

Anterior Glenohumeral Capsular Reconstruction Using a Human Acellular Dermal Allograft



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Abstract: Anterior capsular reconstruction needs to be done for most cases of anterior shoulder instability. Several surgical techniques using tendinous allografts and autografts have been used for the treatment of anterior glenohumeral capsular reconstruction. However, the outcomes of these procedures are not satisfactory. This study describes a comparatively new technique of using human acellular dermal allograft (GraftJacket: Wright Medical Group, Memphis, TN) in the reconstruction of the anterior capsule to restore anterior glenohumeral stability.

Anterior shoulder dislocations account for 95% to 97% of all glenohumeral dislocations and are often followed by recurrent anterior shoulder instability.¹ Chronic anterior glenohumeral instability is particularly common among young athletes and is often precipitated by a traumatic blow to the abducted, externally rotated, and extended arm.^{2,3} In rarer cases, a traumatic initial anterior dislocation may occur following a blow to the posterior humerus, or a fall on a flexed, outstretched arm. Instability events may range in severity from microinstability, subluxations, to total glenohumeral dislocations.⁴ Particularly in populations of 20 or younger, recurrent dislocation rates following a primary dislocation are as high as 90%.⁵ Conservative treatment strategies include immobilization and physical rehabilitation, but in some cases, surgery may be indicated.⁶

Determining the etiology of anterior instability is crucial in informing surgical management, where soft tissue and/or osseous pathologies may exist. Soft tissue damage often includes Bankart tears,⁷ humeral

avulsions of the glenohumeral ligament,⁸ and stretching of the capsule.⁹ Osseous injuries often include Hill-Sachs lesions¹⁰ and, less commonly, bony Bankart lesions.¹¹

For patients with soft tissue pathologies for which primary repair of the capsulolabral complex is not possible because of excessively patulous or absent capsular tissue—few surgical options may exist. A number of techniques for anterior capsular reconstruction have used tendinous allografts and autografts, but are associated with variable biomechanical results, decreased range of motion in the operative arm, and insults to neighboring nerves.¹²⁻¹⁴ The use of human acellular dermal allografts in open anterior capsular repairs has shown superior results to tendon transfer techniques, but is still associated with long recovery periods.¹⁴

The present article describes our preferred technique using GraftJacket human acellular dermal allograft in the reconstruction of the anterior capsule to restore anterior glenohumeral stability. This technique has the added benefits of an arthroscopic procedure, including quicker recovery time, decreased postoperative pain, and general preference by patients.^{15,16}

Surgical Technique

Preoperative assessment is described in Table 1. Antibiotic prophylaxis and general anesthetic are administered to the patient. A bean bag positioner is used to assist in placing the patient in the lateral decubitus position, with the operative arm up (Fig 1A). The patient is then rolled approximately 30° to align the glenoid parallel to the floor. Examination under general anesthetic is carried out to confirm anterior instability.

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Table 1. Preoperative Assessment

- Full history and physical examination including history initial dislocation, subsequent dislocations, and treatment to date
- Focused physical examination for instability, including assessment of Beighton score, assessment of rotator cuff, and special tests for instability: apprehension test, relocation test, load and shift test, and assessment of sulcus sign.
- Radiographs including AP glenohumeral joint, scapular Y-view, axillary view, and Bernageau view
- CT with 3D reconstructions to better assess bone loss
- Consider MRI to assess labral pathology and rotator cuff integrity.

CT, computed tomography; MRI, magnetic resonance imaging; 3D, 3-dimensional.

The operative shoulder and axilla are prepared with a chlorhexidine solution and draped in a sterile fashion. The operative arm is secured in a SPIDER Limb Positioner (Smith & Nephew, London, England), and abducted to 60° with slight traction.

