JSES International 5 (2021) 60–65

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Distal tibia allograft glenoid reconstruction for shoulder instability: outcomes after lesser tuberosity osteotomy

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ARTICLE INFO

Keywords:
Distal tibia allograft
shoulder instability
lesser tuberosity osteotomy
glenoid bone loss

Level of evidence: Level IV; Case Series; Treatment Study

Background: Distal tibia allograft reconstruction of the glenoid in shoulder instability has garnered significant attention over the last decade. Prior studies demonstrate significant improvement in all reported patient outcomes albeit the approach is through a subscapularis split. There have not been prior studies evaluating outcomes after lesser tuberosity osteotomy which provides excellent exposure to the anterior glenoid.We hypothesize there is significant improvement in functional outcomes and no deleterious effects after lesser tuberosity osteotomy for distal tibia allograft reconstruction of the glenoid for shoulder instability.

Methods: A retrospective review was performed from 2016 of 2019 of patients undergoing distal tibia allograft reconstruction of the glenoid through a lesser tuberosity osteotomy. Patients were indicated if they had recurrent anterior shoulder instability with >20% glenoid bone loss and evidence of an off-track lesion. Clinical, imaging, and operative data were evaluated. Objective follow-up data evaluated at minimum 2 years included radiographs, range of motion, DASH, SANE, VAS, SST, ASES, and Constant scores.

Results: A total of 12 patients were available with average follow-up 28 months, average age 26 years old, and average glenoid bone loss of 33%. The patients demonstrated significant improvement in their clinical outcomes at final follow-up: DASH 42.9-8.9 ($P = .004$), SANE 32.2-85 ($P = .00005$), VAS 4.6-1.1 ($P = .003$), SST 7-11.4 ($P = .01$), ASES 50.2-90.5 ($P = .001$), and Constant 37.6-86.2 ($P = .01$). Range of motion at final follow-up was forward flexion to 161.4° (135-170°), external rotation 49.5° (40-65°), and internal rotation to T12-L1 (T7-L2) vertebral body.

Conclusion: The present study demonstrates the effectiveness of a lesser tuberosity osteotomy in exposure of the glenoid for reconstruction with a distal tibia allograft. The functional integrity of the subscapularis is maintained and the patient-reported outcomes are comparable with current literature.

Traumatic anterior shoulder instability represents a wide spectrum of disease. Distal tibia allograft reconstruction of the glenoid signifies an extreme end of the spectrum for treatment of shoulder instability. Patients who undergo distal tibia allograft reconstructions tend to have large anterior glenoid bone loss (>20%), off-track bipolar lesions, or are involved in revisions after failed coracoid transfer procedures. Since its introduction as a technique by Provencher et al in 2009,[20] distal tibia allograft reconstruction has gained traction in patients with significant bone loss and after multiple revision surgeries.[6,12,18] This remains a niche procedure for which clinical data are relatively sparse as it remains in its infancy of development and understanding. Nonetheless, a number of studies have demonstrated promising clinical outcomes of patients who undergo this procedure.

Yamamoto et al[23] provided us with the concept of the glenoid track in 2007 at which point our algorithm for the treatment of shoulder instability has undergone a multitude of changes. As an orthopedic community, we have focused increasingly on bipolar lesions, or bone loss on both the glenoid and humerus, that may predispose patients to recurrent instability.[5,8,9,14,17] Recurrence, as noted by Hovelius et al in 2008,[13] is the essential cause of early joint arthropathy and ultimate failure after these injuries and interventions. Given these findings, expanding our armamentarium to include increasingly complex, bone-based reconstructive procedures is imperative to protect our patients' long-term outcomes. Biomechanically, Bhatia et al[2] demonstrated improved glenoid contact area with a distal tibia allograft which distributes forces across a larger surface area. In their study, they also found the distal

Institutional Review Board approval was provided by Cedars Sinai (STUDY00000209).

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https://doi.org/10.1016/j.jseint.2020.09.018

tibia allograft outperformed Latarjet in terms of increased contact area and decreased peak force with the arm in the apprehensive position of abduction, external rotation.

