



Superior Capsular Reconstruction using the Long Head of the Biceps Tendon: The Biceps Loop Technique

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Abstract: Irreparable rotator cuff tears can be treated in several ways. Superior capsular reconstruction has been reported as an excellent option, particularly for the young and active patients. We propose capsule reconstruction using the long head of the biceps tendon in a modified way. After its tenotomy at the musculotendinous junction, the long head is rerouted through a humeral bone tunnel and attached to a suture anchor in the posterior aspect of the superior glenoid rim. Further investigation is required, but this modified technique appears promising.

Introduction (With Video Illustration)

Irreparable rotator cuff (RC) tear is a frequent and challenging clinical condition.¹ Several treatments have been described for this disorder, but young and active patients, particularly those without advanced joint degeneration, remain a challenge.^{2,3} In these cases, joint-preserving techniques are better alternatives to avoid or postpone a shoulder replacement.⁴

Described by Mihata et al.,⁵ the superior capsular reconstruction (SCR) has gained popularity in recent years.⁶ However, many surgeons have questioned the value of this technique because of its complexity, high cost, and concerns regarding graft healing. Numerous variations have been added trying to improve its feasibility, either by reducing complexity or costs.⁷⁻¹¹ The

use of the long head of the biceps tendon (LHB) has emerged as an alternative graft, adding potential advantages: lower cost, less surgical complexity, lower morbidity at the donor site, and greater healing potential.¹²⁻¹⁴ It is a biological autograft, with one end already attached to the superior glenoid rim, avoiding the necessity of an allograft.⁸

The purpose of this study is to describe a modified arthroscopic SCR technique (Video 1 and Fig 1), using the LHB as an autograft. After its tenotomy, the LHB is transferred through a bone tunnel from anterior to posterior on the greater tuberosity (GT) and fixed with a suture anchor at the posterior aspect of the superior glenoid rim.

Surgical Technique

Preoperative Evaluation and Patient Information

A preoperative magnetic resonance imaging (MRI) scan is strongly recommended, since it helps to evaluate the cuff tear and predict its reparability (Fig 2). It is also important to check the integrity of the LHB and to estimate the length of the track for the graft in the MRI (Fig 2). The patient is advised that if the intraoperative length of his or her tendon is considered insufficient, we will proceed with the technique described by Barth et al.,¹⁵ in which the capsular reconstruction is performed by fixing the LHB to the GT with an anchor, after detachment at the musculotendinous junction.

Patient Positioning and Diagnostic Arthroscopy

The patient is positioned in the beach chair position after general anesthesia and interscalene nerve block.

