Technical Note

Arthroscopic Biological Augmentation for Massive Rotator Cuff Tears: The Biceps-Cuff-Bursa Composite Repair

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Abstract: Surgical repair of massive and chronic rotator cuff tears is difficult due to tendon retraction and severe atrophy, and the resultant retear rate in the structurally weak tendons is high. Commercially available patches and bioinductive scaffolds have been used to provide strength and superior healing environment in partial and complete rotator cuff tears. Biological biceps autograft has been used for superior capsular reconstruction, and the subacromial bursa has been shown to have significant pluripotent stem cell potency for tendon healing. We describe our technique for combined use of the long biceps tendon (LBT) and vasculature-preserved subacromial bursa as autografts in rotator cuff repair augmentation. The technique involves obtaining a LBT graft of sufficient length using a "traction and tenodesis" technique. The subacromial bursa is mobilized as a continuous layer (vascular bursal duvet) by maintaining its medial and lateral vascularity. All-suture anchors are used to minimize the insertion apertures (3 mm) in tuberosity. The bursa is advanced laterally, and the mobilized cuff is repaired together as a biceps-cuff-bursa composite unit. Combined use of the biceps and bursa as biological autografts has the advantage of structural and regenerative augmentation, and the autografts are easily accessible without added cost.

Introduction

Massive and chronic rotator cuff tears are associated with tendon retraction and severe atrophy. Surgical repair of these structurally weak tendons is difficult, and the resultant retear rate is high. Tendon augmentation using commercially available structural and bioinductive scaffolds have been used to provide a superior healing environment in partial and complete rotator cuff tears.[1] Superior capsular reconstruction in conjunction with tendon repair has also been described as an augmentation strategy in these difficult tears.[2-6] The use of subacromial bursa as a biological augmentation tissue has been evaluated in basic science studies, and arthroscopic techniques for bursa-augmented repairs have been described recently.[7-11]

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Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received April 22, 2021; accepted July 1, 2021.

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2212-6287/21627

https://doi.org/10.1016/j.eats.2021.07.003

The purpose of this report is to present an arthroscopic technique for biologically augmented repair of massive retracted rotator cuff tears. The technique involves using the long tendon of the biceps and subacromial bursa as autografts for deep and superficial tendon augmentation, and the repair is performed as a biceps-cuff-bursa composite unit.

Surgical Technique

Arthroscopic biologically augmented cuff repair is useful in chronic massive rotator cuff tears associated with severe atrophy and tendon degeneration (Fig 1).

The procedure is performed with the patient in a standard beach-chair position, and the arm is supported by an upper-limb positioner. A 30° arthroscope (ConMed Linvatec, Largo, FL) is used via the posterior portal for diagnostic arthroscopy. The key steps and surgical pearls of the technique are summarized in Tables 1 and 2, respectively, and the steps are demonstrated in Video 1.

Step 1: Diagnostic Assessment and Associated Lesions

Arthroscopic evaluation is performed to identify the rotator cuff tear pattern and to assess tendon quality and reparability. Subscapularis tears are frequently