An important consideration in this procedure is subscapularis management. There have been a number of studies in the shoulder arthroplasty literature comparing subscapularis tenotomy, subscapularis peel and lesser tuberosity osteotomy with equivocal results.[4,10,15,16] Despite this, there are proponents of each side but those that maintain the native insertion of the subscapularis via split or lesser tuberosity osteotomy tend to have improved results.[3,11] The main concern in shoulder instability is the importance of the subscapularis in the dynamic stability of the glenohumeral joint.[21] Previous studies[22] have shown subscapularis insufficiency after shoulder stabilization can potentially increase the risk of recurrent disease. Provencher[1,19] has demonstrated positive outcomes of their distal tibia allograft cohorts by use of a subscapularis split but there has not been a published cohort of this procedure through a lesser tuberosity osteotomy. A potential advantage of a lesser tuberosity osteotomy in this procedure is the exposure it provides particularly if there is concomitant humeral head injury that needs to be addressed.

Our goal is to present a series of patients who underwent lesser tuberosity osteotomy for treatment of shoulder instability with a distal tibia allograft. We hypothesize there is significant improvement in functional outcomes and no deleterious effects after lesser tuberosity osteotomy for distal tibia allograft reconstruction of the glenoid for shoulder instability.

Methods

After study approval by the institutional review board, a retrospective evaluation was performed of patients who underwent shoulder stabilization and glenoid reconstruction with distal tibia allograft through a lesser tuberosity osteotomy. All surgeries were performed by an experienced shoulder and elbow fellowship-trained orthopedic surgeon.

A retrospective review was performed of patients who underwent a distal tibia allograft glenoid reconstruction from 2016 to 2019. A total of 14 patients were identified who underwent this procedure with an approach via the lesser tuberosity osteotomy. Patients who had a history of recurrent instability with at least 20% glenoid bone loss were included in the study. Glenoid bone loss was evaluated by preoperative CT or MRI scan and confirmed intraoperatively via direct measurement. Primary and revision surgeries for shoulder instability were included. Patients were excluded if they had a history of neurologic injury or a seizure disorder. All clinical, radiographic, and operative data were evaluated for laterality, glenoid bone loss, presence of Hill-Sachs lesion, and whether concomitant humeral head procedures were performed. Humeral head Arthrosurface procedures were indicated in patients who had previous Remplissage and demonstrated deep, engaging Hill-Sachs on arthroscopic examination. Demographic collected included age, sex, and hyperlaxity. Objective data were collected including range of motion at follow-up, clinical subscapularis strength, and radiographs to evaluate healing of the osteotomy site and allograft. The senior author performed all radiographic evaluations in terms of preoperative bone loss and postoperative osteotomy and graft healing. Patient-reported outcomes were followed including DASH (Disabilities of the Arm, Shoulder and Hand), SANE (Single Assessment Numeric Evaluation), VAS-pain (Visual Analog Score), SST (Simple Shoulder Test), ASES (American Shoulder and Elbow Surgeons shoulder score), and Constant scores.

In terms of the rehabilitation protocol, patients were in a sling and non–weight bearing on the operative extremity for a total of 4-6 weeks. Patients were not allowed to actively externally rotate or passively externally rotate past neutral position for 6 weeks and until the osteotomy demonstrated healing. Patients were allowed to begin pendulum activities after 1 week and isometric rotator cuff and deltoid activities after 3 weeks. When the osteotomy demonstrated healing and the patient was at least 6 weeks out, they would begin active assisted and active range of motion activities. Patients were released to full activity approximately 6-9 months postoperatively when they maximize range of motion, maximize scapular stabilization, demonstrate complete osteotomy and graft healing and no evidence of apprehension on physical examination.

Surgical technique

Patients were first positioned in the lateral decubitus position for operative and diagnostic arthroscopy (Fig. 1). A standard posterior viewing portal was first established followed by arthroscopic evaluation of glenoid bone loss and humeral bone loss. In addition, this allowed us to evaluate the nature of the cartilage surface, subluxation of the glenohumeral joint, and engaging of Hill-Sachs lesion, if present. Patients with significant glenoid bone loss (>20%), large Hill-Sachs lesions, or in the revision setting were indicated for distal tibia allograft and repositioned in the supine position.

