Technical Note

Revision of a Failed Latissimus Dorsi Transfer for a Massive Rotator Cuff Tear With Arthroscopic Anatomic Bridging Reconstruction Using an Acellular Human Dermal Matrix Allograft

Rakesh John, M.B.B.S., M.S. (Orth), D.N.B. (Orth), M.R.C.S. (England), M.N.A.M.S., Dip (SICOT), Catherine M. Coady, M.D., F.R.C.S.C., and Ivan Wong, M.D., F.R.C.S.C., M.Ac.M., Dip. Sports Med

Abstract: Latissimus dorsi tendon transfer is a nonanatomic tendon transfer that is often considered a salvage procedure for failed repairs of massive rotator cuff tears. A rupture of the transferred latissimus tendon is an uncommon complication and there is limited literature on its management, especially in the young, active population without cuff arthropathy. In this article, we present a technique of managing a failed latissimus dorsi tendon transfer for a massive rotator cuff tear with an arthroscopic, anatomic bridging reconstruction using an acellular human dermal matrix allograft.

Introduction

Since the advent of arthroscopy, the field of rotator cuff surgery has developed at a fast pace. However, the management of massive, irreparable cuff tears continues to be a difficult conundrum to solve even for the most experienced shoulder surgeons.[1]

Latissimus dorsi (LD) tendon transfer (LDTT) to the greater tuberosity (GT) of the humerus, introduced by Gerber et al.[2] in 1988, can be a useful management option, especially in the young patients with high functional demands. This option is traditionally viewed as a "salvage" technique for failed rotator cuff repairs (RCRs). Good results have been observed in long-term outcome studies published recently, with a reported clinical failure rate of around 10%.[3,4] The nonanatomic transfer of the LD tendon improves external rotation but does not lead to a significant increase in shoulder elevation.[4]

However, the literature is sparse on the management of a failed LDTT in a young person without arthropathy. Conversion to a reverse shoulder arthroplasty is not a suitable option in the younger, active population with high physical demands because it places severe physical restrictions postsurgery; the reverse shoulder arthroplasty implants also tend to wear out sooner in these age groups with poor success rates of further salvage operations.[4]

Bridging, or anatomic reconstruction of the rotator cuff with acellular human dermal matrix allograft (AHDMA), is increasingly being used as a viable, 'biological' solution for massive, irreparable cuff tears with good short-term to medium-term results being reported by different surgical groups across the world.[1,5-10]

Here, we report a technique of salvaging a failed LDTT for a massive RCT (MRCT) with an arthroscopic anatomic bridging reconstruction (AABR) using AHDMA.

Surgical Technique

Step 1: Preoperative Evaluation

A detailed history and thorough clinical examination are important in the diagnosis of a failed LDTT. Significant pain and weakness of the shoulder that do not

From the Division of Orthopaedic Surgery, Department of Surgery, Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada.

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Address correspondence to Dr. Ivan Wong, M.D., F.R.C.S.C., M.Ac.M., Dip. Sports Med, Division of Orthopaedic Surgery, Department of Surgery, Faculty of Medicine, Dalhousie University, Halifax, NS, Canada B3H2E1. E-mail: iw@drivanwong.com

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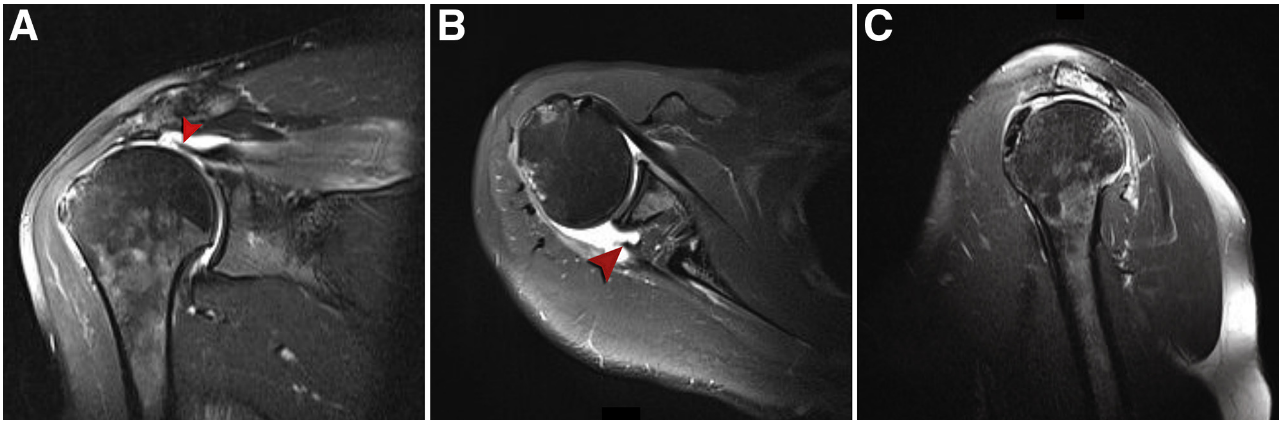

Fig 1. Magnetic resonance images in coronal (A), axial (B), and sagittal (C) planes showing a massive rotator cuff tear with retraction up to the level of the acromioclavicular (AC) joint (denoted by red arrowheads).