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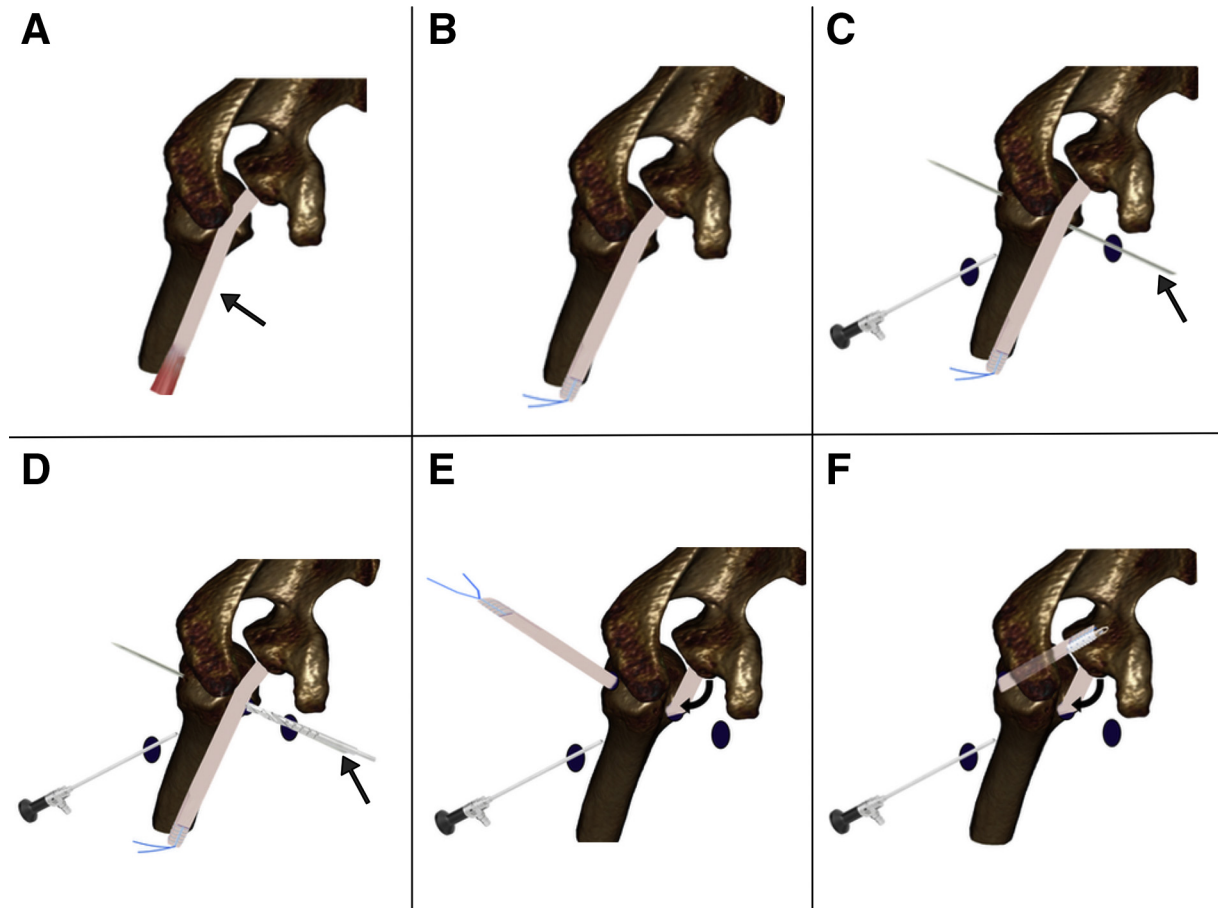


Fig 1. Illustration showing the steps of the biceps loop technique of superior capsular reconstruction. (A) Shoulder and LHB (arrow) before the procedure. (B) After the long head of the biceps tenotomy just proximal to the musculotendinous junction, the distal end of the proximal stump is sutured with a Krackow stitch. (C) A 2-mm guidewire (arrow) is inserted through the anterior portal from the bicipital groove to the posterosuperior aspect of the greater tuberosity with arthroscopic visualization from lateral portal. (D) A cannulated drill (arrow) is introduced from the anterior portal, to create the bone tunnel with the same diameter of the LHB. (E) The LHB is transported through the bone tunnel, exiting the posterior aspect of the greater tuberosity. (F) The posterior bundle of the LHB is fixed to the posterosuperior glenoid rim with a knotless anchor. (LHB, long head of the biceps.)

We use 4 portals to perform the procedure: a posterior portal; an anterior portal; a lateral portal; and an anterosuperior portal. In addition, a 3-cm approach is used at the anteromedial aspect of the arm, just below the inferior border of the pectoralis major.

Initially, we start with a conventional shoulder diagnostic arthroscopy to confirm the irreparability of the cuff and the presence of an intact LHB. The posterior portal is done in standard fashion and a regular 4-mm/30° arthroscope is introduced into the glenohumeral joint.

The anterior portal is used as a working portal and also to make the bone tunnel through the humerus. To obtain a satisfactory angle for this approach, this portal is made slightly medial and inferior than standard, just inferior and lateral to the coracoid process. Its good articular position is confirmed with an outside-in technique, using an 18-gauge needle through the rotator interval, just above the superior border of the

subscapularis tendon. A careful inspection of the joint is performed to verify the LHB's integrity and the extension of the RC tear (Fig 3A).

The scope is introduced in the subacromial space through the posterior portal, and both the lateral and anterosuperior portals are made by an outside-in technique. Bursectomy is performed with a shaver and the supraspinatus (SS) and infraspinatus (IS) tendon stumps are released as possible to gain excursion and check the possibility of repair.

In the present case, there was a massive RC lesion, including a chronic and retracted tear of SS and IS tendons, with insufficient mobility for a tensionless complete repair. The preoperative MRI also showed Goutallier grade III fatty infiltration of SS and IS, predicting bad healing and function prognosis. We then confirmed the integrity of the articular portion of the LHB and progressed to its distal portion preparation.

