Technical Note

Arthroscopic Anterior Shoulder Capsular Reconstruction Using Human Acellular Dermal Graft in Conjunction With Anatomic Glenoid Reconstruction

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Abstract: Capsular insufficiency of the shoulder associated with glenoid bone loss poses a major challenge to orthopaedic surgeons in the management of recurrent anterior instability. Multiple surgical techniques have been described in the literature with varying rates of success, and the majority of these are open techniques. We present a complete arthroscopic technique for anterior capsular reconstruction using acellular human dermal allograft patch in conjunction to an anatomic glenoid reconstruction using a distal tibial allograft in the lateral decubitus position. If the capsular insufficiency is determined irreparable after glenoid reconstruction, the acellular human dermal graft patch is prepared, inserted into the shoulder joint, and appropriately fixed using suture anchors on both glenoid and humerus, all through arthroscopic portals.

Introduction

Recurrent shoulder instability, especially in young patients, continues to be a challenging orthopaedic problem to tackle. Although not a common setting, patients who suffer significant glenoid bone loss combined with capsular insufficiency will present a complex pathology, needing to address not only the bony deficiency, but also the lack of soft tissue support.[1,2]

The Latarjet procedure, which involves the osteotomy and transfer of the coracoid to the anteroinferior portion of the glenoid, is currently the treatment of choice in providing stability through bony augmentation of the glenoid and sling effect from the conjoined tendon.[3] It was shown to be superior to arthroscopic Bankart repair in terms of long-term stability and patient satisfaction, with only 3% of patients experiencing overt instability in the Latarjet group.[4] Despite its merits, the Latarjet procedure, as well as other bony augmentation procedures, do not work as efficiently in the setting of capsular insufficiency or multidirectional instability, and the management of soft tissues should be concomitantly addressed.[5]

Capsular integrity and preservation are important for the Latarjet and other bony augmentation procedures. The Latarjet procedure attempts the triple block effect by restoring the glenoid bone loss through coracoid grafting, the sling effect of the transferred conjoined tendon, and the augmentation of the anterior capsule by the coracoacromial ligament stump.[6] Lafosse et al. demonstrated the benefits of the arthroscopic Latarjet technique, suggesting an anterior capsular resection to improve visualization and graft positioning.[7] Following studies by different authors have recommended the repair of the capsule to increase the stability of the shoulder joint.[8-10] A biomechanical study compared

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The authors report the following potential conflicts of interest or sources of funding: I.W. reports personal fees from Depuy Mitek, Smith & Nephew, CONMED Corp., and Bioventus LLC, outside the submitted work. He is an editorial board member for the American Journal of Sports Medicine *and* Arthroscopy, *and he is a committee or board member of AANA, ISAKOS, and AAC. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

Received September 21, 2022; revised manuscript received November 22, 2022; accepted December 8, 2022.