Fig 2. The arm is positioned in the standard lateral decubitus position using a SPIDER2 arm positioner and the anatomical landmarks are drawn. Portals used: P, posterior portal; A, anterior portal; L, lateral portal; PL, posterolateral portal; N, Neviaser portal.

respond to physiotherapy and anti-inflammatory pain medications are important indicators of a failed RCR or tendon transfer. Plain radiographs are useful to assess for signs of cuff arthropathy. Magnetic resonance arthrogram (MRA) can confirm the diagnosis, quantify the length of cuff retraction, and give valuable information on fatty infiltration (Fig 1).

Step 2: Positioning, Arthroscope Introduction, and Diagnostic Assessment

The patient is positioned in the standard lateral decubitus position (Fig 2, Video 1). The arm is maintained in 45° abduction using the SPIDER2 arm positioner (TENET Medical Products, Smith & Nephew, Andover, MA). A complete, systematic diagnostic arthroscopy of

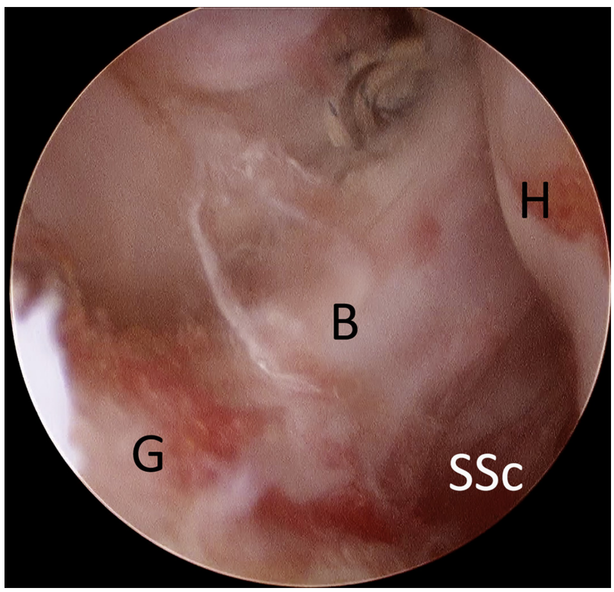

Fig 3. View of the right shoulder from the posterior portal. Note the extensive synovitis and scarring inside the joint, especially around the biceps (B) and subscapularis (SSc) tendons. G, glenoid; H, head of humerus.

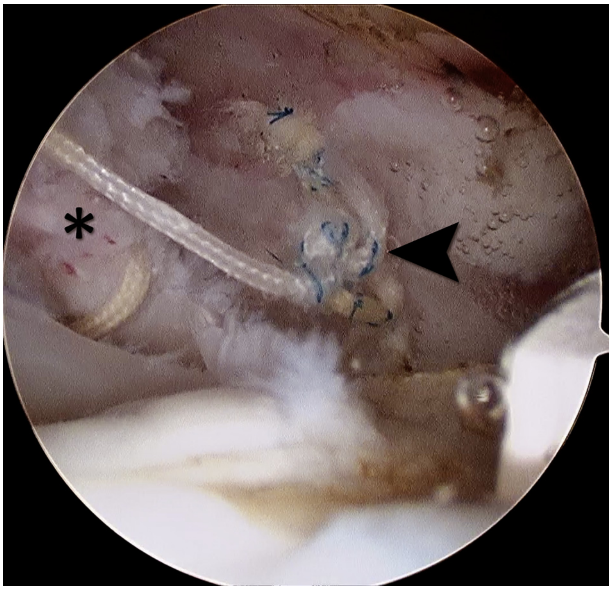

Fig 4. View of the right shoulder subacromial space from the posterior portal. Massive cuff tear (*) visualized in the subacromial space with torn sutures (indicated by black arrowhead) from the previous surgery. The transferred latissimus dorsi was not visualized in the space and had completely retracted.

the glenohumeral joint is carried out through both posterior and anterior portals (Fig 3).

