Cryopreserved bone allograft for the treatment of shoulder instability with glenoid defect

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ABSTRACT

The purpose of this study was to examine outcomes after cryopreserved tri-cortical iliac crest allograft reconstruction for glenoid bone loss in patients with shoulder instability. 10 patients completed the required assessments at a mean follow up of 4.5 years. At final follow up, mean ASES was 92 ± 12 , mean WOSI was 315 ± 319 , with good range of motion. None of the final radiographs demonstrated graft resorption or failure of hardware. The data demonstrated that patients who were treated with glenoid bone grafting with cryopreserved tri-cortical iliac crest allograft can expect good range of motion and functional capacity.

1. Introduction

Glenohumeral instability is a common orthopaedic pathology, as it is the most frequently dislocated major joint in the human body.^{1,2} Glenohumeral instability most frequently affects young, active patients, and is 3 times more common amongst males.^{3,4} Glenoid bone loss can play a significant role in recurrent glenohumeral instability and is often identified as the etiology of failure after shoulder stabilization.^{5,6}

The appropriate surgical management of glenoid bone loss can be challenging, as there are a number of surgical options to address glenoid deficiency. Possible procedures include humeral head disimpaction, osseous/soft tissue transfer, osseous allograft reconstruction, rotational osteotomy of the proximal humerus, capsulolabral reconstruction, coracoid transfer procedures, anatomic allograft and autograft reconstruction and arthroplasty.^{7–9} Anatomic glenoid reconstruction is usually indicated in situations of 25% or greater bone loss,^{10–13} or when revision stabilization is necessary.¹⁴

Bone grafting procedures with allograft were first described by Gerber and Lambert,¹⁵ and have increased in popularity due to the fact that they offer anatomical reconstruction of the glenoid with subsequent restoration of the natural articular arc.¹⁶ Additional benefit of an allograft is the avoidance of harvest site morbidity. Despite these advantages, the reliability of allograft incorporation into the glenoid has yet to be definitively established. Common allograft sources include glenoid, iliac crest, distal tibia, femoral head, and humeral head,^{14,17–19} each of which can be fresh or cryopreserved. However, to date, most of the available literature involves the use of fresh allograft options, and there has been only 1 case report on the use of cryopreserved allograft

for glenohumeral instability.¹⁷ Benefits of using cryopreserved allograft compared to fresh allografts include their wide availability, reduced immunogenicity and low cost. In addition, the shelf life for cryopreserved grafts can potentially exceed 10 years, while fresh grafts are recommended to be implanted within 2 to 4 weeks.

The purpose of our study was to examine the mid-term clinical and radiographic outcomes of cryopreserved allograft reconstruction for glenoid bone loss and instability at our institution. We hypothesized that these patients would report good clinical outcomes with high rates of graft incorporation.

2. Methods

We retrospectively identified patients with shoulder instability who underwent glenoid bone loss reconstruction with cryopreserved allograft by a single surgeon between 2006 and 2014. A total of 17 patients were identified. Exclusion criteria included patients who previously underwent glenoid bone loss reconstruction with autograft, those with less than two-year follow up (0), and those patients with glenohumeral joint arthrosis noted pre-operatively or intra-operatively (1). Due to the makeup of the study, IRB approval was not required according to the guidelines of our institution.

The remaining 16 patients were contacted and asked to complete functional outcome scores including the American Shoulder and Elbow Score (ASES) and the Western Ontario Shoulder Instability (WOSI) Index. The WOSI index is scored as a raw score from 0 to 2100. The best score possible is 0, which signifies that the patient has no decrease in shoulder-related quality of life. The worst score possible is 2100.²⁰ The

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raw score can then be converted to a percentage out of 2100. Additionally, we assessed each patient's active range of motion (ROM). For those patients who were unable to return to the surgeon's office for assessment, a ROM assessment survey was sent to them to be completed and returned. This method of patient self-assessment has been previously validated in shoulder arthroplasty literature.²¹ Post-operative radiographs were obtained and evaluated by the primary surgeon to assess the fixation of screws and to evaluate for bone resorption. The recurrence of instability or additional surgical procedures on the same shoulder was considered a failure.

2.1. Surgical technique

All patients underwent a preoperative CT or MRI. For patients with anterior instability, they were positioned in a semi-sitting beach chair position. After standard anterior surgical exposure through the deltopectoral interval, the interval between the subscapularis and the underlying capsule was developed. The subscapularis tendon was then released from the lesser tuberosity and reflected medially to expose the capsule. For patients with posterior instability, they were positioned in a lateral decubitus position. The surgical exposure required releasing the posterior deltoid muscle, which was repaired through bone tunnels during closure. The interval between the infraspinatus and the capsule was developed. After release from the greater tuberosity, the infraspinatus was reflected medially to reveal the underlying capsule.