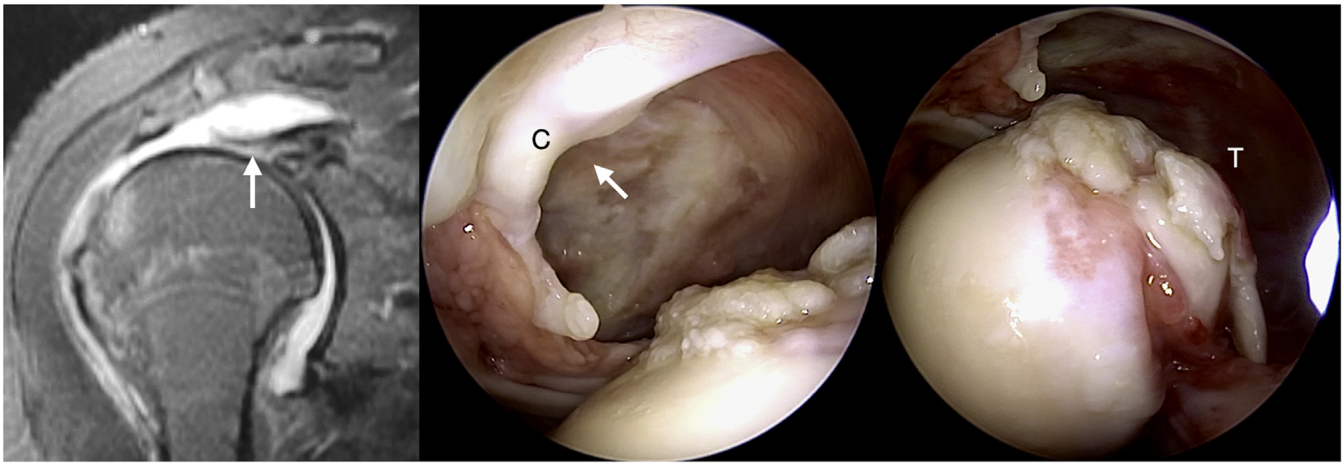

Fig 1. Magnetic resonance image and arthroscopic view (posterior portal) of a massive rotator cuff tear (arrow) in a right shoulder is shown. The torn tendon (C) is atrophic and retracted and the bare tuberosity (T) can be visualized.

Table 1. Key Steps of the Procedure

Subscapularis Tears and Biceps Lesions Necessitate surgical Repair and Tenodesis Using Standard Techniques.
Subscapularis sutures are used for biceps tenodesis, or a separate anchor(s) may be used. The long biceps tendon (LBT) graft length is obtained by maximal intra-articular traction prior to tenodesis knot-tying ("Traction and tenodesis" technique). LBT detachment is performed just proximal to tenodesis.
The subacromial bursa is dissected carefully as a thick layer from the posterior and posterolateral deltoid fascia. Medial and lateral continuity of the bursal layer is preserved, and vascular sheet along the tendon aspect (deep bursal layer) is left undisturbed.
The torn and retracted tendons are released (perilabral and subacromial) without interval slides, and tendons are mobilized as a continuous sleeve.
The tuberosity and frayed edges of the torn tendons are debrided and prepared for repair.
Three or four all-suture anchors are used in a single-row configuration along the medial aspect of the tuberosity.
Sutures are passed from anterior to posterior through the LBT-supraspinatus-bursa complex anteriorly, and through the infraspinatus-bursa complex posteriorly. The lateral bursal layer is left undisturbed to prevent disruption of its continuity with deltoid fascia
Sutures are tied using sliding locking knots, and these are then tensioned laterally. Bursal advancement and adequate LBT coverage are confirmed while sutures are tied.
Static and dynamic assessment (bursal and intraarticular) of the repair is performed to confirm adequacy of repair and biceps-bursal augmentation of the repaired cuff tendons.

Table 2. Technical Pearls and Pitfalls

Pearls	Pitfalls
Biceps harvest with maximal LBT length may result in a severe Popeye deformity if a tenotomy is used; biceps tenodesis should be performed to prevent this deformity.	LBT should be assessed for tendon quality and fraying within the groove and along the superior labrum. Severe fraying or root tears are contraindications for biceps autograft use.
A large superior labral tear should be repaired to secure the proximal LBT stump to the glenoid.	Failure to obtain adequate LBT graft length results in suboptimal LBT-bone contact and inadequate restraint to superior migration. This may also result in sutures cutting through the LBT when knots are tied.
To obtain adequate LBT graft length, the tendon is grasped at the bicipital groove and is pulled as inferiorly as possible into the glenohumeral joint. Approximately, 2-3 cm of LBT graft is optimal.	Incorrect initial plane of bursal dissection may result in bursal tissue damage and bleeding.
Bursal dissection should begin from medial acromial aspect and should be continued laterally. The plane between the bursa and posterior deltoid fascia is used to separate and mobilize bursal tissue as a thick sheet, and the deep aspect of bursa is left undisturbed to preserve vascularity	Inadequate bursal mobilization or incorrect bursal suture passage results in tearing of the bursal tissue and/or inadequate tendon coverage.
All-suture anchors can be inserted via a 3-mm entry hole; this is useful especially in smaller bones to provide maximal bony surface for healing.	
Sutures are passed through biceps and tendon as separate passes. Sutures through the cuff and bursa may be passed together or separately at predetermined points to ensure that the bursal tissue is not under undue tension	
The lateral bursal continuation into deltoid fascia is left undisturbed. This aspect of the bursa is thinner and is away from the repair site. Suturing the lateral aspect may result in bursal tissue disruption.[10]	

