Technical Note

Consider Long Head of Biceps Tendon for Reconstruction of Massive, Irreparable Rotator Cuff Tear

Naser M. Selim, M.D., and Ehab R. Badawy, M.D.

Abstract: Despite the different treatment options for irreparable and massive rotator cuff tears (RCTs), there is no optimal treatment. Thirty percent of total RCTs can be classified as irreparable because of the massive tear size and severe muscle atrophy. The reported treatment failure rate is approximately 40% for massive RCTs. RCTs may be treated conservatively or surgically depending on pain, disability, and functional demands. The surgical treatment options are many, but decision making is a challenge; the real challenge is to apply the correct procedure for the correct indication in each patient. The long head of the biceps tendon (LHBT) was used for augmentation to bridge the gap in immobile, massive RCTs. An arthroscopic biceps-incorporating technique was used for repair of large and massive RCTs, avoiding undue tension on the rotator cuff (RC). Recently, the LHBT was used for superior capsular reconstruction. This article describes the use of the LHBT for reconstruction of massive and irreparable RCTs through the following steps: (1) open exposure of the RCT, (2) debridement and subacromial decompression, (3) biceps tenotomy at the LHBT's origin on the glenoid, (4) LHBT and RC cuff mobilization, (5) passage of the LHBT through the mobilized RC and reflection onto itself, (6) tuberoplasty, and (7) fixation of the RC complex at the RC footprint.

In irreparable rotator cuff tears (RCTs), direct tendon-to-bone repair is not possible despite conventional techniques of surgical release and mobilization, and if reattachment is possible, healing will not occur.[1-4] A massive tear is a tear with a diameter of 5 cm or greater or a complete tear of 2 or more tendons.[5] The size and reparability of a tear are not always related: A massive tear is not necessarily irreparable, and an irreparable tear is not necessarily massive.[6]

RCTs may be small or large; they have a progressive pattern in most cases.[7] Irreparable tears may occasionally be small but are usually large; in exceptional cases, they start as massive tears. Thirty percent of total RCTs can be classified as irreparable because of the massive tear size and severe muscle atrophy.[8,9]

The reported treatment failure rate is approximately 40% for massive RCTs.[10] The treatment options for irreparable and massive RCTs are enormous, but none is optimal. RCTs may be treated conservatively or surgically depending on pain, disability, and functional demands. The surgical treatment options are many, but decision making is a challenge; the real challenge is to apply the correct procedure for the correct indication in each patient.[11]

The long head of the biceps tendon (LHBT) was used for augmentation to bridge the gap in immobile, massive RCTs.[12,13] An arthroscopic biceps-incorporating technique was used for repair of large and massive RCTs, avoiding undue tension on the rotator cuff (RC) repair.[13,14] Recently, the LHBT was used for superior capsular reconstruction (SCR).[15]

This article describes the use of the LHBT for reconstruction of massive and irreparable RCTs through the following steps: (1) open exposure of the RCT, (2) debridement and subacromial decompression, (3) biceps tenotomy, (4) LHBT and RC cuff mobilization, (5) passage of the LHBT through the mobilized RC and reflection onto itself, (6) tuberoplasty, and (7) fixation of

From Knee Surgery—Arthroscopy and Sports Injuries Unit, Orthopedic Department, Mansoura University, Mansoura, Egypt.

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Address correspondence to Naser M. Selim, M.D., Faculty of Medicine, Knee Surgery—Arthroscopy and Sports Injuries Unit, Mansoura University Hospital, Mansoura, Egypt. E-mail: dr.nasserselim728@yahoo.com

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the RC complex at the RC footprint. The technique combines many procedures, each of which can be solely used for the treatment of irreparable and massive RCTs.

Technique

Patient Positioning and Setup

The patient is seated in the semi-sitting position and undergoes general anesthesia. Sterile draping of the affected shoulder is performed. The arm is held in an adducted and internally rotated position. The surgeon stands facing the affected shoulder.

Exposure of RC

The incision is started 2 cm anterior to the middle of the anterior border of the acromion and extends parallel to it to about 2 to 3 cm distal to the anteromedial corner of the acromion. The anterior deltoid muscle is then split along its fibers' orientation just above the coracoacromial ligament at a length of not more than 6 cm to avoid axillary nerve injury. A self-retaining retractor is inserted to expose the humeral head in the subacromial space (Fig 1A).

Subacromial Decompression

The coracoacromial ligament is subperiosteally released from the anterior edge of the acromion. The subacromial bursa is removed. Acromioplasty is performed with a bone rongeur (EMED). The RCT is exposed, the edges are debrided, and stay sutures are placed in the tendon to be used for its mobilization. The adduction and internal rotation of the arm will move the RC and help the surgeon grasp the torn tendons. Any subacromial pathology, including acromial morphology, osteophytes, and acromioclavicular joint abnormalities, is noted and debrided (Fig 1B).