Bony landmarks outlining the clavicle, acromion, scapular spine, acromioclavicular joint, and coracoid are drawn on the patient's skin. Three arthroscopic

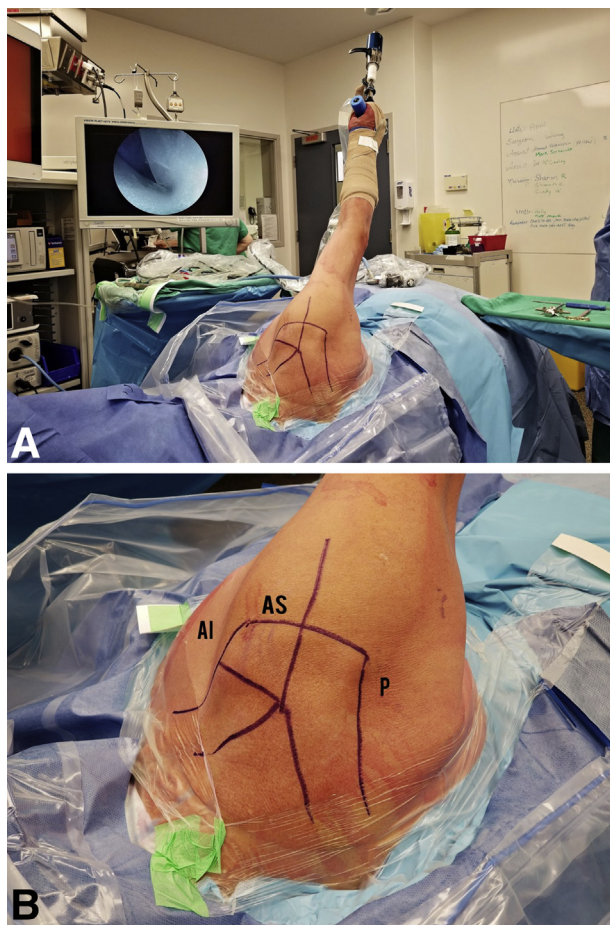


Fig 1. (A) Patient is placed in the lateral decubitus position, right side up, with the arm in 60° abduction using a Spider arm holder (right shoulder). (B) Portal placement with patient in a right lateral decubitus position. (AI, anteroinferior portal; AS, anterosuperior portal; P, posterior portal.)

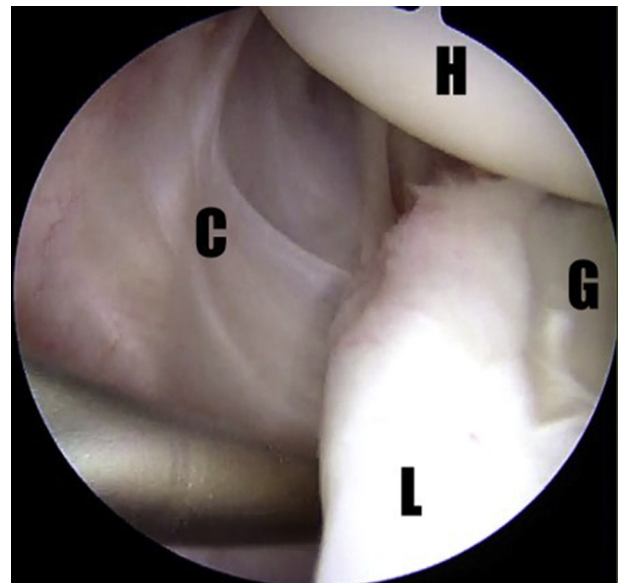


Fig 2. View from the anterosuperior portal (right shoulder). Shaver in anterior inferior portal. (C, capsule [deficient, very thin and can see subscapular muscle through the capsule tissue]; G, glenoid; H, humerus; L, labrum.)

portals are then marked: anterior superior, anterior inferior, and posterior (Fig 1B).

Diagnostic Arthroscopy and Debridement

A standard diagnostic arthroscopy is carried out through the posterior portal, which includes a complete assessment of the capsulolabral complex, glenoid rim, articular cartilage, rotator cuff tendons, and biceps tendons. Anterior superior and anterior inferior portal ends are placed to further evaluate the glenoid bone for possible osseous pathology (Fig 2).