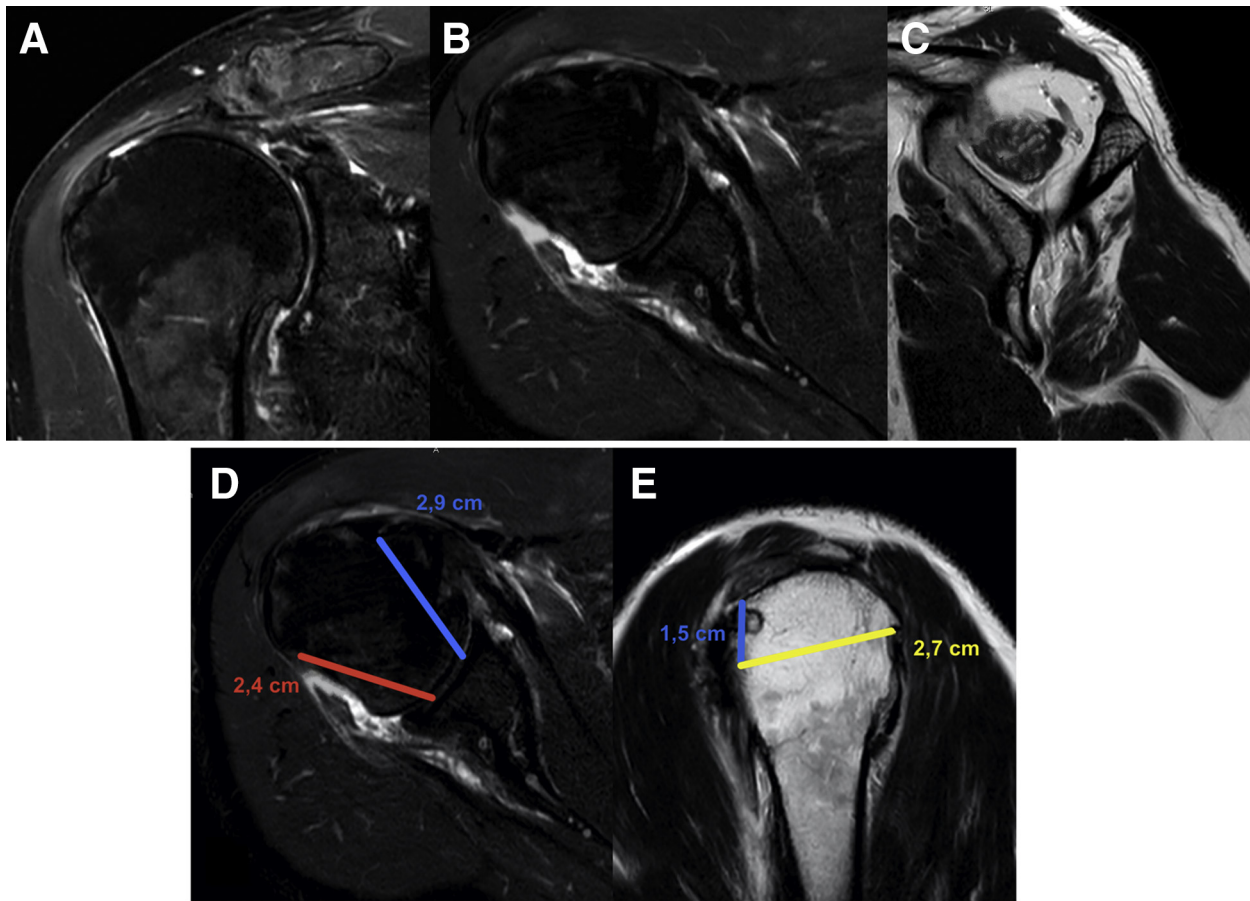


Fig 2. Preoperative MRI scans are recommended to check the severity of the cuff tear, and to measure and estimate the graft track length. (A) Coronal, (B), axial, and (C) sagittal preoperative MRI scans show a massive rotator cuff tear, with advanced fat infiltration of supraspinatus and infraspinatus muscles. (D) The axial view is used to estimate the anterior (blue line) and posterior (red line) tracks for the graft. (E) The sagittal view allows the measurement of intraosseous path (yellow) as well as the vertical distance for the estimated tendon track (blue).