RC Mobilization

Because of tendon retraction of the RC muscle, a prior mobilization of muscles and tendons may be required before fixation. The mobilization is performed by blunt dissection as far medially as possible. A universal grasper forceps (Aesculap) is used for traction on the RC tendons during mobilization or traction using Vicryl (No. 2-0) stay sutures (Ethicon) at the ends of the RC tendons.

Degenerated ends of the tendons cannot be grasped with forceps and are resected. For very small friable tears, a single nonabsorbable stitch is placed to close the tear to prevent the tendon from further damage.

Biceps Tenotomy

The proximal biceps is identified and exposed in its groove through the same incision, and by external rotation of the arm, the bicipital groove is exposed. By use of a curved artery forceps (Arthrex), the LHBT is fished (Fig 2A) and surgically dissected proximally to its origin at the glenoid and is resected. Before tenotomy, Vicryl (No. 2-0) stay sutures are used in the most proximal end of its attachment to the glenoid to avoid

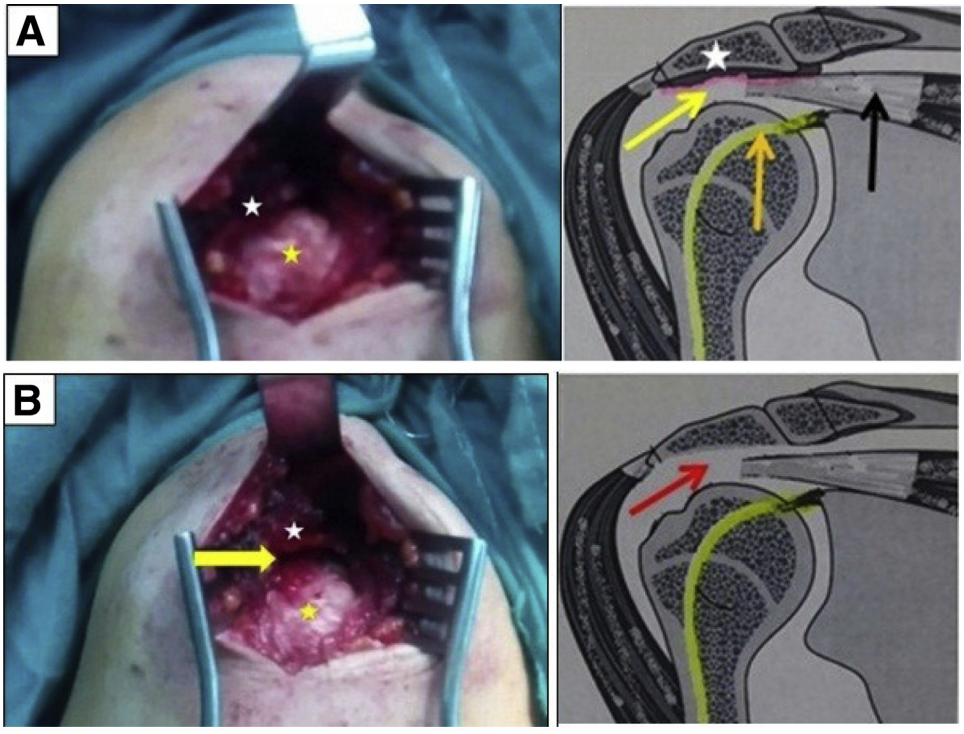

Fig 1. Open exposure (right shoulder with patient in semi-sitting position). (A) The dissection (left) shows the humeral head (yellow star) and the acromion (white star) before subacromial decompression. The illustration (right) shows the acromion (white star), rotator cuff tear (yellow arrow), retracted supraspinatus (black arrow), and long head of the biceps tendon (orange arrow). (B) The dissection (left) shows the humeral head (yellow star), acromion (white star), and subacromial space (yellow arrow) after subacromial decompression. The illustration (right) shows the subacromial space (red arrow) after decompression.