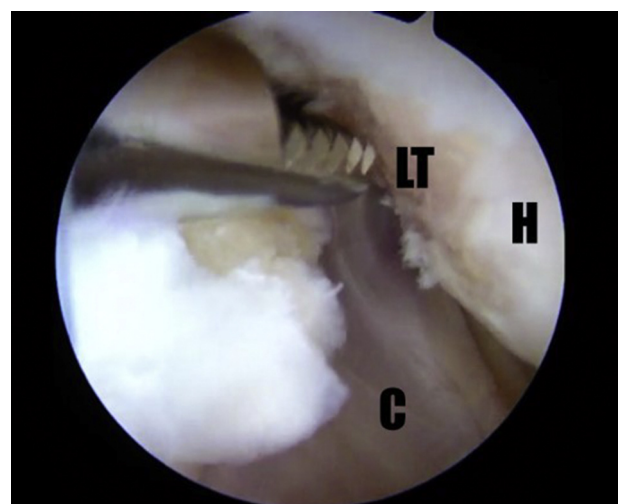


Fig 3. Debridement of lesser tuberosity for anchor placement and capsular attachment using shaver through the antero-inferior portal. Scope view from anterosuperior portal. (C, capsule; H, humerus; LT, lesser tuberosity.)

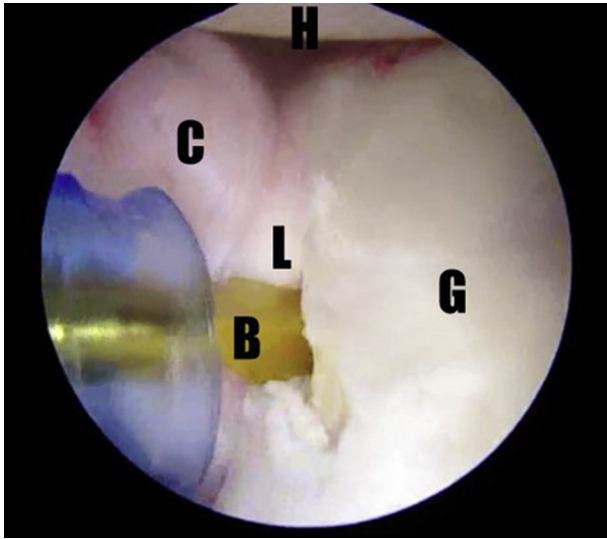


Fig 4. Elevation of capsule labral tissue using Bankart knife. (B, Bankart knife; C, capsule; G, glenoid; H, humerus; L, labrum.)

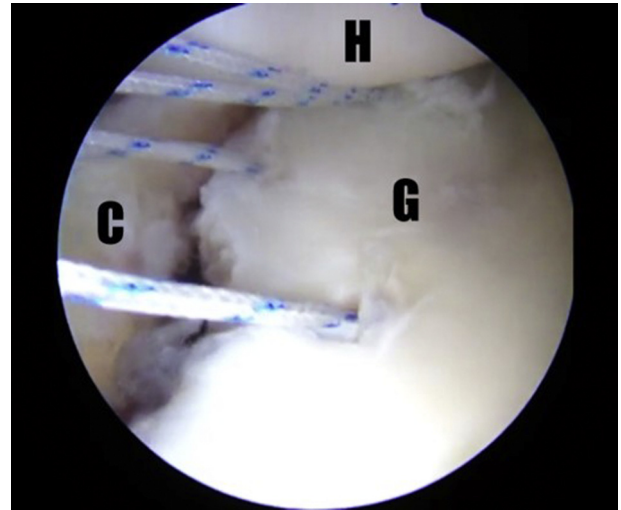


Fig 6. Insertion of 3 single-loaded anchors on the anterior rim of the glenoid in a standard Bankart configuration. View from the anterosuperior anchor. (C, capsule; G, glenoid; H, humerus.)

Debridement of the lesser tuberosity of humerus is done using a shaver and a rasp to get healthy, bleeding bone (Fig 3). The labrum is then elevated off the anterior rim using a Bankart knife to get good access to the anterior glenoid bone (Fig 4). Because the sleeve of the labrum is taken down, we have a suture fixed at the very superior aspect. The anterior glenoid bone is then shaved down to get healthy, bleeding bone.

Anchor Placement

Using a 5-o'clock trans-subscapularis portal, 2 double-loaded Q-fix anchors (Smith & Nephew) are inserted percutaneously into the debrided lesser tuberosity to get fixation onto the humerus (Fig 5). Three

single-loaded 1.8-mm Q-fix glenoid anchors are then placed into the anterior glenoid bone from the anterior-inferior portal (Fig 6). All suture limbs are carried out the posterior portal and kept exterior to the posterior cannula.