The arthroscope is then introduced into the subacromial space with the limb repositioned in 20° of abduction (Video 1). The lateral portal is created just anterior to the 50-yard line for use as the main working portal and for allograft passage into the joint. Two 7-mm Drydoc (Conmed/Linvatec, Largo, FL) cannulas are inserted in the anterior and posterior portals, and a Passport cannula (Arthrex, Naples, FL) is inserted into the lateral portal. Acromioplasty is performed at this stage as necessary (Video 1).

The previous LD tendon was not visualized in the subacromial space as it had completely retracted with ripped intraosseous sutures filling the subacromial space in this particular case. All torn, frayed sutures were removed with the use of a grasper. An MRCT (supraspinatus and infraspinatus) was noted (Figs 3 and 4, Video 1). The edge of the cuff is debrided gently by using a basket punch forceps and radiofrequency ablator. The size of the cuff defect is measured by using a graduated probe from the biceps tendon anteriorly to the teres minor posteriorly and medial to lateral at the central portion of the defect (Fig 5). The remaining tissue over the GT is debrided using a shaver followed by a burr to create a healthy, bleeding, cancellous bony surface.

Step 3: Preparation of a Stable Graft Bed

The posterior goalpost anchor is inserted first over the prepared GT adjacent to the teres minor. We routinely use a triple-loaded Healicoil suture anchor (Smith & Nephew) as goalpost anchors. The posterior-most suture of the anchor is passed through the adjacent teres minor, which is then sewed onto the footprint of the prepared GT using a Spectrum suture passer (Conmed/Linvatec) and secured with a sliding SMC (Samsung Medical Center) knot followed by 3 reversing half-hitch knots to stabilize the posterior edge (Fig 6, Video 1).

Next, a second triple-loaded Healicoil (Smith & Nephew) anchor is placed anteriorly just behind the biceps tendon; the anterior-most suture of the anterior goalpost anchor (AGA) is passed through the biceps tendon and/or anterior cuff tissue and tenodesed at the top of the bicipital groove to create a stable anterior edge (Fig 7, Video 1). Care is taken to make 2 separate skin incisions for both these percutaneously inserted goalpost anchors.

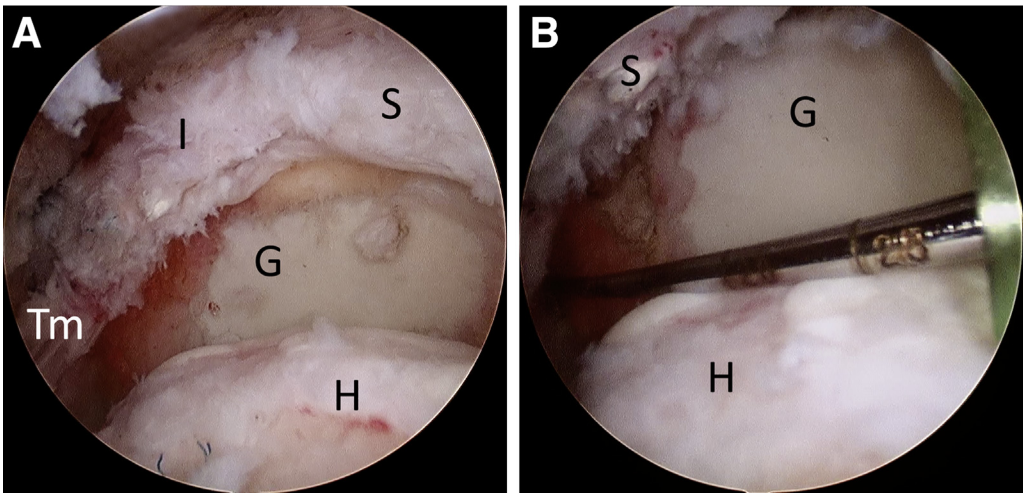

Fig 5. View of the right shoulder from the lateral portal. (A) The edge of the cuff remnant visualized after hardware removal and debridement. (B) The dimensions of the cuff tear being measured with a calibrated probe. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Tm, teres minor.