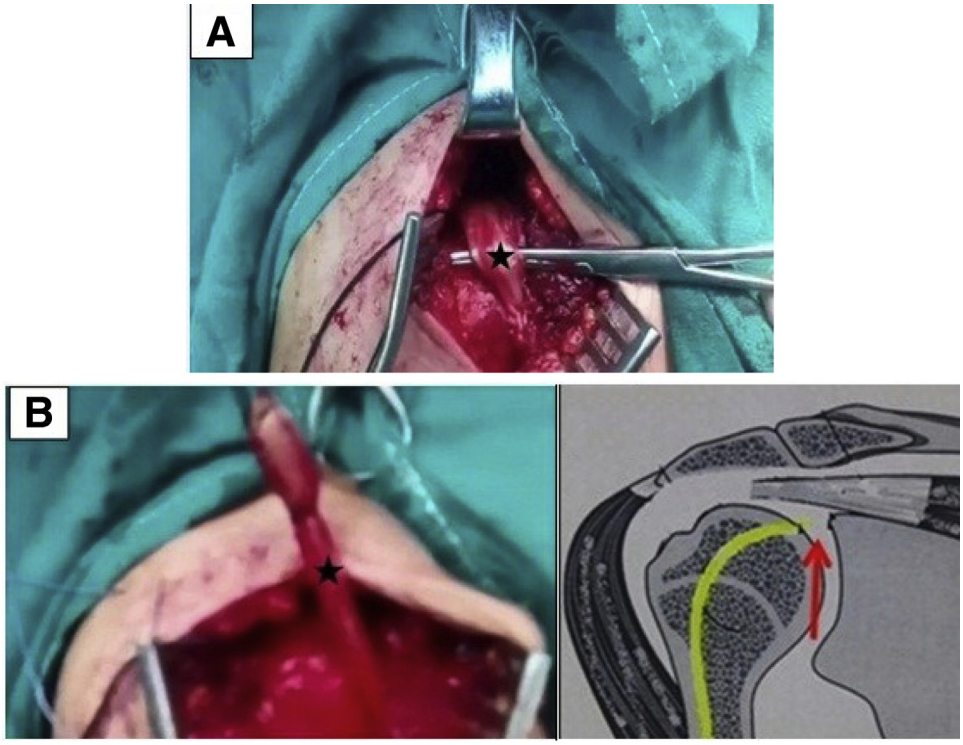

Fig 2. Biceps tenotomy (right shoulder with patient in semi-sitting position). (A) The long head of the biceps tendon (black star) is fished at the bicipital groove and surgically dissected proximally to its origin at the glenoid. (B) The long head of the biceps tendon (black star) is shown after tenotomy and mobilization (left). The illustration (right) shows the biceps tenotomy (red arrow).

its escape distally and to be used later for tendon mobilization.

LHBT Mobilization

After tenotomy of the LHBT, the stay sutures are used for traction on the tendon and mobilization is performed by blunt dissection as far distally as possible (Fig 2B).

Passage of LHBT Through RC

The RC edge is debrided, and 1 to 5 mm is excised from it. At 1.5 to 2 cm medial to the debrided RC edge, 2 transverse punctures are created using a No. 11 scalpel blade. The punctures are placed 1.5 to 2 cm from each other, with one anterior and the other posterior. The stay sutures in the LHBT are retrieved through these punctures and used for passage of the LHBT from anterior to posterior through the punctures in the RC tendon. The LHBT is passed through the anterior RC (Fig 3 A and B) and is then passed in a purse-string manner to the posterior cuff (Fig 3C).

After its passage, the LHBT is reflected onto itself (Fig 3D); thus, a complex is formed (RC insertion complex). The RC complex combines the free end of the LHBT after passage through the RC ends and the distal end of the LHBT before passage through the RC, with part of the RC ends in between.

Tuberoplasty

By use of a curved osteotome (Zimmer Biomet), the most prominent lateral part of the greater tuberosity at the central part of the RC footprint is excised (Fig 4A). Tuberoplasty creates a raw surface for healing of the RC complex after fixation. Tuberoplasty is combined with acromioplasty; this allows the use of screw and washer fixation of the RC complex without prominence and creates a smooth, congruent acromiohumeral (AH) articulation.

Fixation of RC Complex

The RC complex can now be reconnected to the humeral head at the site of tuberoplasty. Fixation is achieved with a 6.5-mm cancellous, fully threaded metal screw and a plastic washer (Fig 4B). The screw should engage the far medial cortex of the humerus to allow stable fixation and tenodesis. The RC complex fixation should be sunken laterally at the site of tuberoplasty without prominence to avoid impingement, allowing full internal and external rotation (Fig 4 C and D). The fixation of the RC complex combines reattachment of the RC to the greater tuberosity and tenodesis of the LHBT at the same time (Video 1).

Discussion

In irreparable RCTs, direct tendon-to-bone repair is not possible despite conventional techniques of surgical release and mobilization, and if reattachment is possible, healing will not occur.[1-4] A massive tear is a tear with a diameter of 5 cm or greater or a complete tear of 2 or more tendons.[5] The size and reparability