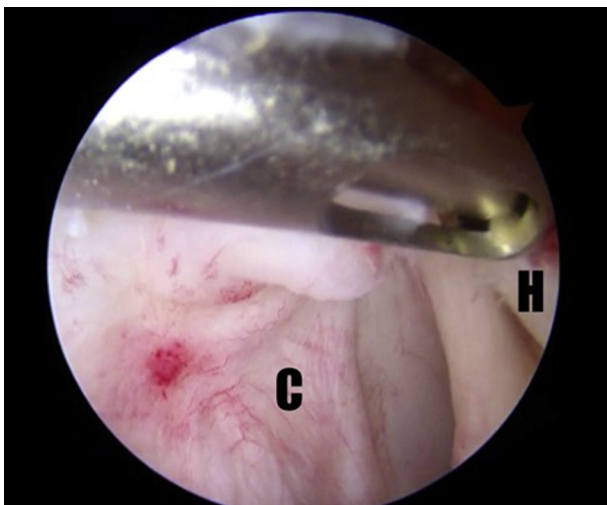


Fig 5. Inferior lesser tuberosity anchor placement using drill guide through anteroinferior portal. (C, capsule; H, humerus.)



Fig 7. Preparation of graft to match anterior capsule size as measured on 3D-printed model. A cellular dermal matrix was cut to 2x2 cm.