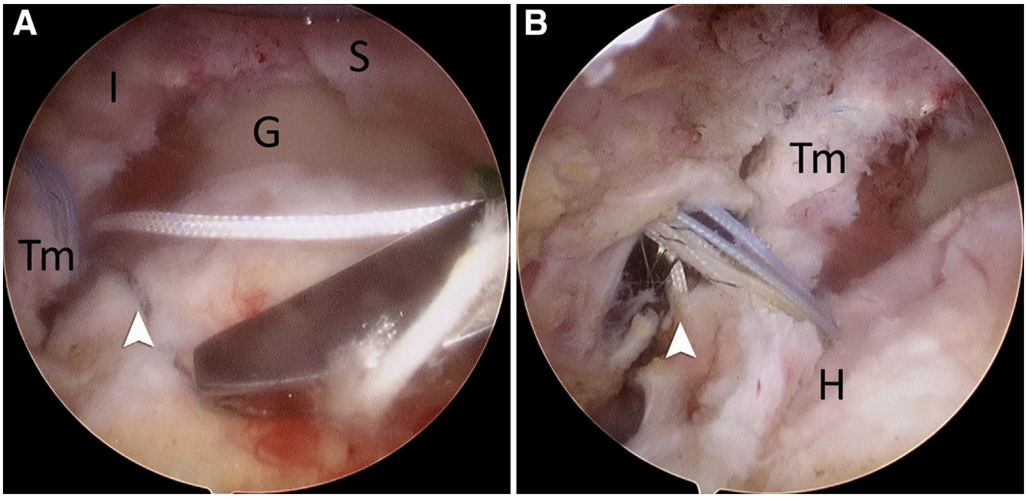

Fig 6. View of the right shoulder from the lateral portal depicting insertion of posterior goalpost anchor. (A) A triple-loaded suture anchor has been inserted just anterior to the teres minor. A grasper is seen retrieving the suture shuttle (white arrowhead), which has been used to take a bite in the teres minor. (B) A SMC knot is being tied (denoted by white arrowhead) with the posterior-most sutures of the triple-loaded anchor to stabilize the graft bed posteriorly. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Tm, teres minor.

Step 3: Preparation of the AHDMA Patch

The AHDMA (Graftjacket, Wright Medical Technology) is rehydrated and cut to the premeasured size on the back table. Multiple short-tailed interference knots (STIKs) are prepared by tying mulberry-type knots over a Wissinger rod (Fig 8). A surgical marking pen is used to mark the midline on the lateral edge of the graft and the points of insertion of the STIKs. The STIK sutures are then passed through the graft by using a Mayo needle—3 each along the medial, anterior, and posterior edges. Four different-colored sutures are used in an alternating fashion; a “road map” is drawn on a piece of paper to help avoid confusion later and prevent graft entanglement (Figs 9 and 10, Video 1). Care is taken to ensure that the knots are placed on the smooth, or “basement membrane,” side of the graft. The graft is then placed on a moist towel clamped around the arm near the lateral portal.

Step 4: AHDMA Implantation

We always suture the graft in a consistent, sequential manner beginning anteriorly, then proceeding to the

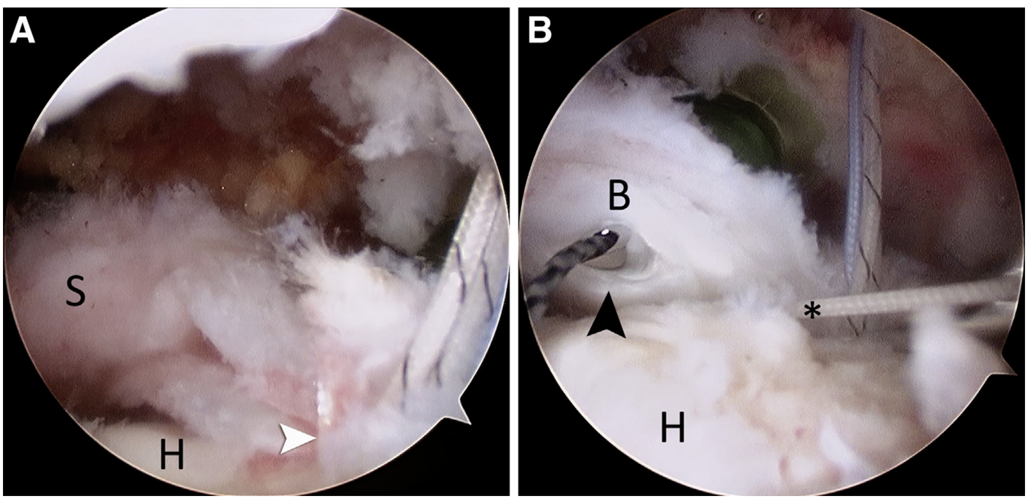

Fig 7. View of the right shoulder from the lateral portal showing insertion of the anterior goalpost anchor. (A) A triple-loaded anchor is inserted just adjacent to the available anterior cuff tissue (denoted by white arrowhead). (B) A suture shuttle passer (black arrowhead) is passed through the anterior cuff tissue and/or biceps tendon. The anterior-most suture (*) of this triple-loaded anchor is used to tie down the anterior cuff tissue and stabilize the graft bed anteriorly. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Tm, teres minor.

