subscapularis healing and a reduced risk of failure. Furthermore, we believe that by preserving the blood supply to the humeral head, this technique can improve graft healing and potentially reduce the risk of graft resorption. Another benefit in preserving the blood supply to the humeral head is the potential to reduce the risk of avascular necrosis in the future (Table I). In our case study, imaging showed healing of the P-LTO and humeral head allograft with no evidence of collapse at the 6-month follow-up; however, we appreciate that longer follow-up is required to evaluate graft resorption or the development of avascular necrosis.

Conclusions

Larger studies with a longer-term follow-up are required to fully evaluate the potential benefits of performing a P-LTO for access to the humeral head when undertaking joint-preserving surgery, such as allograft reconstruction of bone defects after glenohumeral joint instability. We believe that this is a simple technique to gain access to the humeral head, with the potential benefits of preserving the blood supply to the lesser tuberosity osteotomy and the rest of the humeral head.

Disclaimers

Funding: No funding was disclosed by the author(s).

Conflicts of interest: The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Acknowledgments

The authors thank Dr Levente Efe for creating the artistic images and licensing their use in our article.

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