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2212-6287/221243

https://doi.org/10.1016/j.eats.2022.12.006

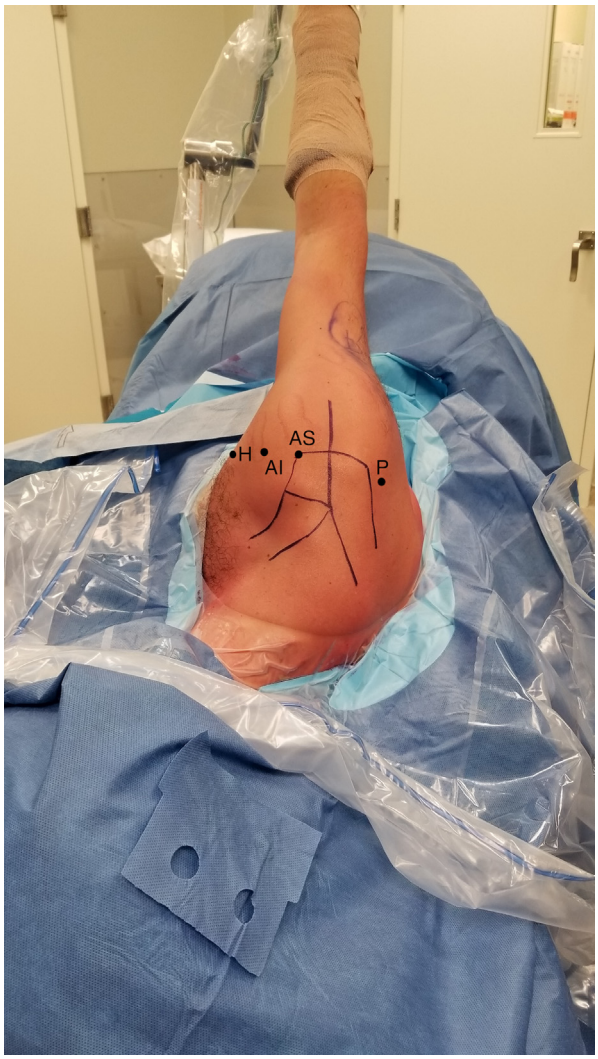

Fig 1. Patient positioning in the semilateral position with anatomic landmarks and portal sites on the right shoulder: AI, anteroinferior portal; AS, anterosuperior portal; H, far medial Halifax portal; P, posterior portal.

outcomes of the open and arthroscopic Latarjet procedures and demonstrated less translation in the open technique attributed mainly to the capsular repair.[11] This emphasizes the importance of preserving the anterior capsule and supporting its repair when the tissue allows it.

The use of distal tibia allograft (DTA) to augment the glenoid has been described with excellent short-term outcomes.[12-17] This procedure can successfully restore the glenoid bone stock. However, this does not address the soft tissue insufficiency, such as a deficient capsule, which can be the case of patients with chronic shoulder instability, as well as patients who are subject to revision instability surgery. Several surgical techniques for isolated capsule management in a capsular insufficiency setting have been described in treating this challenging problem with varying rates of success.[18-21] Peebles et al. have previously reported a combined open technique for bone augmentation and capsular management with DTA and modified T-plasty with capsular shift.[22] However, no previous technical note has shown or addressed the challenging issue of glenoid bone loss and capsular insufficiency in shoulder instability managed with the combination of glenoid and capsular reconstructions with allografts in an arthroscopic fashion.

In this article, we present a surgical technique for arthroscopic anterior capsular reconstruction using GraftJacket Matrix Scaffold (Wright Medical Technology, Arlington, TN), which is an acellular human dermal matrix allograft (AHDMA) in conjunction with anatomic glenoid reconstruction (AGR) using a DTA (Video 1).

Surgical Technique

Preoperative Assessment

A thorough history and physical examination is performed during the initial consultation. Initial event of dislocation and consequent recurrent dislocations, provoking factors, severity of symptoms and attempted treatments are documented. A standard shoulder examination is performed with focus on assessing the instability using apprehension and relocation tests, as well as sulcus, and load-and-shift tests. Integrity of the rotator cuff is also assessed. Generalized hypermobility of the patient is evaluated using the Beighton score.

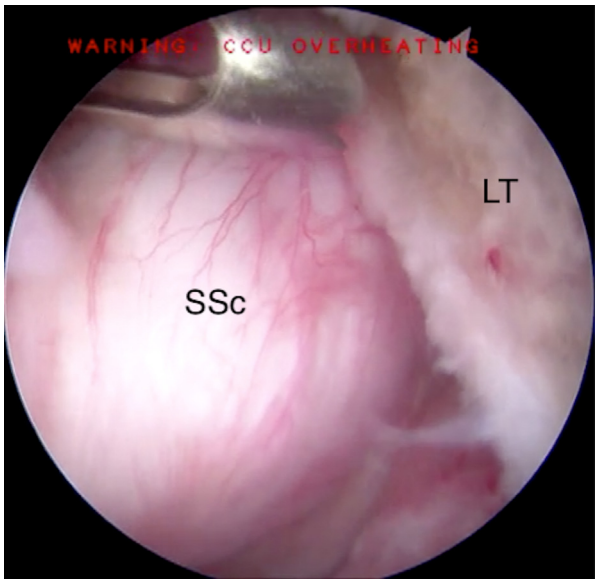

Fig 2. After a broad debridement of the capsular tissue, the lesser tuberosity, which is adjacent to the subscapularis, is debrided and decorticated. Making the placement of the suture anchors easier for the lateral capsular reconstruction, this will also accelerate the healing process. A view from the anterosuperior portal on the right shoulder. LT, lesser tuberosity; SSc, subscapularis tendon.