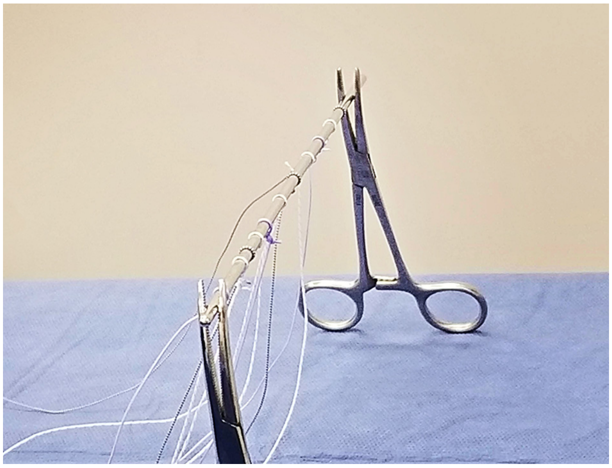

Fig 8. Multiple short-tail interference knots (STIKs) are tied over a Wissinger rod using sutures of 4 different colors.

Fig 10. Image of the allograft patch after passage of the short-tail interference knot (STIK) sutures.

medial edge, and finally finishing with the posterior edge of the graft. The first suture is the middle suture of the AGA, which is retrieved through the lateral cannula and then passed from bottom to top of the anterolateral corner of the prepared AHDMA by using a Mayo needle (Video 1). A STIK is placed above this to retain the suture.

We then sequentially pass the free ends of the STIK sutures around the cuff using a shuttle relay technique with a 45° Spectrum suture passer (Conmed/Linvatec): 3 sutures through the anterior cuff tissue anteriorly through the anterior portal, 3 through the supraspinatus and infraspinatus muscle bellies medially over the glenoid (free ends stored in the Neviaser portal), and 3 from the posterior cannula through the teres minor (Fig 11, Video 1). We then pass the middle suture from the posterior goalpost anchor through the lateral portal and then up through the graft, tying a STIK knot over top this and tensioning it on the graft.

The graft is rolled up into a "taco"-like shape and passed through the PassPort cannula using a "push-pull" technique, wherein the graft is "pushed" into the joint with a grasper at the leading edge while simultaneously "pulling" the free ends of the anchored STIK sutures in the anterior, posterior, and Neviaser portals to remove slack and assist graft unfolding (Fig 12, Video 1). We then sequentially retrieve each limb of these sutures through the lateral portal and SMC knots are tied on the tendon side of the cuff (Fig 13). The 2 goalpost suture anchors on

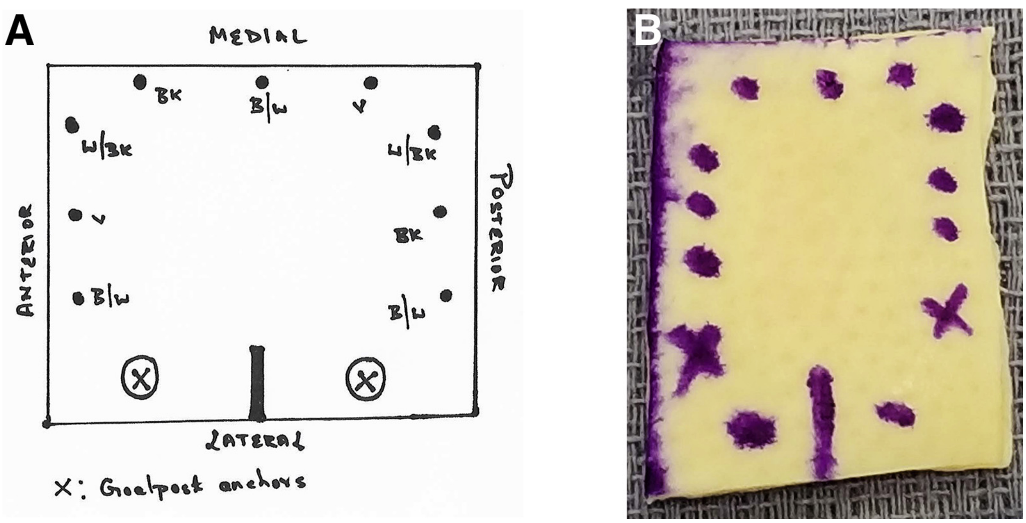

Fig 9. (A) Allograft patch preparation. Each dot represents a point for passage of a short-tail interference knot (STIK) suture, and the longitudinal line in the midline represents the lateral edge of the graft. (B) Image of the allograft patch with dots marked corresponding with the road map. The 2 "X" marks represent the locations where the middle suture of both the triple-loaded goal post anchors will be passed through.