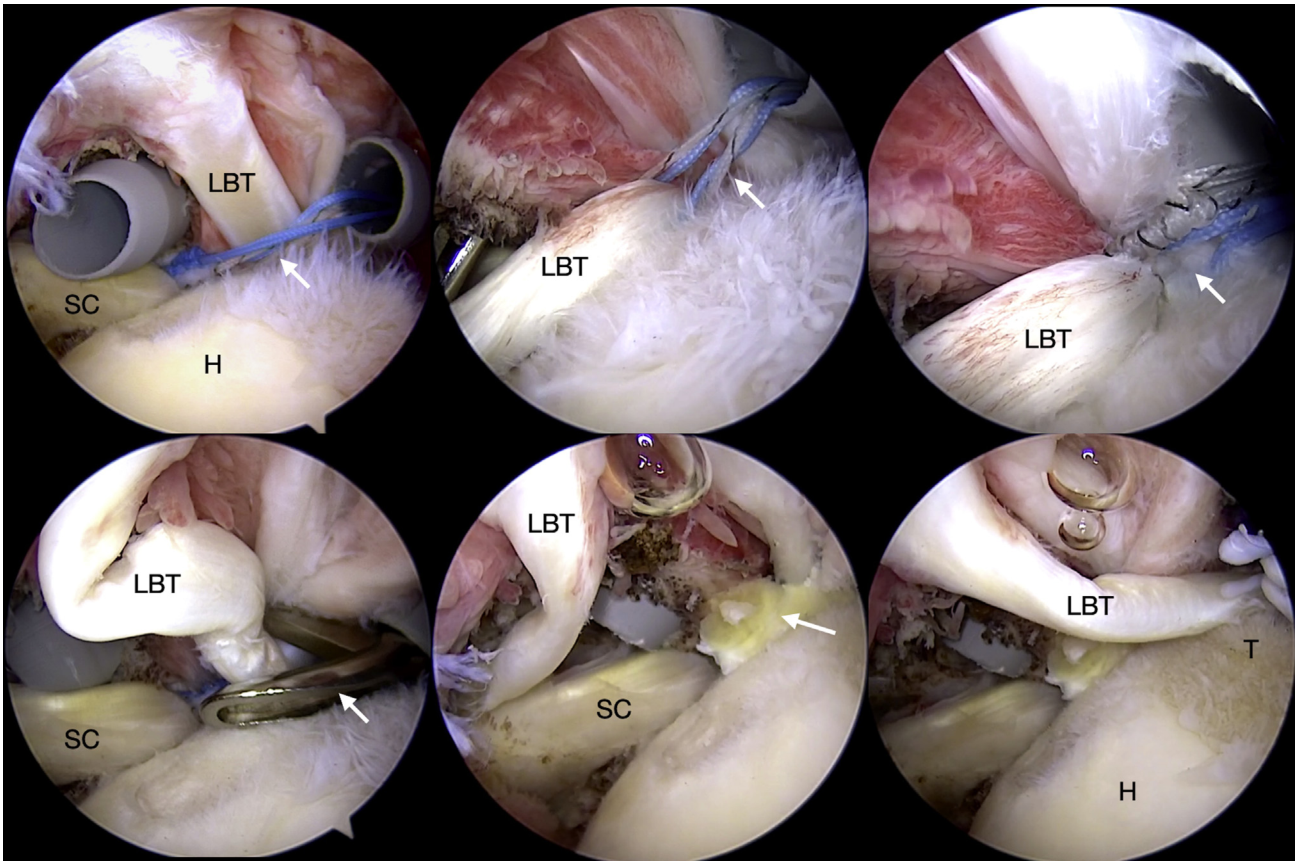

Fig 2. Long biceps tendon (LBT) autograft harvest technique is demonstrated (right shoulder, posterior viewing, lateral working portal). Subscapularis (SC) repair sutures (arrow) are retrieved via lateral cannula and passed around LBT. Nonsliding knots are used to tenodesis the biceps after pulling it out of the groove (top images). LBT is detached proximal to tenodesis sutures (arrow) and this results in adequate tendon length for augmentation (bottom images). H denotes humeral head; T denotes tuberosity.

present and should be carefully evaluated for subsequent repair.