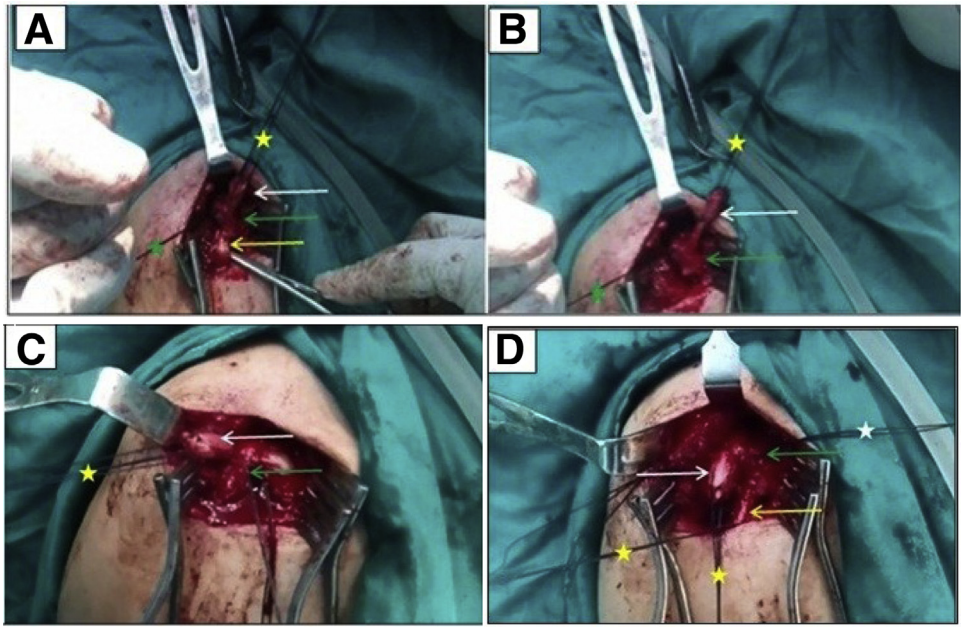

Fig 3. Passage of long head of biceps tendon (LHBT) through rotator cuff (RC) (right shoulder with patient in semi-sitting position). (A, B) Passage of LHBT through anterior cuff, showing LHBT (white and yellow arrows), RC edge (green arrow), Vicryl (No. 2-0) stay sutures in LHBT (yellow star), and Vicryl (No. 2-0) stay sutures in RC edge (green star). (C) Passage of LHBT through posterior cuff, showing LHBT (white arrow), RC edge (green arrow), and Vicryl (No. 2-0) stay sutures in LHBT (yellow star). (D) Reflection of LHBT onto itself after its passage through RC, showing the LHBT (white and yellow arrows), RC edge (green arrow), Vicryl (No. 2-0) stay sutures in LHBT (yellow star), and Vicryl (No. 2-0) stay sutures in RC edge (white star).

of a tear are not always related: A massive tear is not necessarily irreparable, and an irreparable tear is not necessarily massive.[6]

Acute or Chronic

An irreparable tear may rarely be acute but is usually a chronic tear. RCTs cause a cascade of pathologic events, including myotendinous retraction,[16-18] loss of musculotendinous elasticity,[19] fatty infiltration of muscles,[20] and disturbance of the normal force couples of the RC,[21] leading to static superior or anterosuperior subluxation of the humeral head[22-27] and, ultimately, osteoarthritis.[17]

Large or Small

RCTs have a progressive pattern in most cases.[7] Whereas small tears with no or little retraction relatively frequently remain small,[28] large, reparable tears usually increase in size and can rapidly become irreparable with no further increase in pain or disability.[17,29] Irreparable RCTs are usually large and retracted with nonfunctional muscle bellies and severe fatty degeneration, but a small chronic tear may be irreparable when it is friable and unable to be repaired primarily to bone.[30]

Predictable or Unpredictable

Irreparable RCTs are usually unpredictable with respect to their clinical presentation.[30] However, there are key clinical, radiologic, and intraoperative predictors of tear irreparability. Irreparable tears are expected with a long duration of symptoms, pseudoparalysis in anterior elevation[31] and external rotation, the Neer drop-arm sign,[32] the horn-blower sign,[33] anterosuperior subluxation of the humerus, an AH interval of less than 7 mm,[26,34,35] stage 3 or 4 fatty muscle infiltration,[20,36] and tendon retraction to the glenoid (stage 3 on the Patte classification).[4]

Intraoperatively, reattachment of the RC tendons to their footprint can be difficult or impossible.[1-3] The conventional release is inadequate, and extensive release is required for reattachment.[4] Reattachment requires a minimum of 60° of abduction for posterosuperior tears.[3]

Is Surgical Treatment Mandatory?

The treatment options for RCTs are many, but there is no optimal treatment. Irreparable and massive RCTs may be treated conservatively or surgically depending on pain, disability, and functional demands.[11] The spectrum of pain and functional disability varies widely: A shoulder may function well in the setting of a large painless tear, whereas a small painful tear may result in substantial shoulder dysfunction and disability.[30] The dysfunction is determined by the patient alone and his or her tolerance level to pain.