For all patients, a lateral based "T" incision was made about the capsule such that superior and inferior leaflets of capsule can be established. These leaflets were then tagged for subsequent repair and capsulorrhaphy. The joint was visualized and inspected (Fig. 1). A cryopreserved tricortical iliac crest allograft was fashioned to match the native glenoid and fixed provisionally with 0.65 mm Kirshner wires x2 (Fig. 2). Cryopreserved allografts are preferred because of its wide availability and low cost. After confirming optimal location, permanent fixation was obtained with 3.5 mm cannulated screws x2. A #2 FiberWire (Arthrex Inc, Naples, FL) suture was tied to each screw heads for subsequent capsular re-attachment. The graft was shaped with a burr to ensure that its surface was congruent with the native glenoid arc (Fig. 3). Ultimately, the goal was to restore, but not extend, the glenoid surface area.

Finally, capsulorrhaphy was performed over the graft. The #2 FiberWire sutures around the screw heads were passed through the labrum and the capsule and tied in a horizontal mattress fashion. Then, the inferior leaflet of capsule was pulled superiorly and laterally and repaired side to side using #2 Mersilene sutures. Similarly, the superior leaflet of the capsule was pulled laterally and inferiorly and also repaired with sutures. After confirming good range of motion, the subscapularis or the infraspinatus tendons were repaired anatomically with

Fig. 1. Intraoperative image showing glenoid bone loss.

Fig. 2. Intraoperative image showing graft placement held provisionally with Kirshner wires.

Fig. 3. Intraoperative image showing graft fixed with screws and sutures for eventual labral/capsular repair.

#2 FiberWire sutures.

For all patients, the shoulder was immobilized for the first 4 weeks after the procedure. Passive and active assisted motion exercises were initiated at 4 weeks, and active motion was initiated at 8 weeks. Resistive strength training was allowed at 3 months and encouraged to progress as tolerated. High-risk activities, including contact sports, were delayed at least 6 months after surgery and allowed only after full incorporation of bone graft was verified on radiographs.

3. Results

Of the 16 patients who met the inclusion and exclusion criteria, 1 patient had passed away leaving 15 remaining patients. 5 patients could not be reached for the outcome assessments. Therefore, outcome data was collected from the remaining 10 patients at a mean follow up of 4.5 ± 2.5 years (range: 2.3–9.1 years). 2 patients were assessed in-office, and 8 patients were sent surveys to be completed and returned. This cohort included 9 males and 1 female, and the average age at the time of their surgery was 30.0 years. Of the 10 patients, five were classified as having anterior instability, two with posterior instability, and three with multidirectional instability.

At final follow up, mean ASES score was 92 ± 12 (range, 60–100). Mean WOSI was 315 ± 319 (range, 20–1049) with WOSI percentage of $15 \pm 15\%$. Nine of the 10 patients subjectively reported that they were "extremely satisfied" with the surgery while the remaining patient reported that he was "satisfied".

ROM assessed in resulted in average abduction of $174 \pm 19^\circ$,

Fig. 4. (A–C): Pre-operative CT Scan.

forward flexion of $168 \pm 21^\circ$, external rotation at 90° abduction of $75 \pm 16^\circ$, and external rotation with elbow at side of $62 \pm 11^\circ$. Eight patients noted internal rotation to their mid-back while the remaining 2 patients noted internal rotation to their lower back.

All patients received postoperative radiographs during their follow up with the latest set at an average of 27 ± 32 months (range: 2–92 months) from the surgery. All radiographs demonstrated intact screw in good alignment with bone adjacent to the hardware, and congruent glenoid surface (Figs. 4 and 5).

Fig. 5. (A&B): Post-operative X-ray.

Of the 10 patients included in our analysis, 1 patient suffered an injury to the shoulder while weight lifting 14 months after the procedure. After failing non-operative treatments, he was then treated with an arthroscopic repair of superior labrum anterior posterior (SLAP) lesion 29 months following the index procedure. Arthroscopic inspection of the allograft in during this surgery demonstrated excellent healing and incorporation of the graft (Fig. 6). Another patient suffered a traumatic anterior shoulder dislocation 2 years after the glenoid bone grafting procedure while playing collegiate hockey. This patient was treated non-operatively with excellent clinical function and ASES/WOSI scores (100/213).

4. Discussion

There are multiple advantages for using autograft for glenoid reconstruction in patients with recurrent shoulder instability. It is readily available in most patients and generally believed to provide more consistent healing to the native glenoid.