Step 2: Biceps Tendon Harvest ("Traction and Tenodesis" Technique)

Subscapularis tear is repaired using one or two all-suture anchors (Y-Knot RC, ConMed Linvatec, Largo, FL). The superior subscapularis anchor is placed close to the bicipital groove, and sutures are left intact after knot-tying (Fig 2). The long biceps tendon (LBT) is pulled out of the groove to assess for structural quality and absence of severe fraying. The intact sutures from the subscapularis anchor are passed around LBT; the tendon is again pulled out of the groove maximally, and nonsliding knots are used to securely tenodese the LBT to the groove and subscapularis. The LBT is then detached just proximal to the tenodesis site, and this provides the length of the LBT graft for adequate augmentation later.[2] Alternatively, a separate all-suture anchor may be used for the tenodesis procedure, as described previously. The presence of a large superior labral tear is not a contraindication, and additional anchors may be used to repair the superior labral-biceps complex to the glenoid.

Step 3: Subacromial Access and Rotator Cuff Releases

The subacromial space is accessed via the posterior portal. The acromial aspect of the anterolateral bursa is excised and the medial, posterior and posterolateral bursal aspects are preserved. The supraspinatus and infraspinatus tendons are adequately released along the perilabral region, and any adhesions in the subacromial space are excised. Interval releases are not performed, and the entire construct is released as a sleeve. The mobilized tendons are assessed for tension-free reparability, and sites for suture passage are noted.

Step 4: Subacromial Bursal Preparation

Subacromial bursa is harvested for augmentation and mobilized to prevent any disruption and restriction of range. A radiofrequency device (Edge, ConMed Linvatec, Largo, FL) is used at a reduced setting via a lateral portal to gently harvest the bursal tissue (Fig 3). The correct tissue plane is relatively avascular, and dissection is performed from medial to posterolateral. Next, a high posterolateral portal (HPL) portal is created approximately 1 cm anterior to the posterolateral corner of the acromion; this portal is positioned above