A standard deltopectoral approach was utilized. The biceps tendon underwent tenodesis at its resting length to the pectoralis major followed by tenotomy. With a lesser tuberosity osteotomy, there is concern about future biceps tendinitis emanating from the area of the osteotomy. Therefore, a tenodesis was routinely performed. At this point, the bicipital groove, subscapularis and lesser tuberosity was delineated. An osteotomy was performed with a sagittal saw with a bone wafer approximately 2-3 mm thick. The capsule was left attached to the lesser tuberosity along with the subscapularis tendon. With the glenoid exposed, the surgical procedure performed has been described in detail via Provencher et al.[20]

Osteotomy repair

Once the distal tibia allograft was secured in appropriate positioning by the use of Acumed Helical Nails (Hillsboro, Oregon, USA), the focus turned to osteotomy repair. A #2 traction stitch is placed in Mason Allen fashion through the subscapularis tendon. Three bone tunnels are made with a 2.0mm drill bit through the humeral footprint deep to the osteotomy site. Three #5 Nice loops are shuttled through the bone tunnels and placed through the subscapularis tendon along the edge of the osteotomy site. Each Nice loop is tied down to realign the osteotomy site. Next, one limb from each of the Nice loops in addition to a limb from the traction stitch is fixed in a double row fashion with a 4.75 swivel lock. The remaining limbs are secured with an additional 4.75 swivel lock anchor. The fixation is tested with rotational motion of the humerus.

Statistical analysis

Descriptive data were presented with percentages for discrete data and means for continuous data. Paired t-tests were performed to compare patient-reported outcomes measures (DASH, SANE, ASES, VAS, SST, and Constant). Significance was set at $P < .05$.

Results

A total of 12 patients (86%) were available for follow-up on an average of 28 ± 7.4 months (16-40 months); 10 (83.3%) were male