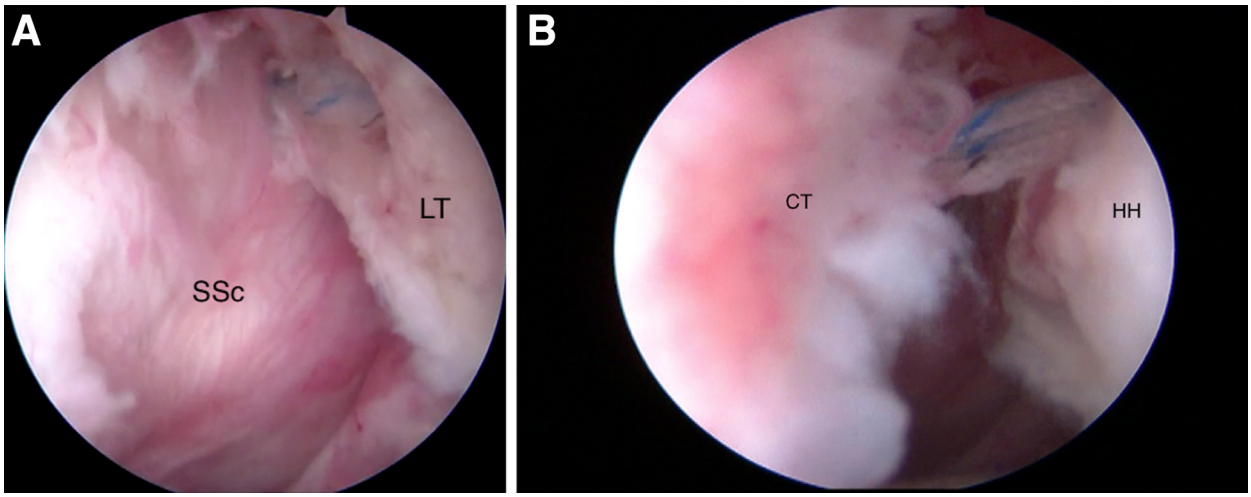

Fig 3. Two double-loaded Q-FIX (Smith & Nephew, Memphis, TN) suture anchors are placed in the lesser tuberosity through subscapularis via the anteroinferior (5 o'clock) portal. A view from the anterosuperior portal on the right shoulder. (A) inferior anchor. (B) Superior anchor. CT, capsular tissue; HH, humeral head; LT, lesser tuberosity; SSc, subscapularis tendon.

Plain radiographs of the shoulder are obtained, including anteroposterior, axillary, and Bernageau views. A computed tomography (CT) scan of the shoulder with 3-dimentional reconstruction allows accurate assessments of the glenoid bone stock and the volume of the Hill-Sachs lesion. Magnetic resonance imaging (MRI) of the shoulder is also obtained to assess the integrity of the rotator cuff muscle.

Positioning and Preparation

After the induction of general anesthesia and intubation, the patient is positioned on a standard articulating operating table (Skytron, Grand Rapids, MI). A beanbag positioner is placed under the patient. The patient is rolled into a semilateral position at 30° from vertical to make the glenoid parallel to the floor. The patient's skin is cleaned with chlorhexidine solution and draped with 2 split shoulder drapes (Tiburon; Cardinal Health, Dublin, OH). The patient's arm is then placed in a pneumatic positioner (Spider 2; Smith & Nephew, Memphis, TN) and abducted 60° in balanced traction (Fig 1).

Evaluation and Glenoid Bony Reconstruction

Skin landmarks (scapular spine, acromion, clavicle, acromioclavicular joint line, and coracoid) are drawn