A patient may be able to cope with the type and intensity of pain; his or her treatment will differ from that

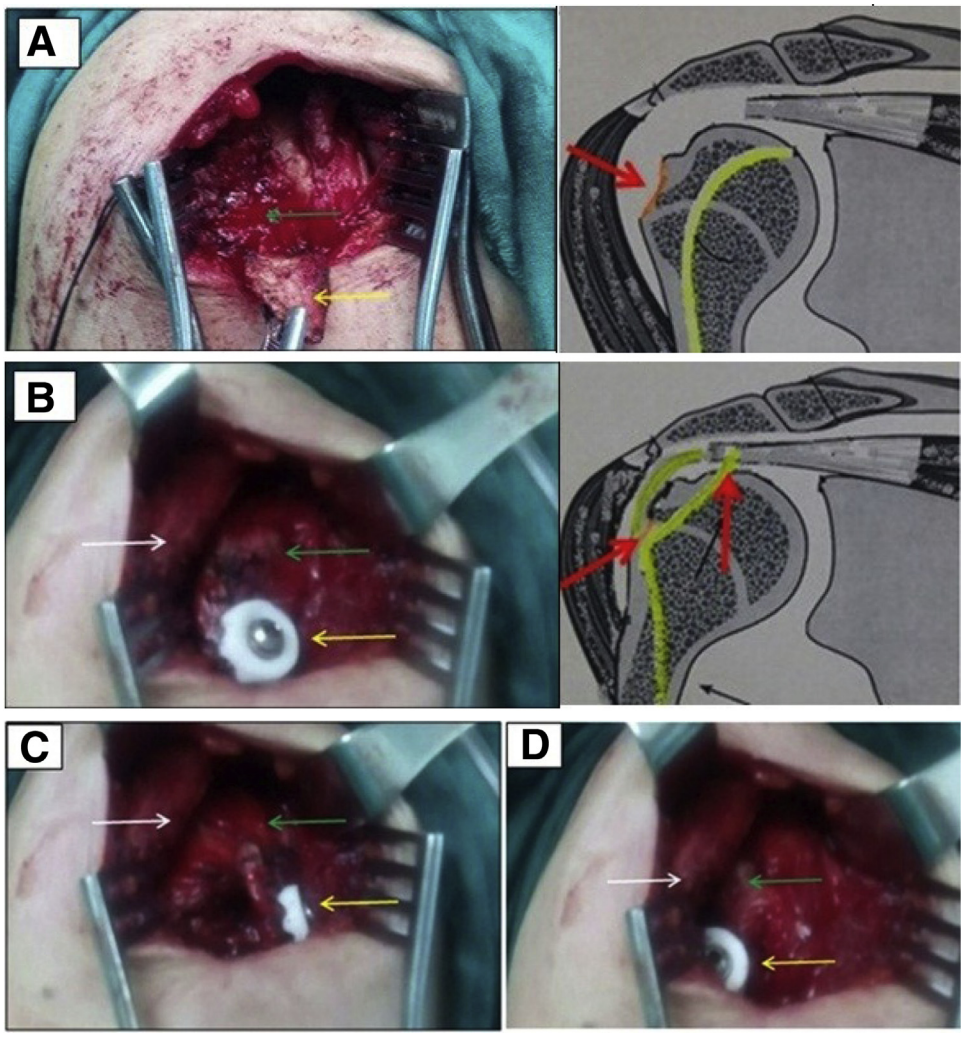

Fig 4. (A) Tuberoplasty (right shoulder with patient in semi-sitting position). The dissection (left) shows that part of the greater tuberosity is excised (yellow arrow), leaving a raw area at the central part of the rotator cuff (RC) footprint (green arrow). The illustration (right) shows the tuberoplasty (red arrow). (B) Fixation of RC complex (right shoulder with patient in semi-sitting position). The dissection (left) shows the screw and washer (yellow arrow), the reconstructed cuff (green arrow), and the anterior acromion (white arrow). The illustration (right) shows passage of the long head of the biceps tendon through the RC and fixation of the RC complex (red arrows). (C, D) Fixation of RC complex (right shoulder with patient in semi-sitting position) in internal rotation (C) and external rotation (D), showing the screw and washer (yellow arrow), the reconstructed cuff (green arrow), and the anterior acromion (white arrow).

in a patient with pain beyond his or her tolerance. Moreover, in a patient with mild weakness with the arm away from the body, the treatment will differ from that in a patient with pseudoparalysis in elevation or rotation. Furthermore, in a patient who wishes to use the arm in space, the treatment will differ from that in a patient who accepts only being able use the hand with the arm at the side.[37]

Conservative Treatment

Conservative treatment is suitable for low-demand patients[38] and moderately symptomatic patients,[17] but substantial structural tendon, muscle, and cartilage deterioration,[17] as well as joint degeneration, is inevitable.

Arthroscopic Debridement

Rockwood et al.[6] in 1995 introduced arthroscopic debridement with subacromial decompression for the treatment of irreparable RCTs. Excision of inflammatory tissue and anatomic structures responsible for impingement will contribute to functional improvement and pain relief after conservative therapy. However, the retracted RC muscles cannot be repaired by the procedure.