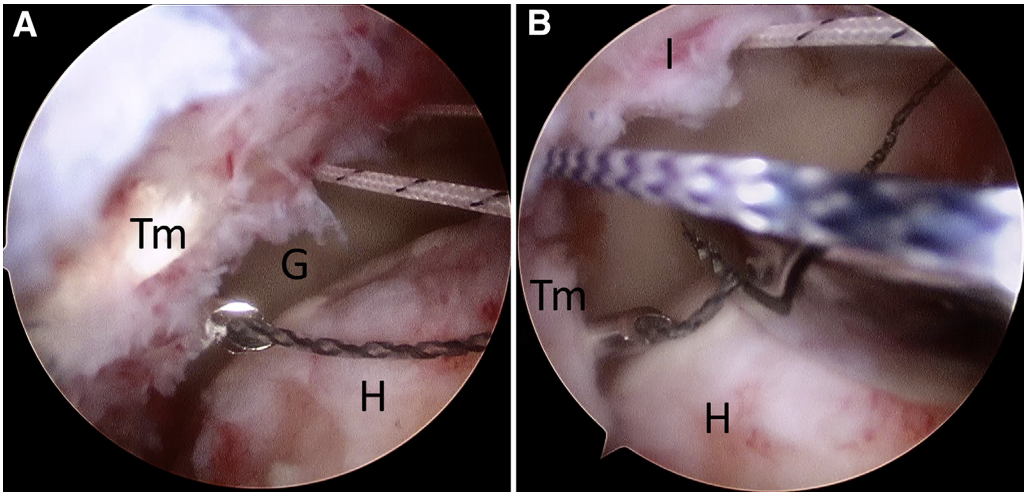

Fig 11. View of the right shoulder from the lateral portal. (A) Sequential passage of short-tail interference knot (STIK) sutures through the cuff tissue using a Spectrum suture passer. Always pass the shuttle posterior to the previous STIK suture to facilitate smooth passage of the graft later and prevent suture entanglement. (B) A grasper (denoted by white arrow) being used to retrieve the last suture shuttle passed through the cuff. Note how the grasper has been introduced inferior to the other sutures for easy suture management. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Tm, teres minor.

the top of the graft are tied next, but the suture tails are kept long enough to allow additional lateral row fixation.

Once all the sutures are tied, we use a Twinfix (Smith & Nephew) metal suture anchor through the center of the graft on the lateral aspect between the 2 goalpost anchors. This is placed percutaneously through the graft and tied with an SMC knot (Fig 14A, Video 1). We then place 2 Multi-Fix knotless suture anchors (Smith & Nephew) for lateral row repair using an awl to identify the location on the GT. We take 1 suture limb each from the 3 medial-row suture anchors, both anteriorly and posteriorly, to complete the lateral row fixation in a classical suture-bridge fashion (Fig 14 B and C, Video 1).

Step 5: Postoperative Rehabilitation

The patient's arm is supported in an abduction sling for 8 weeks, which is removed daily to perform Codman pendulum exercises as well as for elbow, wrist, and hand range-of-motion exercises. Formal therapy and pool therapy can begin at 6 weeks. Active and active-assisted elevation exercises are allowed at 8 weeks, and gentle strengthening is allowed from 12 weeks on.

Discussion

The treatment failure rate for an MRCT involving 2 or more tendons and/or greater than 5 cm in size is as high as 40%.[11] A recent systematic review identified a retear rate as high as 79% for massive cuff tears treated with arthroscopic repair alone.[12] LDTT is often considered a "salvage" procedure for failed RCR in MRCT without glenohumeral arthritis; an intact, functioning subscapularis and minimal fatty infiltration of teres minor are the necessary prerequisites for a successful transfer.[2,13,14]

The AABR technique for MRCT using various biologic and synthetic grafts has emerged as an attractive and promising option in the past decade with good short-term to medium-term results (Tables 1 and 2).[5,6,8,15] In particular, AABR using AHDMA has produced good results and improved function on objective testing.[1,5,7-9,15] Lewington et al.[8] recently conducted a systematic review to analyze the outcomes of bridging