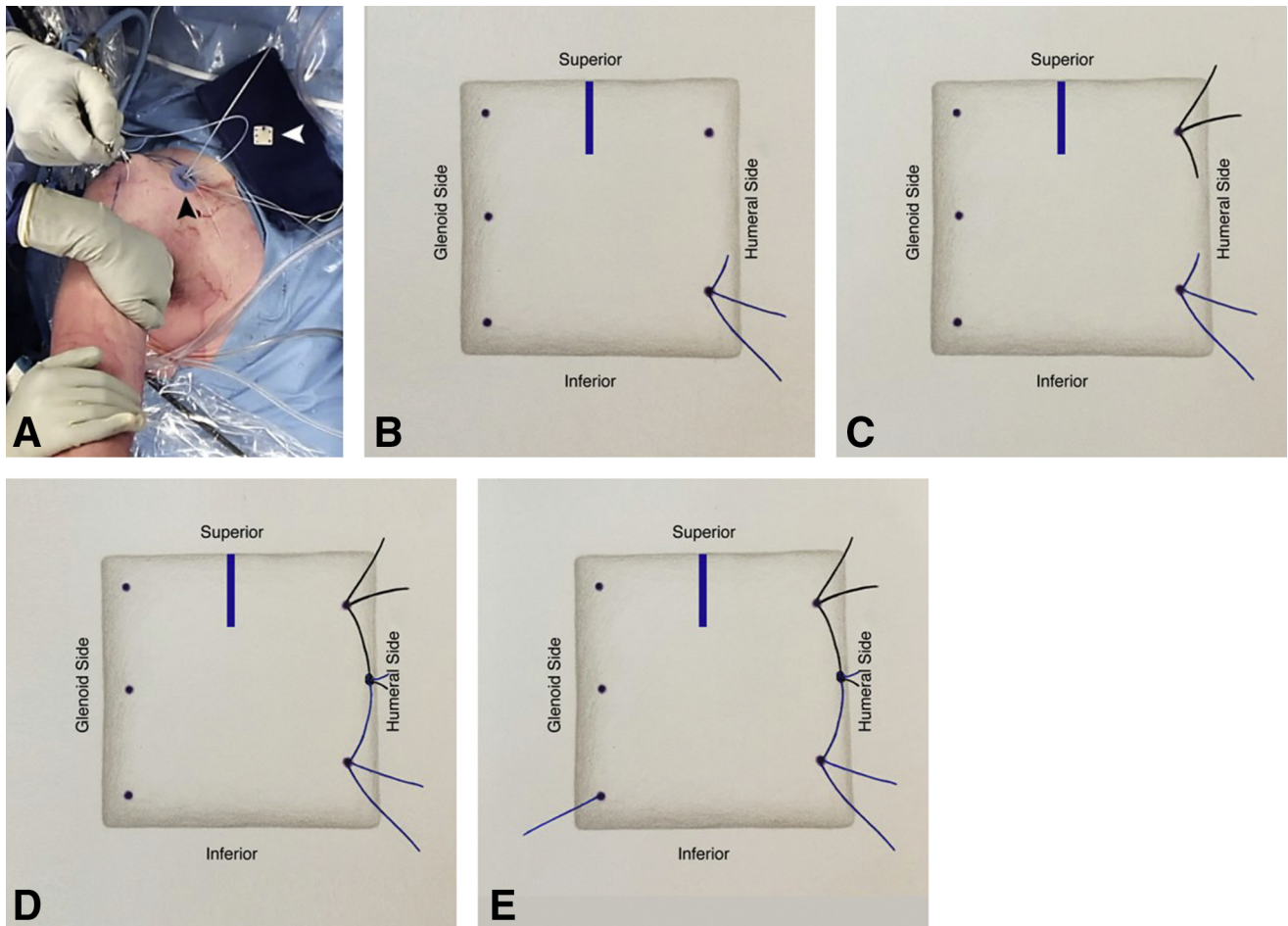


Fig 8. (A) Sutures are managed through the anteroinferior (black arrow) portal to attach to the humeral side of the prepared graft (white arrow) (right shoulder). (B) Three limbs from the inferior humeral double loaded anchor are placed through the inferior humeral side of the graft. (C) Three limbs from the superior humeral double-loaded anchor are placed through the superior humeral side of the graft. (D) One limb from each of the anchors on the humerus are tied together to form a double pulley. (E) One limb of the inferior glenoid anchor is attached to the inferior glenoid side of the graft to help pull the graft into the joint.

Graft Preparation and Suture Management

Before securing the graft, assessment of the capsular tissue and, if possible, plication of the patulous, but intact, posterior capsule should be carried out. We use a pinch-tuck technique using figure-of-8 stitches using a curved-to-the-left, 45° spectrum needle driver with 2 independent high-strength sutures at the 7- and 9-o'clock positions, respectively. Figure-of-8 stitches are done to obtain maximum strength of construct here. The sutures are left untied to first allow for the anterior capsular construction as well as the Bankart repair.

A passport cannula is then placed through the anterior portal to get a larger, 10-mm by 4-mm-diameter cannula, through which to pass the graft. The GraftJacket allograft acellular human dermal matrix (Wright Medical Technology, Arlington, TN) is prepared on the back table. The graft is cut to appropriate dimensions to fit a 3D-printed model of the patient—in our case, a 2×2-cm graft, which is used to

re-create the anterior sling (Fig 7). Markings for 3 sutures are made on the glenoid side of the graft, and 2 markings are made on the adjacent, humeral side of the graft. All markings are made at 3 mm from the edge.

The 4 suture limbs from the 2 humeral anchors are exteriorized from the anterior inferior working portal (Fig 8A), and we are careful to make sure that these are separated and easily identified. The black suture limbs from the inferior anchor and the blue suture limbs from the superior anchor are taken, and 3 of the suture limbs from the interior portal are passed through the graft (Fig 8B), followed by 3 of the superior anchors through a separate hole in the graft using a Mayo needle driver (Fig 8C). Once these are passed, the inferior blue limbs are tied with the superior black limbs to obtain a double-pulley construct (Fig 8D).

We then pull one of the suture limbs from the most inferior glenoid anchor out of the anterior portal, being careful to not tangle this, and pass the suture limb

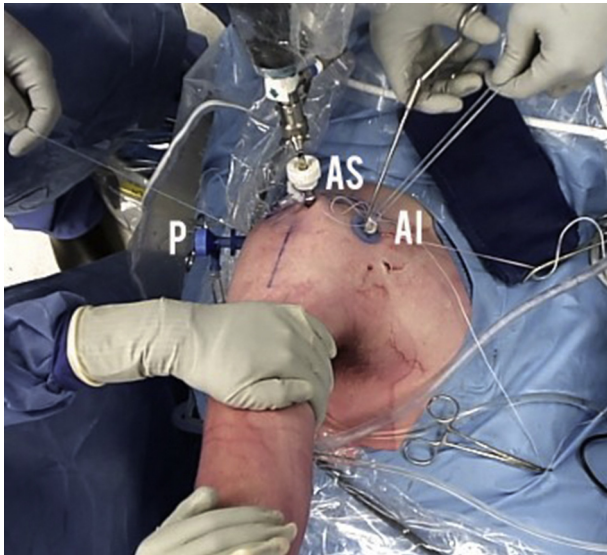


Fig 9. Graft passage by pulling the inferior glenoid suture limb out the posterior (P) portal (Right shoulder). The graft is passed through the AI cannula, pulling on one suture limb from each humeral anchor using a double-pulley technique to attach the graft onto the humerus. View from the AS portal. (AI, anteroinferior portal; AS, anterosuperior portal.)

through the graft and tie it with a stick knot (Fig 8E). This will be used as the first suture to pull the graft inside the glenohumeral joint.