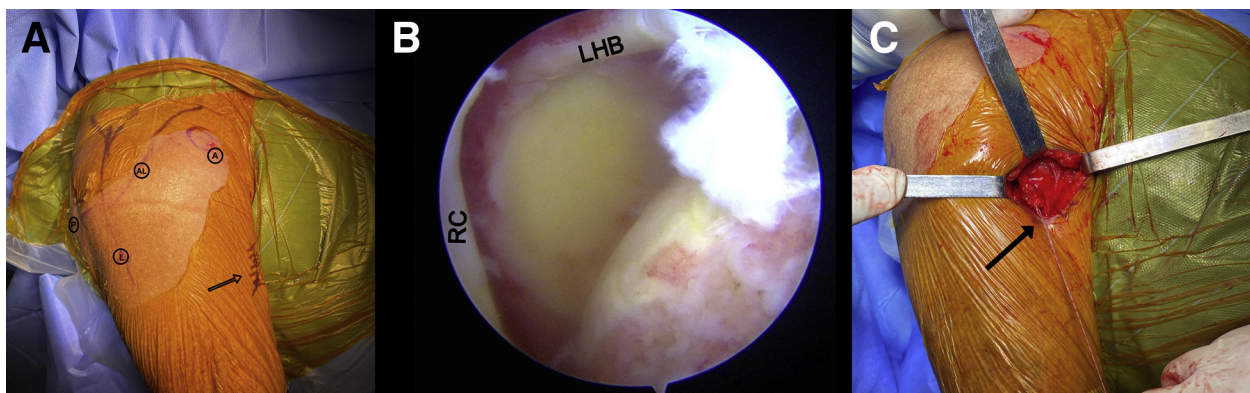


Fig 3. (A) The procedure is performed with the patient in the beach chair position. The right shoulder is visualized showing the portals' positioning: posterior (P), lateral (L), anterolateral (AL), and anterior (A). In addition, a 3-cm anterior incision is planned below the inferior border of the pectoralis major (black arrow). (B) Initially, a diagnostic arthroscopy of right shoulder in beach chair position is performed to check the integrity of the LHB and the reparability of the rotator cuff. (C) Through the anterior incision, the distal end of the proximal stump of LHB is sutured with a Krackow stitch (arrow). (LHB, long head of the biceps; RC, rotator cuff.)

LHB Preparation and Subpectoral Tenodesis

The arm is placed in 90° of abduction and 90° of external rotation, and an anterior approach is performed below the inferior border of the pectoralis major tendon at the anteromedial aspect of the arm (Fig 3B). Retracting the pectoralis major tendon superiorly and the short head of the biceps medially, the LHB is palpated just medial to the pectoral major insertion at the lateral side of the bicipital groove. A soft-tissue tenodesis of the LHB musculotendinous junction is performed at the inferior border of the pectoralis major tendon with a No. 2 nonabsorbable high-strength suture (FiberWire; Arthrex, Naples, FL). A tenotomy is performed immediately proximal to the tenodesis and the proximal stump is sutured using a Krackow stitch with the same type of suture (Fig 3C).

Bone Tunnel Drilling, LHB Transport, and Fixation

With the scope at the lateral portal, the LHB tendon is pulled out of the incision through the anterosuperior portal to measure its diameter (Fig 4A) with a measurement gauge from the long driver located in the biotenodesis set (Arthrex). The length is also measured by inserting a regular arthroscopic probe through the anterosuperior portal until it touches the proximal LHB insertion at superior aspect of the glenoid. Placing the graft and the probe together, the probe is marked where the tendon ends. Then, the length between the end of the probe and pen mark is measured outside of the shoulder with a ruler. As we mentioned before, if the tendon is shorter than needed to complete the patient's track (based on preoperative estimation), we proceed with the fixation to the GT with a suture