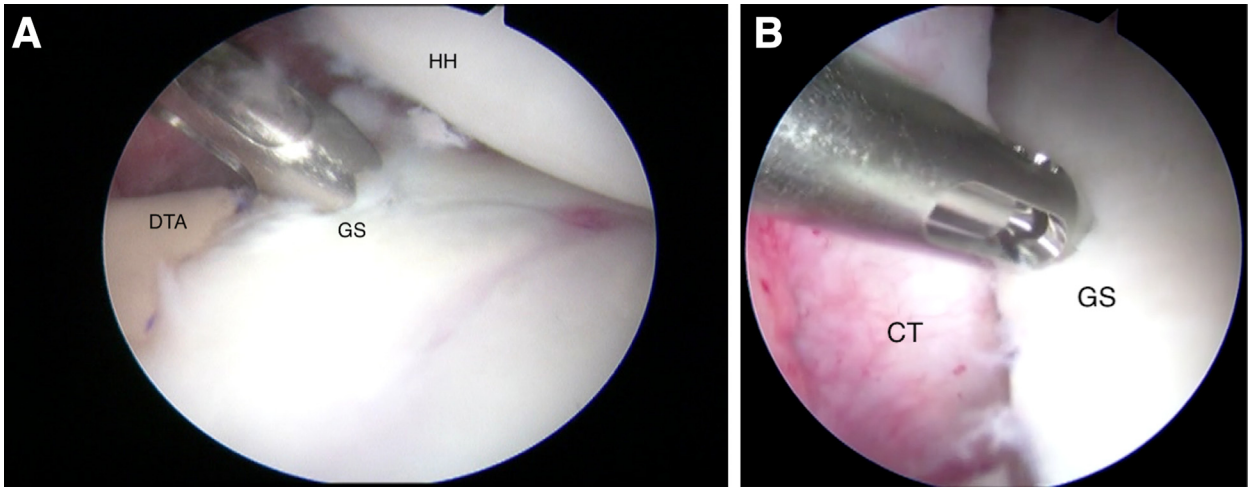

Fig 4. Two single-loaded Q-FIX suture anchors are placed on the anterior portion of the glenoid, at the 6 o'clock and the 3 o'clock locations, respectively. The 6 o'clock anchor is placed first through the anteroinferior portal. Then one of the suture limbs is brought through the posterior portal using a suture retriever, and the other limb remains through the anteroinferior portal. After that, the 3 o'clock anchor is inserted, and one suture limb is brought to the posterior portal using the suture retriever. A view from the anterosuperior portal on the right shoulder: (A) inferior anchor and (B) superior anchor. CT, capsular tissue; DTA, distal tibial allograft; GS, glenoid surface; HH, humeral head.

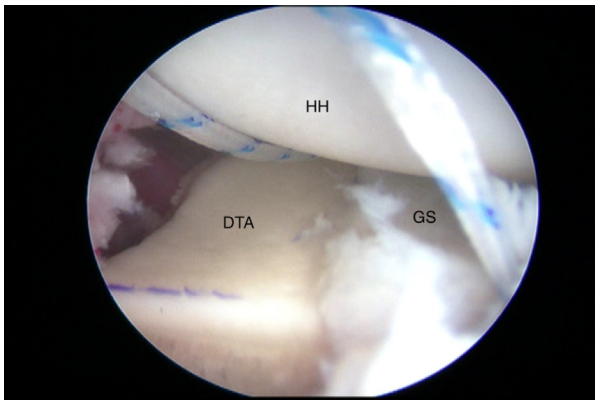

Fig 5. One suture limb from each of the glenoid anchors is retrieved through the anteroinferior portal. Then the suture limbs through the anteroinferior portal are brought outside of the cannula for suture management. A view from the anterosuperior portal on the right shoulder. DTA, distal tibial allograft; GS, glenoid surface; HH, humeral head.

on the patient. Arthroscopic portals are then located (Fig 1). The standard posterior portal is kept medial to be parallel to the glenoid face. We then identify, the anterosuperior and anteroinferior portals. A diagnostic arthroscopy is then performed according to the method described by Snyder.[23] Often, the patient has already undergone surgical stabilization of the shoulder, and the viability of the previously repaired tissues is assessed. Loose suture materials and/or exposed hardware are removed. The glenoid bony augmentation with DTA is performed at this stage using a Halifax portal. The bony augmentation procedure does not interfere with the anterior capsular reconstruction. Performing the bony augmentation with the distal tibial allograft first can make difficult the exposure of the capsular remnant. It is important to do all the assessments and planning for the anterior capsular reconstruction prior to starting the distal tibial allograft glenoid reconstruction. A detailed description of the surgical technique was described in a previously published article.[13,15]

Suture Anchor Placement

Once the anterior capsular tissue is assessed, the necessary equipment and implant for the capsular reconstruction are opened. In this case, there was a previous Bankart repair with a HAGL lesion that was irreparable. Extensive debridement of the remaining capsular tissue is performed. The lesser tuberosity adjacent to the subscapularis is debrided and decorticated before placing the suture anchors to facilitate the lateral capsular reconstruction (Fig 2). While using the anterosuperior portal as a viewing portal, two double-loaded Q-FIX (Smith & Nephew, Memphis, TN) suture anchors were placed in this area through the 5 o'clock, anteroinferior portal through subscapularis (Fig 3, A and B).