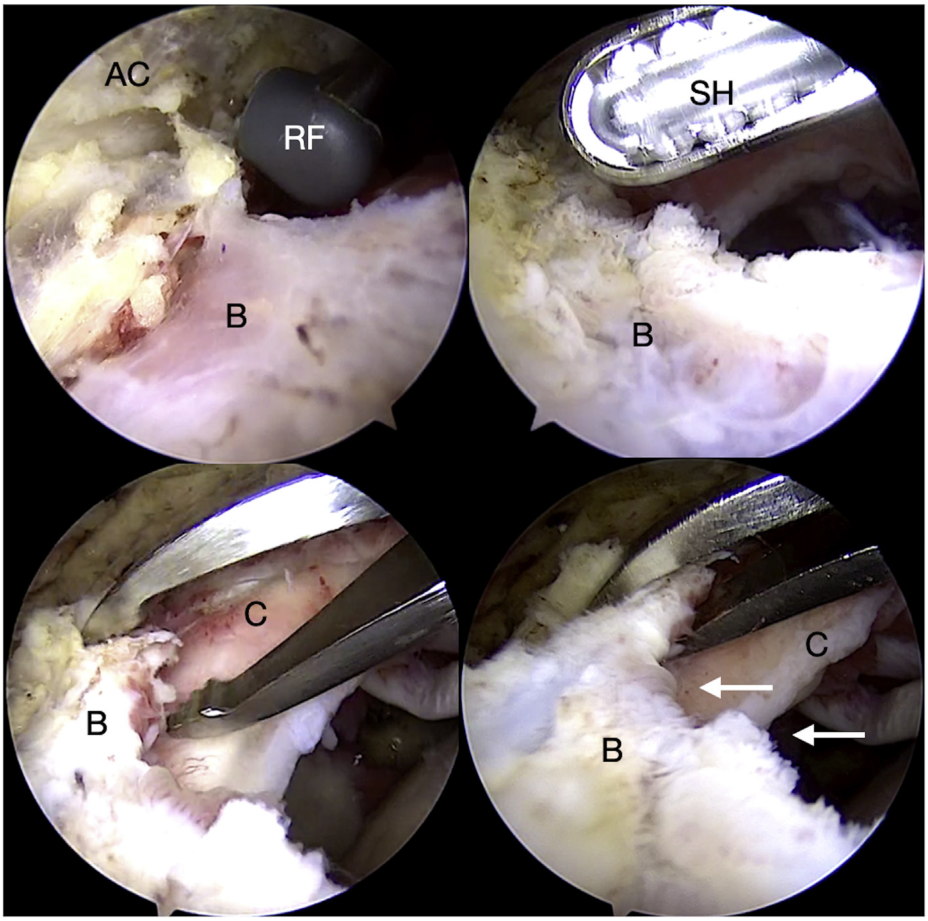

Fig 3. Subacromial bursa (B) harvest technique is demonstrated (right shoulder, high posterolateral High posterolateral portal viewing, lateral working portal). B is released from the deltoid adhesions and sufficiently mobilized for anterolateral advancement (arrows). C, rotator cuff tendons; RF, radiofrequency probe; SH: shaver.

the bursal layer and is used as the main viewing portal for the remainder of the procedure. Bursal dissection is continued further lateral until the bursal tissue is seen attaching to the deltoid fascia. The vascularity of the bursal layer is derived from the suprascapular vessels medially, and the deltoid vasculature posteriorly and laterally; bursal continuity should, therefore, be maintained at its medial (acromial, scapular spine, and musculotendinous) and lateral (deltoid) attachments for preserving vascular connections.[9] The goal is to harvest a previously described "vascular bursal duvet" that is sufficiently mobile to cover the bursal surface of the repaired rotator cuff.

Step 5: Tuberosity Preparation and Suture Anchor Insertion

The greater tuberosity and frayed tendon edges are gently debrided to healthy tissue. A Wissinger rod is used via the posterior portal to carefully retract the bursa to provide an unobstructed HPL portal view of the repair. Three self-punching all-suture anchors (Y-Knot RC, ConMed Linvatec, Largo, FL) are inserted in a single-row configuration along the medial aspect of the tuberosity. The posterior anchor insertion is facilitated by retracting the bursa as described above (Fig 4).

Step 6: Suture Passage Through the Biceps-Cuff-Bursa Complex

An antegrade suture-passing device is used to pass the first suture (anchor 1) through the anterior supraspinatus. The LBT is positioned between the first 2 anchors, and the second suture (anchor 1) is passed sequentially through the LBT and supraspinatus—bursa complex. Similarly, the first suture of the 2nd anchor is passed through the 3 structures, and the second suture (2nd anchor) is passed through the cuff—bursa complex. Subsequent sutures (3rd anchor) are passed via tendon and bursal tissue in a single pass, or further posterolateral via separate passes.[9] The bursal passage points are predetermined using mobility assessment with traction as described above (Fig 5).

Step 7: Knot-Tying, Bursal Coverage, and Biceps Fixation

Sliding locking knots (Nicky's knot) are used to secure the biceps-cuff-bursa complex to the tuberosity. The