Arthroscopic debridement with subacromial decompression has little effect on strength.[4] It may be associated with humeral head escape after acromioplasty,[39] and it does not slow the progression of osteoarthritis.[37]

Subacromial Spacer Implantation

An implanted balloon allows frictionless gliding of the humeral head in the subacromial space, thus reducing pain. Moreover, it maintains or increases the AH interval and thus restores the force couples of the RC, improving clinical outcomes.[40,41] This treatment is contraindicated in patients with fixed humeral head elevation, chronic pseudoparalysis, or subscapularis tears.

Biceps Tenotomy or Tenodesis

Walch et al. in 1997 introduced arthroscopic tenotomy of the biceps as a routine pain treatment in RC disease.[42] Boileau et al.[43] in 2007 performed isolated

arthroscopic biceps tenotomy or tenodesis to improve symptoms in patients with massive, irreparable RCTs.

Impingement of the tendon stump within the joint may occur if the tenotomy is not performed close to the origin on the glenoid.[44] A Popeye deformity may occur after tenotomy if the flattened part is not stuck at the entrance of the bicipital groove.[45] Pain along the course of the biceps may occur after tenodesis if there is excessive tension on the tendon.

Tuberoplasty

Fenlin et al.[46] in 2002 introduced an open surgical procedure described as "tuberoplasty" to create a smooth congruent AH articulation and used it as a treatment option for massive, irreparable RCTs. In 2004, Scheibel et al.[47] introduced an arthroscopic approach for tuberoplasty called "reversed subacromial decompression" and used it for the treatment of massive RCTs.

With tuberoplasty, increased superior migration of the humeral head may occur in the long term, and a poor functional outcome was associated with an AH interval of less than 4.3 mm.[10] Progression of osteoarthritis was observed, although it did not interfere with the clinical result.[46,47]

Partial Repair

Burkhart et al.[48] in 1993 introduced the concept of a suspension bridge in RCTs, which developed into functional cuff tears.[49] Repair of the margins of the torn RC was designed to restore the force couples and facilitate force transmission. Posterior fixation is important in restoring abnormal glenohumeral kinematics.[50] Partial repair leaves the greater tuberosity uncovered.[44]

Complete Repair

Interval slide, margin convergence, and medialization for complete repair can aid in reducing tension on the tendon, minimizing gap formation and restoring the normal kinematics of the humeral head. Bigliani et al.[51] in 1992 introduced open interval-slide surgery. Tauro[52] popularized an arthroscopic interval-slide technique. Lo and Burkhart[53] defined the anterior interval slide as a release from the rotator interval and defined the posterior interval slide as a release of the interval between the supraspinatus and infraspinatus tendons.

An interval slide does not allow for sufficient mobilization. Sufficient mobilization is allowed with a release of the coracohumeral ligament from the coracoid undersurface instead of a release from the rotator interval. Complete repair using an interval-slide technique has no advantages over partial repair in terms of treatment outcome.[54]

Burkhart et al.[55] suggested margin convergence as a method of reducing strain and increasing fixation strength. Shindle et al.[56] performed a margin-convergence technique in U-shaped RCTs. The efficacy of margin convergence is doubtful in severely degenerated, poorly vascularized RCs. With margin convergence, only 46.2% of RCTs were healed.[56]

Liu et al.[57] reported that medialization of the RC tendon of 3 mm to up to 10 mm had a negligible impact on the moment arm during elevation. Yamamoto et al.[58] reported that medialization of 10 mm or greater resulted in significant limitation in range of motion.

Interposition Autograft

Mori et al.[59] in 2015 used fascia lata autograft for partial repair of high-grade irreparable RCTs. Mihara et al.[60] in 2016 used the iliotibial band with a Gerdy tubercle bone block autograft for irreparable RCTs. Interposition autografts are indicated in high-grade Goutallier fatty degeneration, that is, grade 3 or 4.

Graft Augmentation

Soler et al.[61] in 2007 used porcine dermal collagen implants as augmentation in RCT repair. Encalada-Diaz et al.[62] in 2011 performed RC repair augmented with a polycarbonate polyurethane patch. Neviaser et al.[63] in 1978 used a freeze-dried graft for repair of massive RCTs. Yoon et al.[64] in 2016 performed patch augmentation and bone marrow stimulation in massive RCTs.

The healing rate was shown to be significantly higher in a group of patients who underwent GraftJacket acellular human dermal matrix augmentation (Wright Medical Technology) than in a group without augmentation (85% vs 40%).[65] Neviaser[66] in 1971 and Rhee et al.[12] in 2008 described biceps augmentation for massive RCT repair. Cho et al.[13] in 2009 and Ji et al.[14] in 2014 performed RC repair with biceps augmentation in massive RCTs. Graft augmentation has shown mechanical and biological advantages and a decrease in the high tension applied to the torn tendon while pulling the torn tendon edge to the lateral footprint.[67]

Superior Capsular Reconstruction

Mihata et al.[68,69] used interposition patch fascia lata autograft folded 6 to 8 times for complete repair of the subscapularis tendon and partial repair of the infraspinatus and teres minor tendons. Chillemi et al.[15] in 2018 used the proximal long head of the biceps as an autograft after tenotomy, applying 2 medial suture anchors to the superior glenoid and 2 lateral transosseous tunnels to fix the autograft.