Securing of the Graft

Using the most inferior glenoid anchor, the graft is then passed inside the shoulder, allowing for a single point of fixation. A double-pulley technique is then used to shuttle the humeral sutures all the way down to the humerus. This allows for a bridging mattress suture,

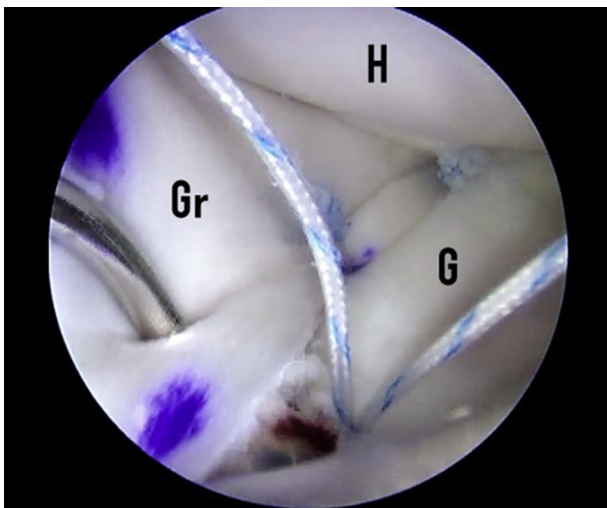


Fig 10. Bankart repair of new anterior capsular allograft tissue onto 3 glenoid anchors. (G, glenoid; Gr, graft; H, humerus.)

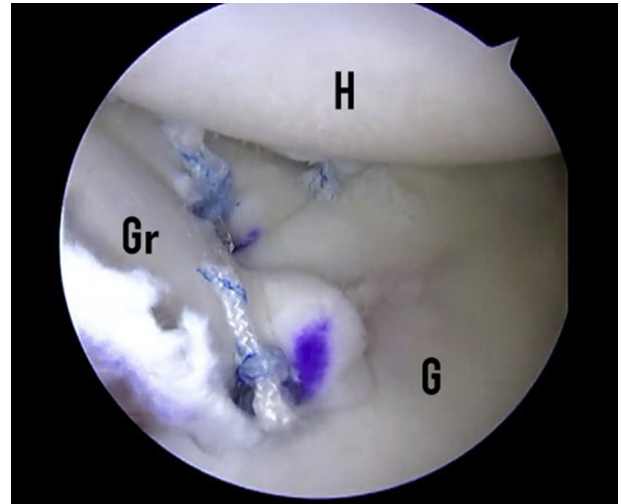


Fig 11. Final view of Humeral head well balanced over glenoid with the anterior capsular graft well tensioned. (G, glenoid; Gr, graft; H, humerus.)

which is then tied with a Revo knot. We then concentrate our efforts onto the inferior humeral anchor, which is tied with a simple stitch all the way around with an SMC knot to get better fixation onto the humerus. Once this is done, we focus our attention to repair the remaining part of the graft onto the glenoid. Using a grasper to tension the graft, and a curved-to-the-right 45° spectrum needle, we pass the sutures through the graft and tie them with an SMC knot (Fig 9). This retensions the glenoid side of the graft anatomically onto the glenoid. We do the same with the superior anchor at this time. We then ensure that the humerus is completely stable over the glenoid. We then fix the Bankart on top of this graft back up to the superior aspect of the glenoid using a knotless suture anchor (Fig 10).

After completing the capsular reconstruction, we then tie the 2 posterior plication stitches with Revo knots to close down the patulous construct both at the 7- and 9-o'clock positions, allowing the shoulder to be completely stable and balanced (Fig 11 and Video 1). Wounds are irrigated and closed layer by layer, and the patient is brought to the recovery room. Postoperative rehabilitation was ensured by the physiotherapist (Table 2).