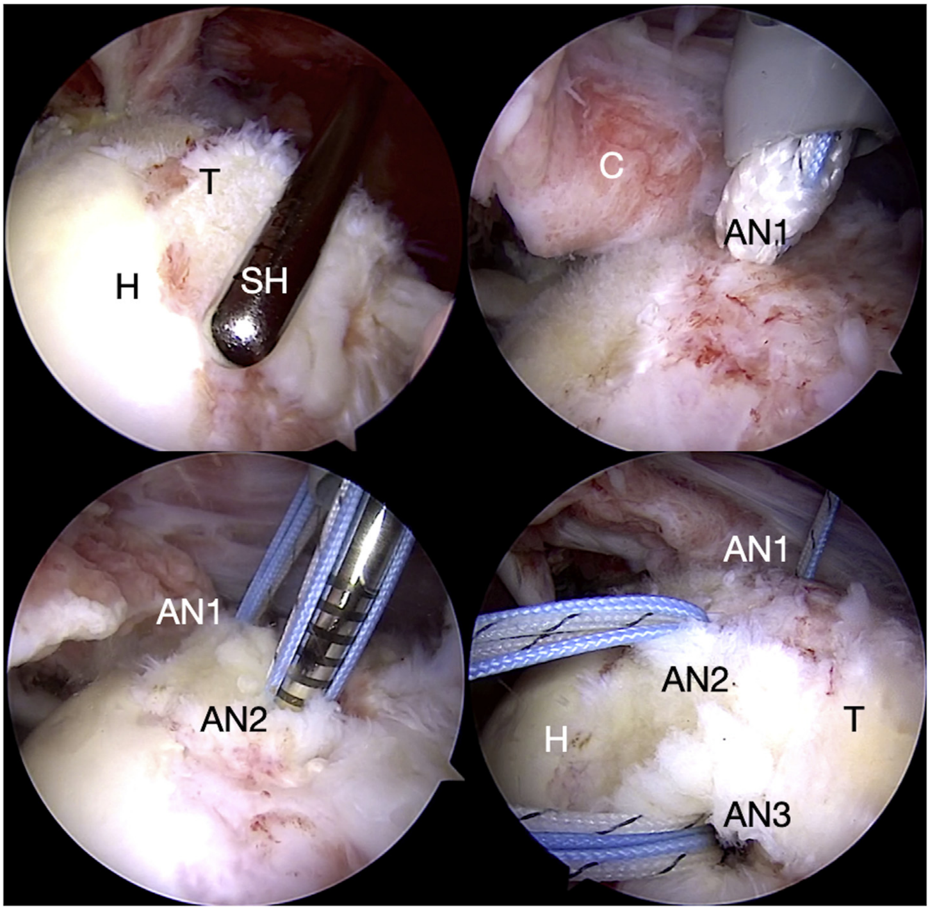

Fig 4. The tuberosity (T) is debrided (top left image) and 3 all-suture anchors (AN1, AN2, and AN3) are passed along the medial aspect of the tuberosity in a single row configuration (top right and bottom images). C, torn cuff tendon, H, humeral head, right shoulder, high posterolateral portal view; SH, shaver.