Two single-loaded Q-FIX suture anchors are then placed along the anterior portion of the glenoid, at approximately the 6 o'clock and the 3 o'clock locations. The 6 o'clock anchor is inserted first through the anteroinferior portal (Fig 4, A and B). One of the suture limbs from this anchor is brought through the posterior portal using the arthroscopic suture retriever, while the other limb remains through the anteroinferior portal. The 3 o'clock anchor is then inserted, and one suture limb is brought to the posterior portal using the arthroscopic suture retriever (Fig 5). Then suture limbs through the anteroinferior portal were brought outside of the cannula for suture management.

Allograft Preparation

GraftJacket is opened and prepared on the back table. The GraftJacket allograft requires soaking in saline solution for 10 minutes before its application. The size of the graft is determined preoperatively using the 3D model, and this is confirmed with an arthroscopic measuring tool before cutting the graft to an appropriate size (Fig 6, A-D). A marking pen is used to indicate the outer surface of the graft once it is in the final position. Once the graft is prepared, the suture limbs from the glenoid bone anchors that were retrieved through the anteroinferior portal were placed through the medial side of the graft using the free suture needle. The sutures will be passed through the graft in an outside-to-inside direction, and each suture will pass through each corner of the medial side of the graft. A short-tailed interference knot (STIK) is tied on the graft using both of these sutures, which will aid in shuttling the graft inside the glenohumeral joint.

The humeral Q-FIX anchors are double loaded with 2 sets of different-colored sutures. All four suture limbs from the inferior humeral anchor are brought through the anteroinferior portal using the suture retriever (Fig 7). Three suture limbs were passed together through the lateral-inferior aspect of the graft, from inside-to-outside direction. The other four suture limbs from the superior humeral Q-FIX anchors were then brought out through the anteroinferior portal using the suture retriever. Again, 3 suture limbs were passed together through the lateral-superior aspect of the graft, from inside-to-outside direction. One suture from each of the anchors was tied together to create a double pulley for a mattress suture insertion of the graft.

Allograft Insertion and Fixation

The suture limbs from the glenoid anchors are kept outside the cannula with tension. The arthroscopic grasper is used to push the lateral aspect of the allograft through the anteroinferior portal all the way down to