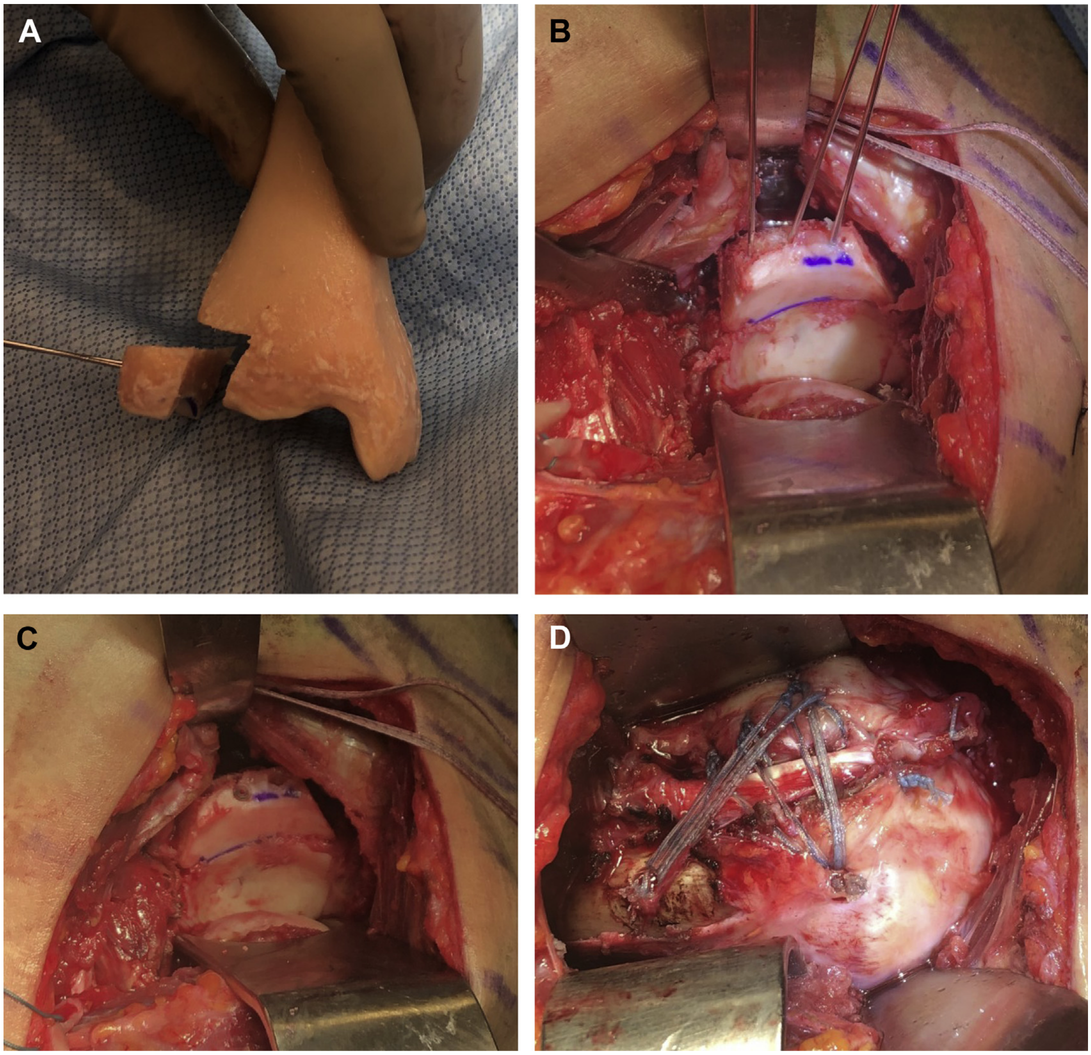

Figure 1 (**A**) The anterolateral portion of the distal tibia allograft is measured and cut followed by (**B**) placement along the anterior glenoid and secured in place. (**C**) Allograft is secured with final implants. (**D**) Lesser tuberosity osteotomy repair in double row technique.

and 2 were female patients. Of the two patients unavailable for follow-up, one was due to loss of insurance and the second was unreachable. One female patient had a history of Ehlers Danlos. Eight (66%) cases were on the right shoulder. At the time of surgery, the average age was 26 ± 5.5 years old. Five (41.6%) were primary shoulder instability procedures, whereas the remainder were revision cases. The average glenoid bone loss was 33% (25-50%) with a Hill-Sachs lesion present in 11 of the 12 (91.6%) patients; however, 2 of these were noted to be shallow on arthroscopic examination. Owing to Hill-Sachs lesions, four (33%) patients underwent Arthrosurface (Arthrosurface, Franklin, MA, USA) procedures to fill a large humeral head defect.

Patients demonstrated significant improvement in their clinical outcomes at the final follow-up when compared with preoperative data (Fig. 2): DASH 42.9-8.9 ($P = .004$), SANE 32.2-85 ($P = .00005$), VAS 4.6-1.1 ($P = .003$), SST 7-11.4 ($P = .01$), ASES 50.2-90.5 ($P = .001$), and Constant 37.6-86.2 ($P = .01$). Patients demonstrated significant improvement from preoperative scores at the one-year follow-up visit as well: DASH 42.9-16.3 ($P = .04$), SANE 32.2-82.1 (0.0003), VAS 4.6-1.4 ($P = .03$), SST 7-10.6 ($P = .02$), ASES 50.2-83.8 ($P = .008$), and Constant 37.6-76.9 ($P = .02$). When comparing 12-month follow-up to final follow-up, each variable demonstrated continued improvement although none reached significance on statistical testing.

In a subgroup analysis excluding the four patients who underwent humeral head resurfacing for a large Hill-Sachs lesion, patients demonstrated significant improvement in their clinical outcomes at the final follow-up when compared with preoperative data: DASH 40.7-8.7 ($P = .03$), SANE 43.6-85 ($P = .002$), VAS 4.7-1.4 ($P = .004$), SST 7.2-11 ($P = .02$), ASES 48.9-88.1 ($P = .006$), and Constant 40.5-87.0 ($P = .02$).

As for range of motion at final follow-up, the average forward flexion was to 161.4° (135-170°), external rotation 49.5° (40-65°), and internal rotation to T12-L1 (T7-L2) vertebral body. Belly press was intact on all patients but noted to be weak in one patient (8%).

There were no complications in this cohort including recurrence of instability or infection. Each patient demonstrated healing of their osteotomy on plain radiographs as demonstrated in Figure 3. In addition, each graft was noted to have appropriate positioning in terms of articular congruency on the anterior glenoid on radiographic evaluation. One patient had evidence of early arthritis; however, his scores remained significantly improved with maintained motion: DASH 72.5-24.1, SANE 25-85, VAS 8-1, SST 3-10, ASES 21.7-83.3, Constant 20-85.7 with forward flexion to