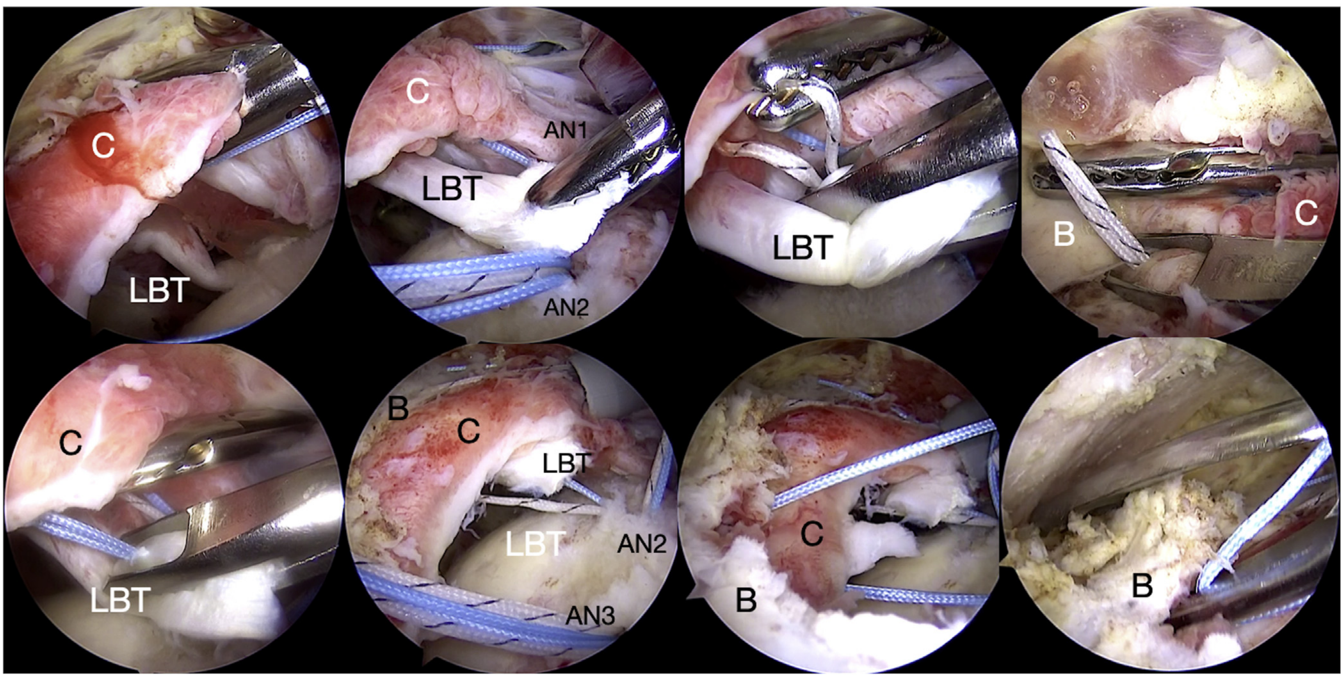

Fig 5. Sutures are seen passing through the biceps graft (LBT), cuff tendon (C) and bursa (B) together as a composite unit. The anterior-most suture (AN1) passes through the supraspinatus only (C, top left image), and the next 2 sutures are passed through all 3 structures (top images). Thereafter, sutures are passed through C and B (bottom images, right shoulder, high posterolateral portal view).

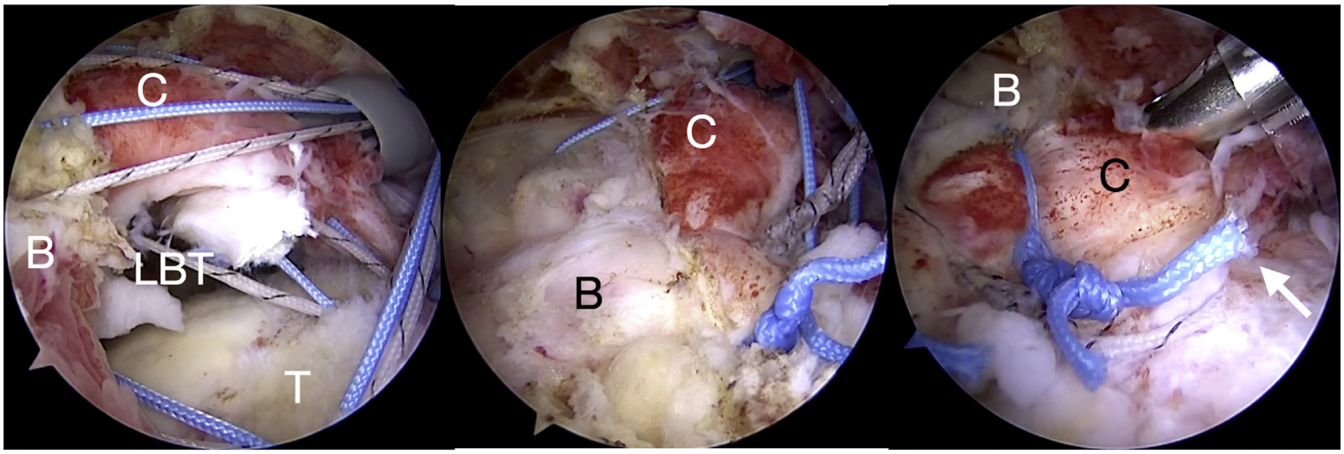

Fig 6. Arthroscopic view prior to knot tying shows the distribution of sutures through the long biceps tendon (LBT)-C-B complex (left image). Sliding knots are used to advance the bursa (B) laterally over the repaired tendon (C) at its edge (middle image). The LBT is covered by the supraspinatus (arrow, right image) as the sutures are knotted. HPL portal view; T, tuberosity, right shoulder.

bursa is seen covering the superficial aspect of the cuff (vascular bursal duvet), and the cuff tendons are visualized advancing over the LBT as the knots are tied (Fig 6).

Step 8: Final Repair Assessment

The repair integrity is visualized and probed to ensure secure fixation (Fig 7). Dynamic flexion-extension and rotational assessment should be performed to ensure correct tension on the tendon—bursa composite repair. The arthroscope is placed in the glenohumeral joint, and the LBT is assessed to confirm its correct position and secure fixation.

Discussion

The technique presented here describes a method for using biological autografts for augmentation of a torn and structurally weak rotator cuff tendon. The procedure involves use of readily available autograft tissue, and provides both structural strength and regenerative potential. The advantages and disadvantages of the procedure are listed in Table 3.

The LBT is often intact in massive rotator cuff tears and is useful as an autograft for augmentation. The LBT also provides a secondary restraint to superior migration similar to a superior capsular reconstruction, and possibly prevents retears in massive retracted tears.[2-6] The dense structure of the LBT further adds to the repair strength and prevents suture cut-out from the weak tendons. A prerequisite is the presence of an intact LBT and absence of severe fraying within the LBT tendon.