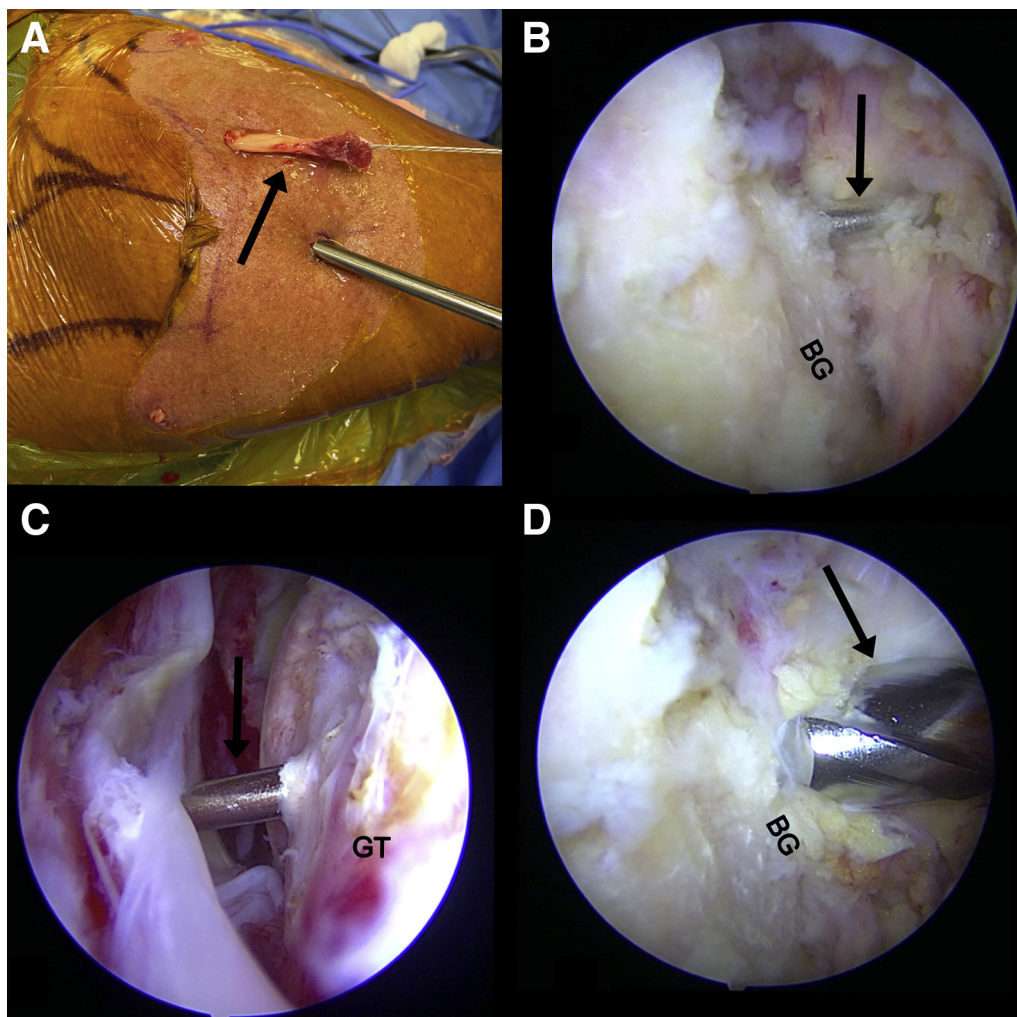


Fig 4. (A) Superior view of the right shoulder with the patient in the beach chair position. The LHB tendon (arrow) is pulled out through the anterosuperior portal for its measurement. (B) Arthroscopic view from lateral portal of the right shoulder in the beach chair position, showing the anterior aspect of the humerus and bicipital groove (BG). A 20-mm guidewire (arrow) is introduced through the anterior portal and progressed from the BG to the posterolateral aspect of the greater tuberosity (GT). (C) Arthroscopic view from lateral portal, showing the guidewire (arrow) exiting the posterior aspect of the GT. (D) Arthroscopic view from lateral portal, showing the canulated drill (arrow) starting the bone tunnel. (LHB, long head of the biceps.)