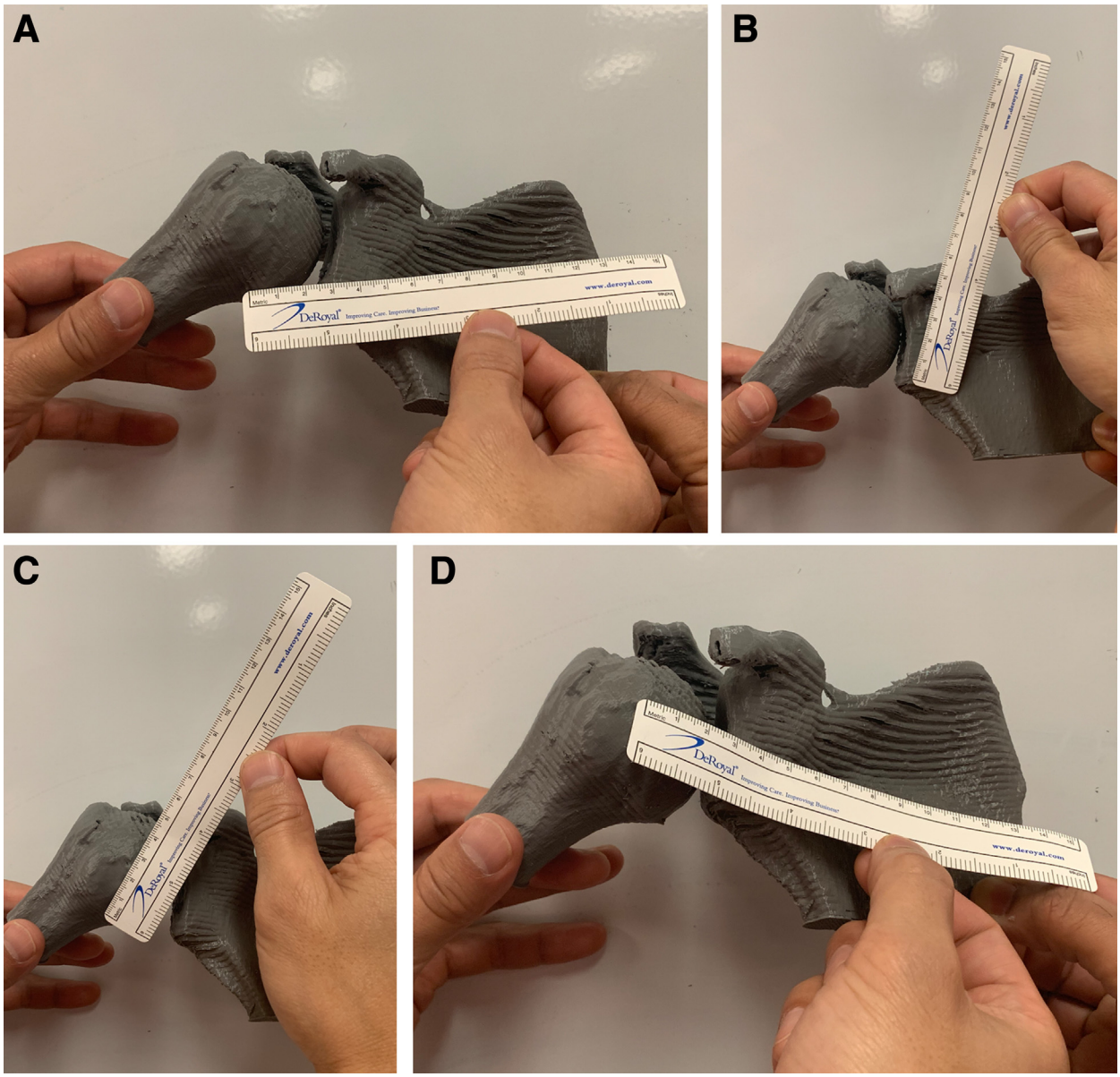

Fig 6. The size and dimensions of the graft are determined preoperatively using the 3-dimensional printed model of the right shoulder. These are also confirmed with an arthroscopic measuring tool before cutting the graft to an appropriate size: inferior border (A), medial border (B), lateral border (C), and superior border (D).

the humeral anchors. The sutures from the humeral anchors that were tied in a mattress fashion over the graft are used using a double-pulley fashion to seat the graft and then tied together using a REVO knot to complete the mattress stitch (Fig 8). The remaining suture from the inferior humeral anchor is then tied together in a simple suture configuration with an SMC knot. The final suture from the superior humeral anchor is also tied together in a simple suture configuration with an SMC knot.

The medial aspect of the graft is then pulled down to the glenoid by pulling the glenoid anchor sutures that were brought through the posterior portal. Once the allograft is fully seated on the glenoid, the arthroscopic grasper is used to pull the STIK knot of the glenoid anchor suture, and then sequentially tied down using an SMC knot (Fig 9). The appropriate tension of the allograft is then assessed, which should allow a full range of motion of the shoulder, including the external rotation while not being too slack to cause the glenohumeral joint dislocation (Fig 10). Once the assessment is satisfactory, the glenohumeral joint is irrigated, the arthroscopic equipment is retrieved, and the portals are closed.

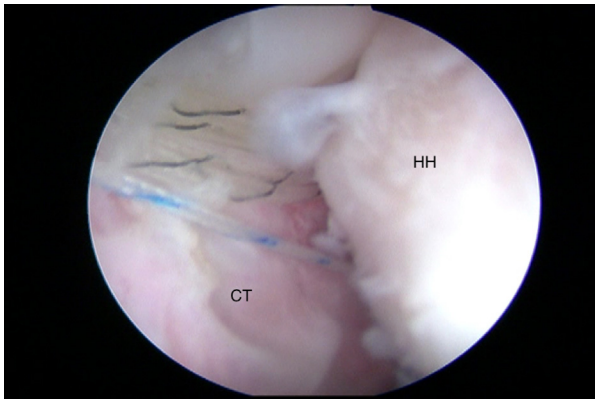

Fig 7. The humeral Q-FIX anchors are double-loaded with two sets of different-colored sutures. All 4 suture limbs from the inferior humeral anchor are brought through the anteroinferior portal using the suture retriever. Three suture limbs are then passed together through the lateral-inferior aspect of the graft, from inside-to-outside direction. The same step is repeated with the superior humeral Q-FIX anchor and then passed through the lateral-superior aspect of the graft in an inside-out fashion. A view from the anterosuperior portal on the right shoulder. CT, capsular tissue; HH, humeral head.