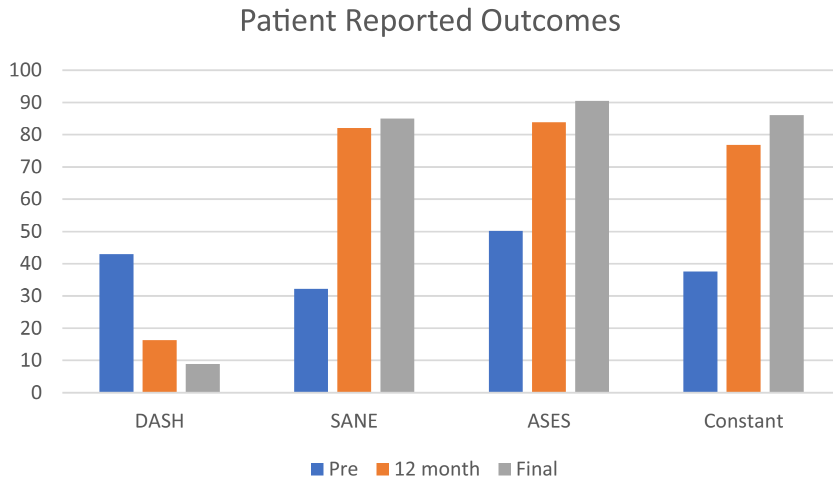

Figure 2 Patient-reported outcomes. Significant improvement from preoperative vs 12-month follow-up and preoperative vs final follow-up. No significant difference from 12-month follow-up to final follow-up. Significance $P < .05$.

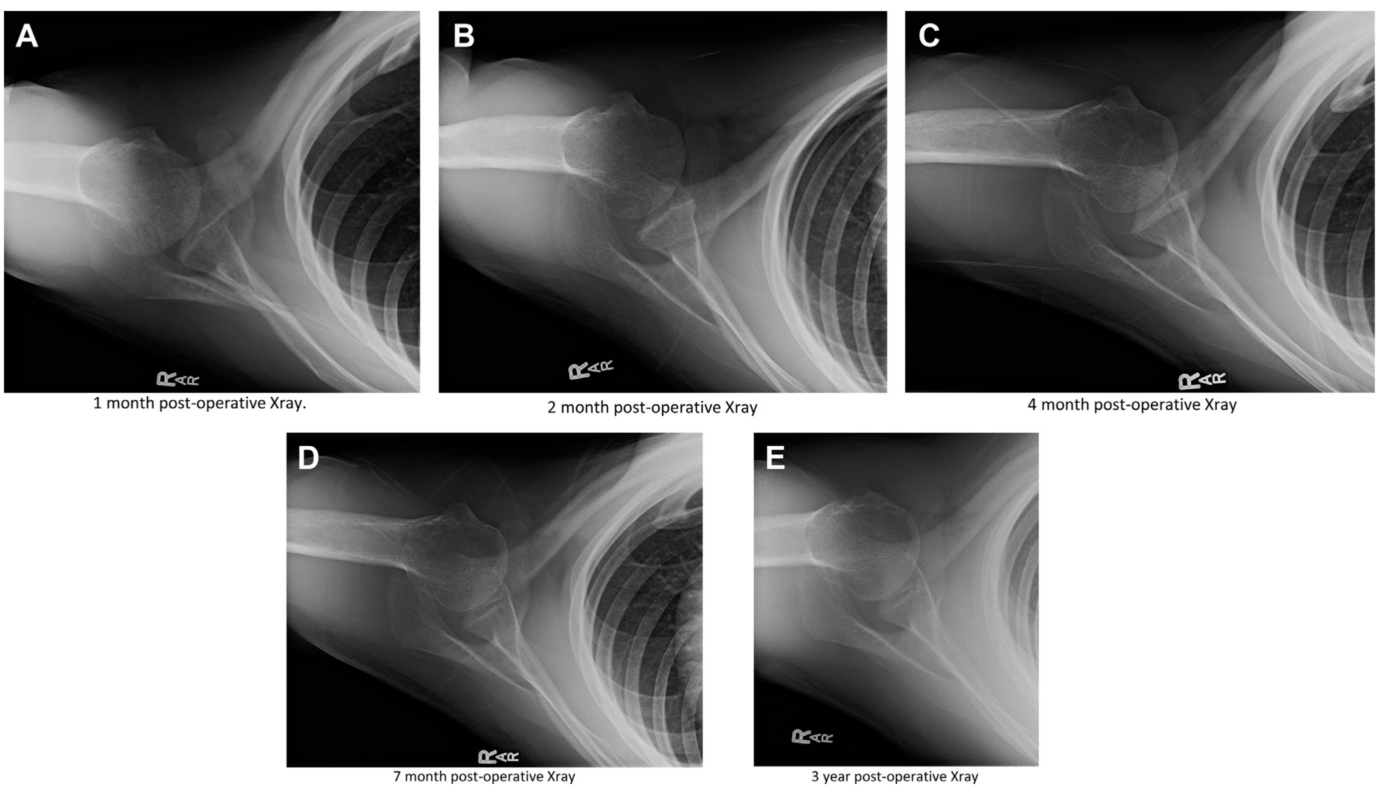

Figure 3 Plain axillary radiographs of a patient demonstrating osteotomy and allograft healing from (**A**) 1 month postoperatively, (**B**) 2 months postoperatively, (**C**) 4 months postoperatively, (**D**) 7 months postoperatively, and (**E**) 3 years postoperatively.