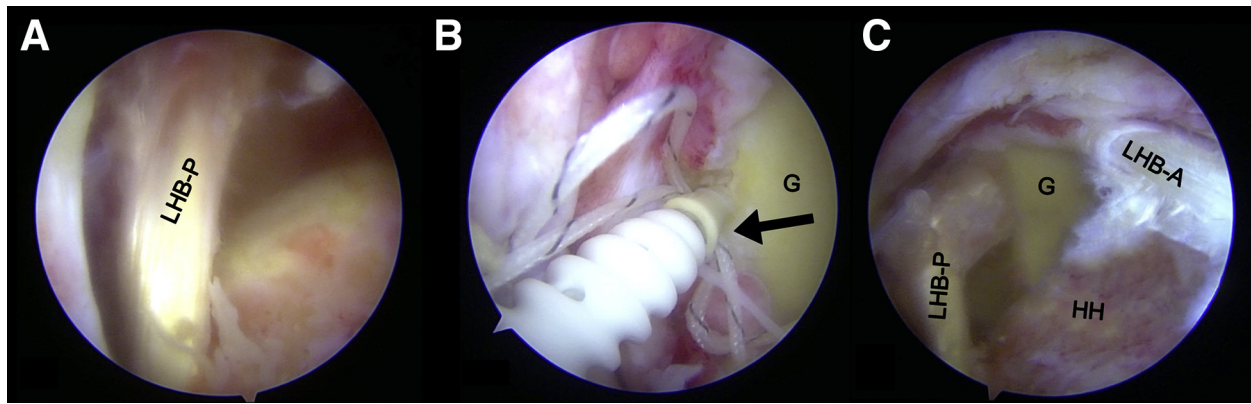


Fig 5. Subacromial arthroscopic view from lateral portal of the right shoulder with the patient in in beach chair position. (A) The posterior bundle of the long head of the biceps (LHB-P) is visualized exiting the bone tunnel on the greater tuberosity (GT). (B) A knotless anchor (arrow) is inserted through the posterior portal, fixing the LHB-P to the posterosuperior rim of the glenoid (G). (C) Visualization of the native fixation of the anterior bundle of the LHB (LHB-A) and LHB-P already crossing the humeral head (HH) bone tunnel and fixed to the posterosuperior aspect of the glenoid (G).

anchor (Fig 1). In this case, the tendon measurement was 10 cm, which was considered satisfactory to perform the biceps loop technique.

A 2-mm guidewire is introduced through the anterior portal and progressed from the bicipital groove until the posterosuperior aspect of the GT (Fig 4 B and C). A bone tunnel is drilled with the tendon's corresponding diameter, which in this case was 6 mm (Fig 4D). A No. 5 nonabsorbable suture (ETHIBOND; Johnson & Johnson, New Brunswick, NJ) is passed through the bone tunnel with a knot pusher, to be used as a shuttle. Both ends of the Krackow suture fixing the LHB are passed into a loop of this shuttle suture and then pulled out through the posterior portal, carrying the tendon carefully through the bone tunnel by direct visualization (Fig 5A). Next, we check the mobility and length of the tendon to reach the posterosuperior aspect of the glenoid.

With the patient's arm in 45° of abduction and in neutral rotation, viewing from the posterior portal, a 4.75-mm knotless anchor (SwiveLock; Arthrex) is then placed at the posterosuperior glenoid rim, fixing the posterior bundle of the LHB tendon (Fig 5B). The native fixation of the anterior bundle of the LHB and the anchor fixation of the posterior bundle of the LHB tendon are then tested with a probe and confirmed by visualization (Fig 5 C and D). Pearls and pitfalls are outlined in Table 1.

RC Repair

After the biceps tenodesis, we also perform a partial repair of the RC to the medial aspect of the footprint. The IS and part of the SS tendons are repaired by standard technique with 2 metallic suture anchors. In this case, we used 4.5-mm TWINFIX ultra Ti anchors with two #2 sutures (Smith & Nephew, Andover, MA). At the end of the procedure, the wounds are irrigated and closed.

Postoperative Rehabilitation

The patient is immobilized with an abduction sling for 6 weeks. Gentle exercises for hand, wrist, and elbow are recommended during this period. Active flexion of the elbow is restricted for 4 weeks. After 6 weeks, physical therapy is initiated, including passive and active assisted exercises for range of motion of the shoulder. Strengthening exercises are initiated after 3 months. Heavy lifting and overhead activities are delayed for approximately 5 months.

Discussion

SCR is an emerging alternative treatment for massive irreparable RC tears, particularly in young and active patients, or whenever we want to avoid a shoulder replacement. It acts as a static stabilizer of the glenohumeral joint, preventing superior migration of the humeral head.^{6,8,16} Many authors have reported good clinical outcomes after SCR, with pain relief and

Table 1. Advantages and Disadvantages of the Biceps Loop Technique

Advantages	Disadvantages
Minimally invasive and low morbidity procedure.	Depends on LHB integrity.
Less-advanced arthroscopic skills required compared with original SCR.	Pain related to the maintenance and over tension of the LHB remains a concern.
Fewer suture anchors required, minimizing costs.	Risk of proximal humeral fracture during the bone tunnel drilling.
Avoidance of allograft cost and risks.	As a newer procedure, its efficacy still needs to be proven.
Anatomy is not grossly altered, making revisions easier.	