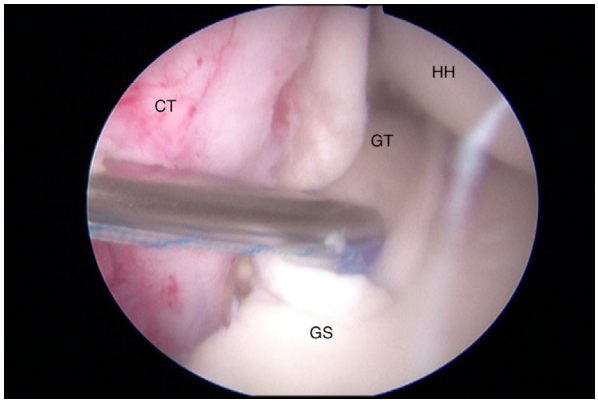

Fig 9. The medial aspect of the graft is pulled down to the glenoid by pulling the glenoid anchor sutures that are coming through the posterior portal. Once the allograft is seated on the glenoid, the grasper is used to pull the STIK knot of the glenoid anchor suture, and then it is tied down with an SMC knot. A view from the anterosuperior portal on the right shoulder. CT, capsular tissue; GT, graft tissue; GS, glenoid surface; HH, humeral head.

Postoperative Care

The details of the postoperative rehabilitation protocol will depend partly on the additional procedures performed in addition to the capsular reconstruction. The patient is placed in a sling (abduction with a wedge) (SlingShot; Breg, Carlsbad, CA) and is required to wear for the first 6 weeks postoperatively, except for range-of-motion exercises and for showering once the wound is fully healed. Physiotherapy commences at 5 days postoperatively, with a focus on gradual, gentle range of motion initially. The main focus for the initial 6 weeks is the mobility and passive range of motion, and the patients are restricted from active range of motion or terminal stretching. At 6 weeks postoperatively, once the patient achieves a full passive range of motion, then active range of motion exercises are initiated. The patient is instructed to avoid any strengthening and lifting for 12 weeks to avoid excessive stress on the graft. Introduction of sport-specific

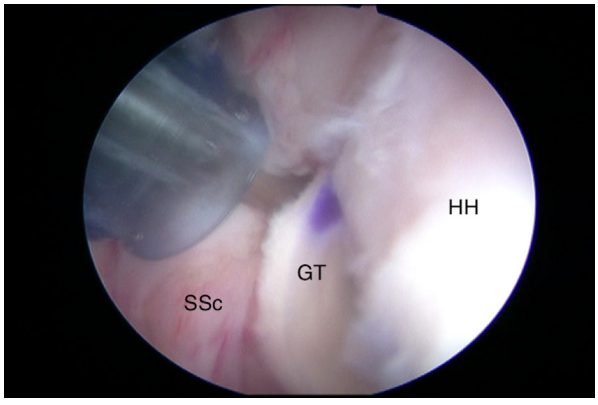

Fig 8. One suture from each of the anchors is tied together to create a double-pulley for a mattress suture insertion of the graft. This helps seat the graft, and then, the sutures are tied together using a REVO knot to complete the mattress stitch. A view from the anterosuperior portal on the right shoulder. GT, graft tissue; HH, humeral head; SSc, subscapularis tendon.