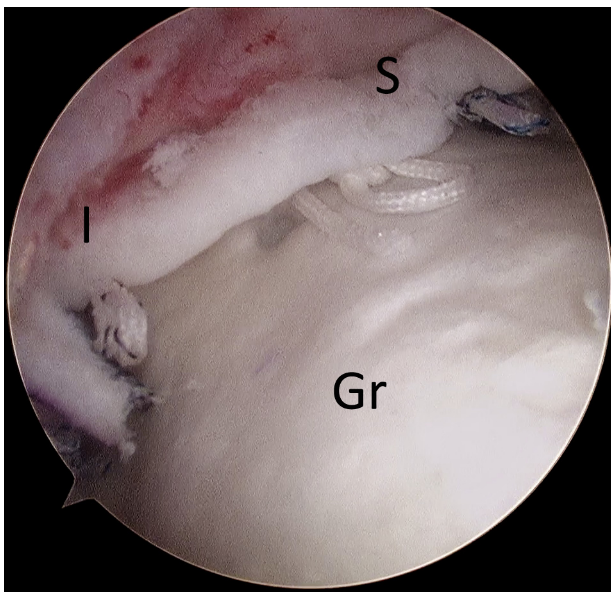

Fig 12. View of the right shoulder from the posterolateral portal showing the unfolded acellular human dermal matrix allograft (AHDMA) inside the joint bridging the cuff defect with good tension. S, supraspinatus; I, infraspinatus; Gr, graft.

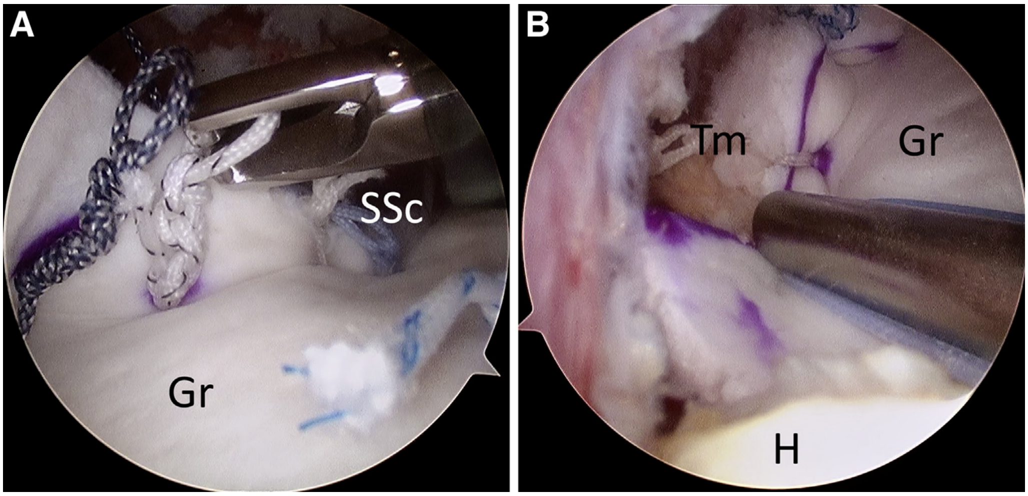

Fig 13. View of the right shoulder from the posterolateral portal. (A) Short-tail interference knot (STIK) sutures being retrieved using a loopy grasper outside the joint. (B) The graft being tied down with a SMC knot (Samsung Medical Center) and reversing half-hitch knots with the correct partner threads of the retrieved STIK suture. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Tm, teres minor; Gr, graft; Ant, anterior; post, posterior.

graft reconstruction in large, massive cuff tears; they noted a lower retear rate compared with nonanatomic repair techniques, minimal complications, and good improvement in functional outcomes. Jones and Snyder[1] reported their experience with 109 shoulders (106 patients) with MRCT treated with the AABR technique with a minimum follow-up of 1 year and several patients with follow-up between 2 and 7 years. They noted a retear in 15% patients (16/106) at the 3-month follow-up on MRA; at the 1-year follow-up, 74% of previously intact reconstructions were still intact with a significant improvement in different functional outcome scores at medium-term follow-up.

Management of a ruptured LDTT, whether after a primary or a secondary transfer, is a difficult challenge even for an expert shoulder surgeon. After a thorough search of the available literature, we could not find much data focusing on the management of this complex problem, especially in young patients with no/minimal arthropathy. We believe that in selected cases with LDTT failure, AABR with AHDMA can be an effective technique to restore painless motion, strength, and function.