LHB, long head of the biceps; SCR, superior capsular reconstruction.

Table 2. Indications and Contraindications of the Biceps Loop Technique

Indications	Contraindications
Young and active patients with irreparable RC tear.	>30% partial tear of LHB.
Absence of degenerative joint disease.	Longitudinal tear of LHB.
Inappropriate candidates for a shoulder replacement.	Total lesion of the LHB. Severe osteoporosis of the humeral head.

LHB, long head of the biceps; RC, rotator cuff.

improved function.¹⁷⁻²⁰ However, the procedure is technically demanding and expensive, requiring several suture anchors, as well as one of the different options of an external graft.⁵

We demonstrated a modified arthroscopic SCR technique using the LHB in this report. The use of the LHB has many advantages over the autologous tensor fascia lata, allografts, or synthetic grafts^{8,9} (Table 1). First, the tendon is a local structure and can be easily handled during arthroscopic surgery, without the need to approach other parts of the body, reducing donor-site morbidity. Second, the use of an autograft minimizes the risks of postoperative complications of an allograft, such as infection and nonhealing. Third, the present technique transfers the LHB into a bone tunnel through the proximal humerus, which creates a larger contact area for healing and also reduces the demand for suture anchors, reducing surgical time and costs. Finally, the associated tenotomy and tenodesis possibly reduces postoperative pain due to LHB pathologies while preserving biceps muscle strength and cosmesis.²¹

Most of SCR techniques using the LHB uses only the intra-articular portion of the tendon, leaving a graft that has its strength questioned, since it could be not enough to recreate the fulcrum of the joint.^{7-9,11} Only few authors have described different techniques using both intra- and extra-articular portions of the LHB.¹⁰ In this present technique, the tendon crosses the joint twice, which theoretically doubles the strength properties of the graft, while it distributes the load more evenly over the humerus. We believe this method creates a more

Table 3. Tips and Pearls

Preoperative assessment of LHB by MRI and intraoperative thorough glenohumeral joint evaluation is essential to assure LHB presence and feasibility to perform this technique.

The anterior portal is positioned more inferior and medial than traditional, just inferior and lateral to the palpable coracoid process. Retrieve the LHB through the anterosuperior portal before drilling the humeral head.

Ensure that there is a considerable bone bridge between the drill holes.

Final tension for the graft can be adjusted just before the final fixation.

LHB, long head of the biceps; MRI, magnetic resonance imaging.

reliable way to restore the fulcrum necessary to joint mobility. In addition, this technique easily permits the association with a partial RC repair. We believe this is recommended whenever possible, particularly for the subscapularis and infraspinatus tendons, to better restore the anterior and posterior force couples and enhance the joint biomechanics.²²

Concerning the dimension of the tendon, previous authors reported that the length of the LHB from its origin until the musculotendinous junction is approximately 13.8 ± 2.6 cm with average diameter of 6 mm.^{23,24} Therefore, the LHB is generally long enough to be transferred through a humeral tunnel and fixed to the posterior aspect of the glenoid rim without excessive tension. If the intraoperative measurement of the tendon length turns out to be shorter than preoperative track calculation, we can change the surgical technique and proceed a SCR, as described by Barth et al., before creating the bone tunnel.¹⁵ In contrast, if the tendon is too long to give adequate tension, this can be easily adjusted by making an extra cut before definitive fixation.

The limitations and contraindications of this modified technique are listed in Table 2. The main limitation is a poor-quality tendon or the absence of the intra-articular portion of the LHB. Thus, preoperative assessment of LHB clinically, by MRI and intraoperative thorough glenohumeral joint evaluation, is essential to assure LHB feasibility to perform this technique. Another potential concern is the risk for development of pain generated by an overtensioned LHB. Fortunately, it has not been our experience with the pilot cases submitted to this technique. Fracture of the proximal humerus during the bone tunnel drilling is another concern, although this complication has not occurred. Our idea is that cautious drilling and keeping a good cortical bridge greatly minimizes this risk. Pearls and pitfalls of the procedure are discussed in Table 3.

SCR is considered a treatment option for patients with massive irreparable RC tears in whom it is desired to avoid other currently available techniques, such as reverse total shoulder arthroplasty. We believe that our technique can be an effective procedure for selected patients to avoid progression to cuff tear arthropathy. Further clinical trials are needed to investigate the long-term benefits and downsides of this technique.

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