The regenerative potential of subacromial bursal cells has been evaluated in basic science studies, and the

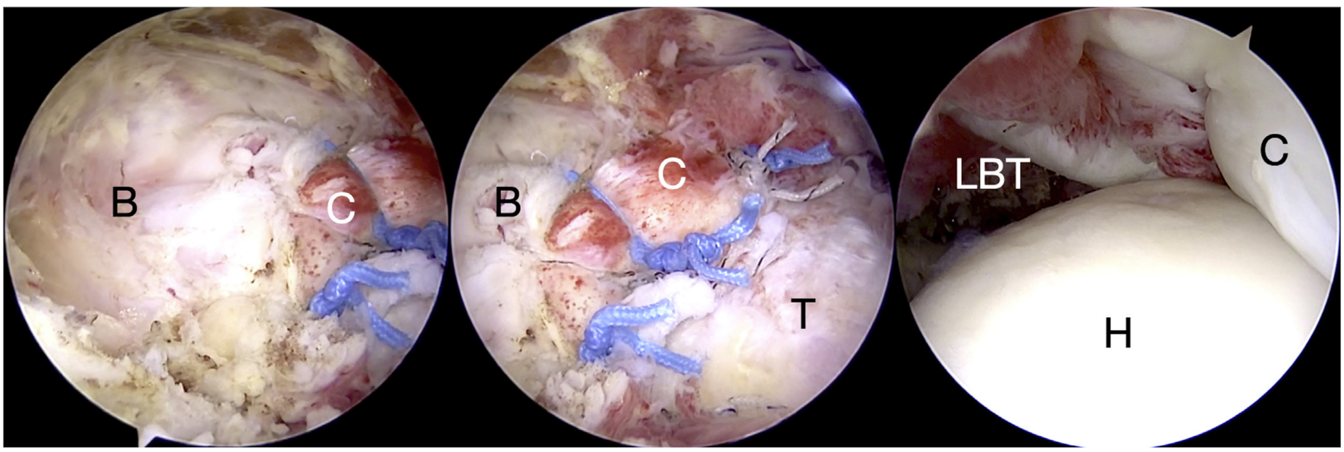

Fig 7. Final view shows the bursal (left and middle images) and articular aspects (right image) of the repaired and augmented cuff tendons. The "vascular bursal duvet" (B) is seen adequately covering the repaired tendons (C). The long biceps tendon (LBT) is seen securely fixed to the tuberosity (T) in conjunction with the repaired tendon (C). H, humeral head, right shoulder, high posterolateral portal view.

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
Biceps tendon is usually intact and available as graft tissue. Similarly, subacromial bursa is readily available in rotator cuff repairs.	Consistency and quality of LBT graft and bursal tissue cannot be predicted.
Standard rotator cuff repair techniques can be used for repair. No special instruments or additional sutures like PDS are necessary in the repair.	Open rotator cuff repair techniques may not provide an adequate view of the dissection region, and correct graft harvest may be difficult.
The regenerative potential of subacromial bursa has been proven in several basic science studies. Use of subacromial bursa for augmentation provides added vascularity and structural strength to the repair.	Long-term benefits, as compared to other augmentation tissues, are not known and need to be studied in a randomized control trial.
Biologically augmented cuff repair is a low-cost alternative to commercially available patches and scaffolds.	

possible advantages of increased healing potential and better incorporation of the cuff at the tendon-bone interface have been suggested.[7,8] The subacromial bursa extends from medial to lateral across the posterosuperior rotator cuff and is relatively thicker and structurally stronger medially and posteriorly. During bursal augmentation, medial and lateral bursal attachments should be kept intact for preserving vascularity, and the entire sheet should be mobilized as a single structure and sutured to the tendon during cuff repair.[9] A possible disadvantage with this technique may be the inability to predict the thickness and ability to dissect an intact vascular bursal layer; however, in a large series of cases, the author has found consistent and adequate bursal tissue that can be harvested in every single case.

The technique described here yields adequate biological tissue that provides structural and regenerative potential for repair and healing of a chronic massive tear. The degenerative rotator cuff is "sandwiched" between the two autografts, and there is no need for additional patches or biological scaffolds. The procedure can be performed with routine instruments and anchors, and is faster and easier to perform compared with current techniques using scaffolds.

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