This foremost advantage of this anatomic reconstruction technique is that it has the potential for biological regeneration of "cuff-like" tissue, thereby

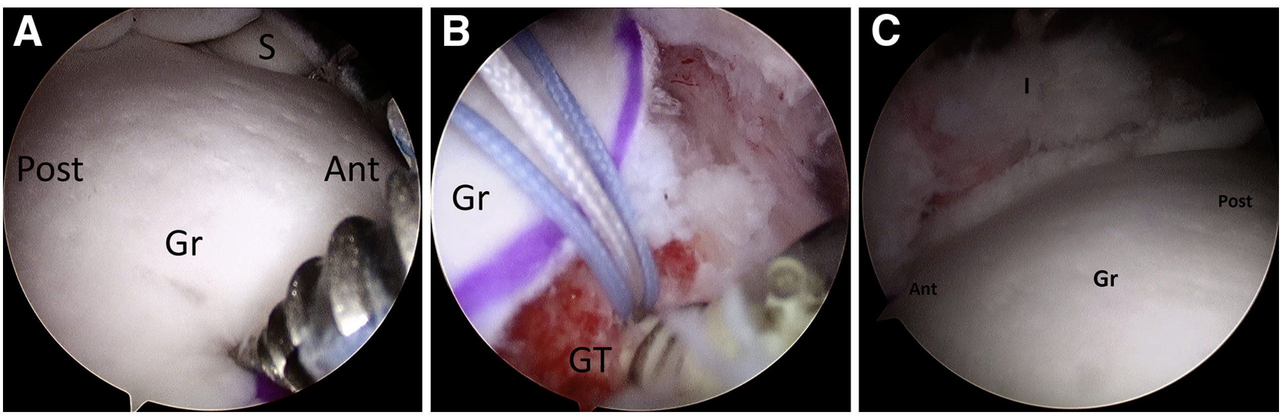

Fig 14. View of the right shoulder from the posterolateral portal. (A) A Twinfix metal suture anchor (denoted by orange arrow) is inserted percutaneously into the middle of the lateral edge of the graft between the 2 goalpost anchors, and an SMC (Samsung Medical Center) knot is tied to complete the medial row fixation. (B) A knotless Multifix anchor (denoted by white arrow) being inserted to complete a lateral row fixation in a suture-bridge configuration with 1 suture each from the 2 goalpost anchors and the middle medial row anchor. (C) Final view of a well-tensioned allograft patch completely bridging the cuff defect. G, glenoid; H, head of humerus; S, supraspinatus; I, infraspinatus; Gr, graft; Ant, anterior; Post, posterior; GT, greater tuberosity.

Table 1. Pearls and Pitfalls of the AABR Technique

Pearls	Pitfalls
Size the graft accurately with a calibrated probe.	Improper sizing can lead to overtensioning or undertensioning of the graft.
Always retrieve the suture shuttle posterior and parallel to previous sutures and advance in a systematic sequential manner.	Failure to do so can lead to suture entanglement during graft passage or unravelling.
Fold the graft into a "taco"-like shape with the STIK sutures on the inside while passing it into the joint.	STIK sutures can get caught in between sutures with a risk of unloading and entanglement.
Use a Passport cannula in the lateral portal for graft passage.	Other cannulas may decrease maneuverability and visibility during graft passage and increase chances of cannula loss.
Debride the GT adequately to ensure "crimson duvet" to assist in healing and uptake of the graft.	

AABR, arthroscopic anatomic bridging reconstruction; GT, greater tuberosity; STIK, short-tail interference knot.

Table 2. Advantages and Disadvantages of the AABR Technique

Advantages	Disadvantages
Arthroscopic, single-stage technique	Expense of using AHDMA may be an issue in community hospitals
Anatomic reconstruction with potential for regeneration of "cuff"-like tissue	Steep learning curve requiring advanced arthroscopic skills and familiarity with AABR technique and handling AHDMA tissue
Potential to arrest superior migration of humeral head, decrease pain, and increase function	
Availability of good tissue in case of revision scenario—does not burn bridges!	
Avoids donor-site morbidity associated with autograft harvest	

AABR, arthroscopic anatomic bridging reconstruction; AHDMA, acellular human dermal matrix allograft.

arresting superior migration of the humeral head and cuff arthropathy.[5,15,16] It does not burn any bridges for the patient and the surgeon because in the event of an eventual failure, other options for management are still open. A revision surgery might be easier than the primary surgery in this unique scenario because of the possible availability of good tissue.[8] Other advantages are that it is a single-stage, all-arthroscopic technique that avoids large incisions through perishoulder muscles and it avoids issues related to donor-site morbidity associated with autografts.[1,6,8,17]

The primary disadvantage is the challenging surgical technique and the associated steep learning curve.[6,8,10] A familiarity with advanced arthroscopic skills and AABR technique is necessary to perform this procedure successfully in failed LDTT cases.[6,15,17] The availability of AHDMA in some centers and the high costs involved are the other disadvantages currently.[8,17]

Conclusion

Failure of an LDTT is a difficult, challenging problem with limited literature on revision. AABR with AHDMA is a viable treatment option for surgical salvage in select cases of symptomatic, failed LDTT for irreparable MRCTs.

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