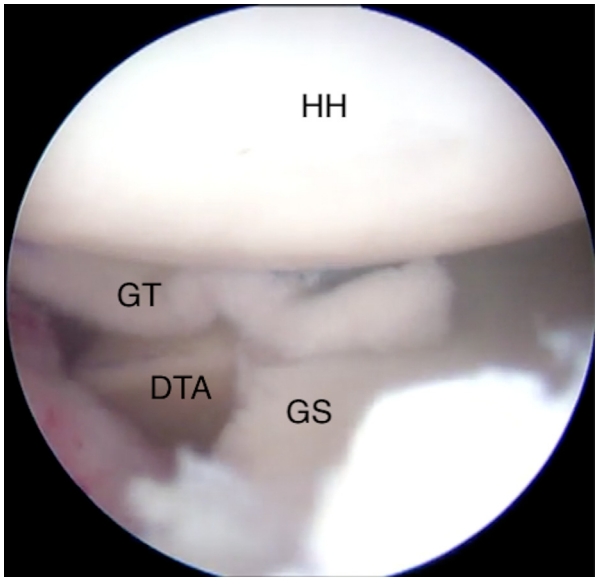

Fig 10. The appropriate tension of the allograft is assessed. It should allow for a full range of motion of the shoulder, including external rotation while avoiding a glenohumeral joint dislocation. A view from the anterosuperior portal on the right shoulder. DTA, distal tibial allograft; GS, glenoid surface; GT, graft tissue; HH, humeral head.

Table 1. Advantages and Disadvantages of the Technique

Advantages	Disadvantages
Addresses multiple components of shoulder instability	Requires a high level of arthroscopic skill
Arthroscopic minimally invasive technique	Higher cost of allografts
Faster recovery compared to open techniques	Demands a delicate suture management
Promotes better diagnostic inspection of shoulder joint and surrounding soft tissue and allows repair	Possible challenging operation in cases of graft entanglement
Reproducible due to using allografts	Availability of allografts
Avoidance of donor site morbidity and complications	Unavailable long-term outcomes

retraining usually commences at 16 weeks post-operatively, depending on the patient's progression.

Discussion

The all-arthroscopic anatomic glenoid reconstruction technique using a distal tibial allograft has recently revealed satisfactory short-term functional outcomes and an excellent safety profile in a 16-month follow-up, with no intraoperative or postoperative complications, and no incidence of dislocation during the follow-up period.[15] Furthermore, the technique resulted in a reduction in nerve injuries, as compared to other arthroscopic techniques addressing the glenoid bone loss.[12] This effect can be attributed to the subscapularis-sparing approach, while inserting the graft, which uses an inside-out guide for optimal placement of the medial Halifax portal parallel to the glenoid and away from nerves.[12,13]

After securing the glenoid graft, the technique proceeds to address the anterior capsular reconstruction. This order ensures positioning the capsular graft onto the glenoid without interfering with the DTA screws. Arthroscopic anterior capsular reconstruction using AHDMA is emerging as a reasonable adjunct for the treatment of capsular insufficiency.[24] The use of AHDMA is our preferred choice. In comparison with other allografts and autografts, AHDMA provides a significantly larger contact area with the underlying bone and better anatomic replication of native anterior capsule, while eliminating donor-site morbidity and significantly decreasing nerve complications.[20,25,26] It also gives the tissue a consistent and strong mechanical strength.[24] The latter advantage is important, especially in patients with generalized tissue laxity, as their own tissue will most likely show some degree of laxity.

This technique provides an all-arthroscopic technique for 2 complex pathologies, which by itself reduces surgical risks and ends up in better cosmesis, decreased postoperative pain, and faster recovery. Being an all-arthroscopic procedure, it also allows for a clear view of the glenohumeral joint during the graft positioning and confirms the humeral head reduction in an anatomic position within the joint following the graft placement. It also gives the advantage of adjusting graft sizes for better healing and obtaining an optimal glenohumeral track (Table 1).

Limitations of this technique may include the need of 2 allografts to compensate for the bony and capsular defects, including their cost, potential availability, and risk of infection. Also, the need for delicate suture management during insertion of the allografts and the possibility of increased operative time in cases of graft entanglement make this a technically demanding procedure in general (Table 2). For these reasons, fluid extravasation should be acknowledged as a possible complication.

Conclusion

This technique describes a multifactorial approach with the use of allografts for the management of shoulder instability due to glenoid bone loss and irreparable or insufficient capsular tissue. This procedure is usually performed in a revision setting, where both bone loss and capsule incompetence need to be addressed for shoulder stability.

Table 2. Pearls and Pitfalls of the Technique

Pearls	Pitfalls
Use of a 3D model for preoperative and intraoperative planning and graft measurement	Cadaveric graft availability
It's an all-arthroscopic procedure to augment shoulder stability	Graft associated costs
Both techniques can be easily performed during the same surgical case.	Requires familiarity and a learning curve for both procedures
Avoids donor site harvesting and morbidity	Suture management for capsular reconstruction can be demanding and requires high-level arthroscopic skill.

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