The two most common autograft procedures are the Bristow and Laterjet procedures. One of the largest studies of the Bristow procedure was done by Hovelius et al. They evaluated 319 patients with an average follow up of 15.2 years. Overall satisfaction rate was 95%, with 86% reporting good to excellent Rowe scores and WOSI scores of 84.7%. Their recurrence rate was 20%.²² An additional study by Schroder et al. reported on 52 Navy midshipmen with 26-year follow up. Their failure rate was 15.4% with 69% of WOSI scores being good to excellent. 15% of the patient underwent a revision surgery on that shoulder.¹² Results have been promising for the Bristow procedure, but longer-term studies have demonstrated increased risk of glenohumeral arthritis, external rotation loss, and recurrence rates up to 18%.²³

The Laterjet is similar to the Bristow procedure, although it uses a larger coracoid osteotomy of 2–3 cm. This increased length allows the

Fig. 6. (A–C): Post-operative arthroscopic images of shoulder demonstrating excellent healing and graft incorporation.

fragment to be placed perpendicular to the base of the glenoid and demonstrates improved stability.²³ The Latarjet has become the preferred technique for autograft procedures. The largest study on outcomes of the Latarjet procedure was by Young et al. evaluating over 2000 patients. 76% had good to excellent Rowe scores, and 83% returned to their preinjury sports level. They reported a 1% failure rate with no significant external rotation loss (average loss of 5.1°).²⁴

However, there are also several disadvantages of using autograft. For example, autograft is typically taken from the iliac crest, which does not match the articular contour of the glenoid surface. In addition,

there is significant donor site morbidity, with complication rates range from 3 to 40% percent.^{25,26} Complications include fracture, nerve injury, hematoma formation, and harvest site pain.

In order to avoid these complications, many surgeons have advocated the use of allografts for glenoid reconstruction. Although many different sources for allografts are available, they can generally be divided into fresh or cryopreserved. In comparison to cryopreserved grafts, fresh allografts have higher tissue viability and healing potential when used within 2–4 weeks of harvesting.^{27,28} As such, most reports of allograft reconstruction for glenoid defect have utilized fresh allografts. For example, Provencher et al. reported a series of 3 patients whose glenoid deficiency was reconstructed with distal tibial fresh allografts.¹⁴ From their early promising results, the authors noted advantages of distal tibia in reconstructing glenoid defect such as matching articular conformity, presence of articular cartilage, and dense bone capable of bearing weight.

The largest case series by Zhao et al.²⁹ included 52 shoulders with a mean follow-up of 39 months treated with bi-cortical iliac crest and non-rigid fixation; unfortunately, the type of graft preservation was not mentioned in this study. In all cases, the grafts healed to the glenoid at 3 or 6 months, and glenoid remodeling was complete within 12 months with most patients demonstrating robust bone capsule formation on the anterior side of the glenoid. The Oxford score improved from 30 to 42, and the Rowe score improved from 35 to 92.

While theoretically associated with reduced healing potential, cryopreserved allografts also avoid the major disadvantages of fresh allografts including disease transmission, availability, and cost.^{30–34} Unfortunately, there has only been one published report on using cryopreserved allograft for glenoid reconstruction. This case report by Tjoumakaris et al. discusses a 19 year-old active marine treated with cryopreserved allograft for significant bipolar bone loss. At 4.5 months postoperatively, radiographs and a CT scan were taken demonstrating incorporation of the allograft tissue with no hardware complications. The patient was released to full, unrestricted active duty at that point.¹⁷

Data from this study supports the hypothesis that cryopreserved allografts can successfully be used to reconstruct glenoid bone defects in patients with shoulder instability. While complications were noted in 2 patients, both shoulders demonstrated healing of the graft to the host glenoid.

There are several limitations to this study including retrospective nature of the study, low number of patients, and relatively short follow up. In addition, post-operative motion in some patients was obtained through patient assessments. Although this method has been validated, intra-operative assessments could have improved the reliability of the measurements. Most importantly, routine post-operative CT scan were not performed to clearly assess healing of the graft onto the native glenoid. Instead, post-operative radiographs were utilized to confirm that the allograft was present about the entire length of the screws, recreating the normal contour of the glenoid surface.

Despite these limitations, the data seems to suggest that cryopreserved allograft can successfully restore the glenoid bone stock and lead to a clinically stable joint. Given the potential advantages of cryopreserved allografts, additional research with larger cohort of patients should be conducted to validate the hypothesis that cryopreserved allograft can be successfully used to reconstruct glenoid deficiency.

5. Conclusion

At a minimum 2-year follow-up, patients with shoulder instability who were treated with glenoid bone grafting with cryopreserved tricortical iliac crest allograft demonstrated excellent functional outcomes and satisfaction. Therefore, cryopreserved allograft may provide a low cost and widely available alternative to reconstruct glenoid surface.

Conflict of interest

None.

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