The current evidence suggests that for symptomatic cases of irreparable, massive RCTs, SCR is an alternative with good to excellent early clinical outcomes; however, long-term follow-up will determine the longevity and ultimate role of this method in the treatment of irreparable, massive RCTs.[70] SCR is performed in young patients with massive, irreparable posterosuperior RCTs with no arthritis and in patients with Goutallier fatty degeneration of stage 3 or higher with retraction of the

Table 1. Advantages of Technique

Step	Advantages
Open reconstruction	Easier identification is possible.
	Less surgical time is required.
	The technique can be used for irreparable and massive tears.
Subacromial decompression	CAL release (no cutting) avoids anterior instability.
	Acromioplasty avoids impingement on the reconstruction.
	Subacromial bursectomy decreases pain.
	Debridement of the RC edges decreases pain.
	Subacromial decompression increases the subacromial space.
Combined tenotomy and tenodesis	Tenotomy decreases pain.
	Tenodesis avoids the Popeye deformity after tenotomy.
	The tension of the LHBT after its fixation, along with the reconstructed cuff, helps to depress the head and decrease its proximal migration.
Passage of LHBT through RC	LHBT graft passage through the RC ends simulates the RC cable.
	LHBT graft is a local graft, thus avoiding the need for distant graft.
	LHBT graft provides a biological reconstruction and encourages healing.
	LHBT passage through the RC decreases the tension and the need for excessive mobilization of the RC.
	LHBT graft acts as a sling for mobile tears, as a bridge for immobile tears, and as an augmentation for partially reparable tears.
Tuberoplasty	A smooth congruent AH articulation is created.
	A raw surface is created for healing of the RC complex after fixation.
	Tuberoplasty plus acromioplasty allows fixation of the RC complex without prominence.
Fixation of RC complex	Anatomic reconstruction is achieved.
	Fixation is performed at the RC footprint.
	The fixation combines the free end of the LHBT after passage through the RC ends and the distal end of the LHBT before passage through the RC, with part of the RC ends in between.
	The method of fixation is simple and inexpensive.
	The method of fixation gives a stable reconstruction.

AH, acromiohumeral; CAL, coracoacromial ligament; LHBT, long head of biceps tendon; RC, rotator cuff.

supraspinatus or infraspinatus tendons going up to the glenoid or just medial to it.[71] It is contraindicated if a fixed high-riding humeral head is present.[71] Although SCR is a joint-preserving procedure, it is a technically challenging procedure that necessitates a prolonged surgical time, which increases the risk of complications such as infection.[11]

Tendon Transfer Procedures

The ideal candidate for a tendon transfer procedure is a young, active patient with severe disability related to weakness and loss of rotation, without glenohumeral osteoarthritis.[1,72,73] Irreparable posterosuperior cuff tears are commonly treated with latissimus dorsi tendon transfer; for irreparable anterosuperior tears, pectoralis major tendon transfer is used.[74,75]

Latissimus Dorsi Transfer

The latissimus dorsi transfer was adopted by Gerber et al.[76] in 1980 for irreparable RCTs. Latissimus dorsi transfer is preferred over teres major transfer because the latissimus dorsi has 33.9 cm of excursion and has a predictable insertion anterior to the teres major tendon and 7 mm lateral.[77,78]

The outcomes after latissimus transfer in properly selected patients show significant pain relief; however, the functional outcome is much less predictable. Subscapularis dysfunction appears to be a relative contraindication to latissimus transfer, with several studies showing an association with poor clinical outcomes.[36,79]

Pectoralis Major Transfer

Wirth and Rockwood first described pectoralis major transfer in 1997 in patients with irreparable anterosuperior RCTs.[74] Pectoralis major transfer can be a viable option for relatively young patients with isolated irreparable subscapularis tears without arthritis.[80] The pectoralis major tendon is also useful for transfer because it has the second longest excursion of 18.8 cm.[78] However, it is a technically demanding procedure, and care should be taken to avoid injury to the musculocutaneous nerve.