160, external rotation to 45, and internal rotation to L1 vertebral body.

Discussion

Our understanding and utilization of distal tibia allograft reconstruction of the glenoid in shoulder instability has grown significantly over the last decade. Since first described by Provencher et al,[20] the technique has garnered significant attention. Today, this procedure has provided orthopedic surgeons an alternative for patients with significant glenoid bone loss. This present study demonstrates comparable outcomes to previous studies with the addition of a lesser tuberosity osteotomy. The benefit of a lesser tuberosity osteotomy is the exposure provided to the anterior glenoid to perform this reconstructive technique. A secondary benefit is the access it provides to large humeral head lesions if a reconstructive procedure is indicated.

Looking back at subscapularis management in shoulder instability, Sachs et al[21] demonstrated patient satisfaction was directly related to integrity of the subscapularis after instability surgery. In addition, Scheibel et al[22] demonstrated the importance of maintaining subscapularis function after surgery in preventing recurrent disease. When referencing the arthroplasty literature regarding subscapularis management, there have been a number of comparative studies with varying results. In a systematic review, Choate et al[7] provided a comprehensive review comparing subscapularis peel, subscapularis tenotomy, and lesser tuberosity osteotomy. The lesser tuberosity osteotomy group demonstrated increased rates of image confirmed intact musculotendinous unit, higher rate of normal belly press and lift off and higher Constant and WOOS scores. Given these results and the theory that bone-to-bone healing is predictable, lesser tuberosity osteotomy could be considered a favorable approach for shoulder instability.

Provencher has demonstrated great results by use of the subscapularis split in previous studies. In a study of 27 patients undergoing distal tibia allograft reconstruction,[19] they showed improvement of ASES 63-91 and SANE 50-90.5 with evidence of allograft healing of 89%. These patients also demonstrated final forward flexion to 177°. In a separate study evaluating success of distal tibia allograft after failure of Latarjet,[1] they demonstrated improvement in ASES 40-92 and SANE 44-91 with union in 92% of allografts. Final motion was forward flexion to 152° and external rotation to 22.5°. These results are impressive and comparable with our findings in this present study.

In this study, patients demonstrated improvement in DASH 42.9-8.9 ($P = .004$), SANE 32.2-85 ($P = .00005$), VAS 4.6-1.1 ($P = .003$), SST 7-11.4 ($P = .01$), ASES 50.2-90.5 ($P = .001$), and Constant 37.6-86.2 ($P = .01$). Of note, there was no difference when comparing outcomes between the 12 months and final follow-up although there was a trend toward continued improvement over that time. There was evidence of healing of the allograft and the osteotomy in all cases on plain radiograph. Given the evidence of healing on plain radiograph and maintained function on physical examination, there was no indication for advanced imaging. Final forward flexion was to 161.4° and external rotation to 49.5°. Based on these data, the use of lesser tuberosity osteotomy does not have deleterious effects on patients' postoperative outcome or function. In fact, these results demonstrate similar outcomes to those described in the previous studies mentioned. In addition, this approach allows for a more robust exposure when dealing with humeral head lesions.

Although these numbers are promising, there are a number of limitations to the study. For one, it is retrospective in nature. Second, it is a case series without a direct comparative group. Third, the numbers are low although not surprising given this procedure is not commonly performed. Fourth, Both primary and revision cases were included which increases the heterogeneity of the sample. Fifth, all preoperative and postoperative radiographs were analyzed solely by the primary surgeon. Finally, we included humeral head resurfacing in our cohort that adds heterogeneity, but there was no difference between the resurfacing and non-resurfacing groups in terms of clinical outcomes. In addition, in the setting of distal tibia allograft with humeral head resurfacing, the lesser tuberosity osteotomy provides necessary exposure to perform the procedure.

Conclusion

The present study demonstrates the effectiveness of a lesser tuberosity osteotomy in exposure of the glenoid for reconstruction with a distal tibia allograft. The functional integrity of the subscapularis is maintained and the patient-reported outcomes are comparable with current literature. Our findings provide a surgeon another option for exposure in the setting of significant glenoid bone loss.

Disclaimer

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.

There were no grants or research funds provided for this project.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2020.09.018.

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