Table 2. Postoperative Rehabilitation

- 0-2 weeks: immobilization in sling with ROM exercises for wrist and elbow, with some very early passive shoulder ROM exercises started at initial physiotherapy visit on POD5
 - 2-6 weeks: pendulum and gentle passive ROM exercises
 - 6-12 weeks: active ROM, light strengthening, discontinue sling
 - 12 weeks: continue ROM and progressive strengthening exercises
- POD5, postoperative day 5; ROM, range of motion.

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none"> • Faster recovery time compared to tendinous grafts • No harvest site morbidity • Superior mechanical strength of construct compared to tendon grafts • Superior postoperative range of motion compared with an open procedure • Benefits of an arthroscopic procedure: faster healing time and less postoperative pain • Direct visualization of the glenohumeral joint to ensure proper anatomic position of the humeral head within the joint • Acceptability to patients 	<ul style="list-style-type: none"> • Skill-dependent nature of arthroscopy • Need for careful suture management during graft insertion • Possibility of increased operative time in cases where graft becomes entangled • Potential for higher instability recurrence rates postoperatively • Possibility for incorrect measurement of the injury resulting in inappropriate graft size • May not be effective for patients with concomitant pathologies of the shoulder • Long-term outcomes unknown

Discussion

In this article, we describe a method for anterior glenohumeral capsular reconstruction using an acellular dermal allograft for the treatment of recurrent anterior instability. This technique may be used when primary repair of the capsulolabral complex is not possible because of excessively patulous or absent capsular tissue. It may also be used in patients with refractory anterior instability, or for whom previous primary surgical repair has failed.

A number of other surgical techniques have emerged in attempt to reconstruct the anterior capsule, each of which produces variable degrees of range of motion, failure rates, need for revision surgery, and nerve damage.¹⁴ For instance, semitendinous and gracilis tendon autografts have been used to reconstruct the anterior capsule. Warner and colleagues showed symmetric flexion and external rotation comparable to the nonoperative shoulder following such procedures, as well as an absence of pain 24 months postoperatively. This technique, however, requires long periods of immobilization and physical therapy before achieving full recovery. Similarly, anterior capsular reconstruction using hamstring tendon autografts and tibialis tendon allografts have been shown to improve anterior stability but are associated with decreased range of motion in the operative shoulder compared to the contralateral shoulder.¹³

The use of human acellular dermal allografts in open anterior capsular reconstruction has shown promising results. Compared to tendon transfer, these allografts have been shown to produce faster recovery time, enhanced anatomic reconstruction, and eliminate concerns of harvest site morbidity in the case of autografts.¹³ Furthermore, they are of superior mechanical strength than tendon grafts, which are smaller, thinner, and more prone to tearing.^{12,13,17}

The technique described in this article has an added benefit of an arthroscopic procedure, which further decreases healing time and postoperative pain.^{15,16,18} It is also associated with lower morbidity and general acceptability by patients. An arthroscopic technique

also allows for direct visualization of the glenohumeral joint following securing of the graft to ensure the humeral head in its correct anatomic position within the joint. Limitations of this technique may include the technically challenging nature of arthroscopy, the need for careful suture management during insertion of the graft, and possible increased operative time in cases where the graft becomes entangled (Table 3). For these reasons, fluid extravasation should be monitored. Incorrect measurement of the lesion may result in a graft that is either too small or too large. This risk can be avoided using 3D models of the patient's shoulder to measure the graft accordingly. Of note, a meta-analysis of arthroscopic open Bankart repairs for recurrent anterior shoulder dislocations found that although the arthroscopic approach showed significantly improved recovery rates and improved postoperative range of motion for recurrent anterior instability compared with the open procedure, it was associated with higher rates of recurrent instability and need for revision repairs.¹⁸ Recurrent instability may also be higher for patients with concomitant pathologies of the shoulder¹⁹ but can be avoided by carefully carrying out the systematic diagnostic arthroscopy described here. The technique described in this article is expected to decrease postoperative pain, recovery time, and increase range of motion, making it an optimal approach particularly for young athletes. However, long-term monitoring of outcomes, particularly recurrent anterior instability and need for revision surgery should be monitored.

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