Other Tendon Transfers

Transfer of the middle third of the deltoid insertion to the stump of the posterosuperior cuff has been described,[81,82] as has transfer of the trapezius insertion to the greater tuberosity passing underneath the acromion.[83-85]

Reverse Total Shoulder Arthroplasty

Paul Grammont in 1985 introduced the biomechanical concept of medialization of the center of rotation.[86] Reverse total shoulder arthroplasty (RTSA) is the optimal solution among elderly patients with RCTs accompanied by pseudoparalysis and osteoarthritis.[87]

Table 2. Surgical Steps, Pearls, and Pitfalls

Step	Pearls	Pitfalls
Approach	The surgeon should detach part of the anterior deltoid to ease the exposure and repair it at the end of the operation.	The power of the deltoid will be decreased if not reattached.
Subacromial decompression	The CAL is released, not cut.	Cutting will lead to anterior instability.
	Acromioplasty increases the subacromial space.	Without acromioplasty, impingement on the reconstruction may occur.
Biceps tenotomy and release	Stay sutures should be used before tenotomy.	If not used, the tendon will escape distally.
	Tenotomy should be performed close to its origin on the glenoid.	If not, impingement of the tendon stump will occur within the joint.
	The tendon should be released by blunt dissection as far distally as possible.	If not, the tendon length will be insufficient for reconstruction.
RC mobilization	Friable, degenerated, and chronically inflamed edges should be excised.	If not, weak reattachment, less healing power, and more pain will result.
	Two punctures should be performed 1.5-2 cm from the RC edges.	Placement at <1.5 cm may lead to tendon maceration.
	The RC should be mobilized by blunt dissection as far medially as possible.	If not, the RCT will be retracted with difficult reconstruction.
LHBT passage through RC	Passage should be performed from anterior to posterior.	The reverse is difficult to achieve.
	Purse-string passage gives more incorporation with the RC.	Side-to-side attachment to the RC edges will result in a weak reconstruction.
	LHBT passage through the RC simulates the RC cable.	If stitched to the RC edges, the RC cable will not be reconstructed.
Tuberoplasty	Tuberoplasty is performed at the RC footprint.	If not, nonanatomic reconstruction will result.
	Tuberoplasty plus acromioplasty allows fixation of the RC complex without prominence.	If not, prominence of the RC complex and impingement of screw and washer will result.
Biceps tenodesis	The tension of the LHBT is adjusted before its fixation according to the upper end of the pectoralis major.	Excess tension is associated with pain along the course of the biceps tendon.
	Tenodesis is performed with the RC complex at the site of tuberoplasty.	If not, nonanatomic reconstruction will result.
RC complex fixation	The procedure is performed with shoulder flexion to facilitate fixation at the RC footprint and to keep tension on the reconstruction.	If not, difficult fixation at its anatomic site will result.
	The fixation should include the free end of the LHBT after passage through the RC ends and the distal end of the LHBT before passage through the RC, with part of the RC ends in between.	If not, unstable fixation will result.

CAL, coracoacromial ligament; LHBT, long head of biceps tendon; RC, rotator cuff; RCT, rotator cuff tear.

RTSA is indicated to improve elevation in patients with true shoulder pseudoparalysis, irreparable RCTs, RCT arthropathy, or glenohumeral osteoarthritis, as well as for patients who are not candidates for arthroscopic procedures or tendon transfers. Latissimus transfer or teres major transfer could be used with RTSA[88,89] in patients with a positive external rotation lag sign or horn-blower sign.

Considering the high complication rates of RTSA, RC repair should be the first-line treatment option even in the case of nonarthritic large to massive RCTs with pseudoparalysis.[90] The treatment of irreparable RCTs can be challenging for the orthopaedic surgeon. Although many treatment options exist, no singular treatment is the gold standard. Treatment depends on a patient's functional status, as well as the skill and procedural familiarity of the surgeon.[91]

In the described technique, the LHBT is used for reconstruction of massive and irreparable RCTs through the following steps: (1) open exposure of the RCT, (2) debridement and subacromial decompression, (3) biceps tenotomy, (4) LHBT and RC cuff mobilization, (5) passage of the LHBT through the mobilized RC and reflection onto itself, (6) tuberoplasty, and (7) fixation of the RC complex at the RC footprint (Video 1). This technique follows biological and anatomic bases for reconstruction of massive and irreparable RCTs using the LHBT as an autograft, with stable fixation at the RC footprint. The technique combines many procedures described to be used solely as a treatment option for massive and irreparable RCTs. Hence, the technique tries to achieve the advantages and avoid the disadvantages of each procedure.

Our technique combines subacromial decompression, acromioplasty, and tuberoplasty with RC reconstruction (Table 1). Thus, it should decrease the incidence of osteoarthritis[37] and anterosuperior instability.[39] Moreover, this technique combines LHBT tenotomy and

tenodesis, so it will prevent the occurrence of the Popeye deformity and pain along the course of the biceps.[45]

Our technique has a short surgical time and allows early postoperative mobilization. Furthermore, it avoids technically demanding tendon transfer procedures, as well as the high complication rates of RTSA.[89]

However, the technique has some limitations, such as the friable macerated LHBT, insufficient length of the LHBT after mobilization, severe RC retraction going up to the glenoid or just medial to it, and glenohumeral osteoarthritis. The risks of the technique include anterior shoulder instability, impingement on the reconstructed RC complex, impingement of the stump of the LHBT within the glenohumeral joint, RC tendon maceration, and excess tension on the LHBT after reconstruction. These risks can be avoided (Table 2).

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