Technical Note

# All-Arthroscopic Muscle Slide and Advancement Technique to Repair Massive Retracted Posterosuperior Rotator Cuff Tears

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**Abstract:** Symptomatic massive posterosuperior rotator cuff tears without glenohumeral joint arthritis and chronic medial retraction often are deemed "irreparable." These patients often are treated with alternative joint-sparing procedures including superior capsular reconstruction or tendon transfer procedures. Open and arthroscopic-assisted muscle advancement techniques allow maximal lateral tendon mobilisation during rotator cuff repair. In this report, we present an all-arthroscopic technique of complete supraspinatus and infraspinatus muscle scapular detachment and advancement in retracted massive posterosuperior rotator cuff tears. This allows for an anatomical tendon footprint reduction and tension-free repair.

The management of patients with symptomatic massive posterosuperior rotator cuff tears (MRCTs) without significant glenohumeral joint arthritis is challenging. Successful surgical repair is preferential to achieve an optimal functional outcome; however, reported retear rates following repair are as high as 80%.[1] Debate in the literature still exists as to the limits of reparability of MRCTs. Published markers indicating "irreparability" of a rotator cuff tear, including chronicity, tendon length and retraction, and muscle fatty infiltration or atrophy help to identify tears where there is a high probability of failure following conventional rotator cuff repair techniques.[2] Increased medial tendon retraction significantly increases the retear rate following repair,[2-4] and if there is retraction to the level of the glenoid, many surgeons would advocate alternative joint-sparing procedures including partial tendon repair, superior capsular reconstruction, or tendon transfers.

Debeyre et al.[5] first described an open acromial osteotomy to allow advancement of the supraspinatus muscle laterally by completely detaching it from its bony attachment on the scapula, allowing a tension-free rotator cuff repair. More recently, arthroscopically assisted open techniques to completely mobilize and laterally advance the supraspinatus and infraspinatus muscles have been described, with improved reported rates of rerupture and functional outcomes scores for retracted MRCTs.[6,7]

We present our all-arthroscopic stepwise technique of rotator cuff muscle mobilization to complete muscle lateral advancement for repair of massive retracted posterosuperior rotator cuff tears. The supraspinatus and infraspinatus muscles are detached from their scapular attachments all the way to the medial border of the scapula, leaving the muscles superficial fascial attachments intact. This allows anatomical reduction of the tendons, complete coverage of the footprint on the greater tuberosity, and a tension-free repair.

## Surgical Technique (With Video Illustration)

This study was approved by Ramsay Health Care QLD Human Research Ethics Committee (RHC QLD HREC), Protocol 19/41, and written consent was provided by all patients for use of all images, radiographic images, and videos included herein.

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*The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

*Received December 9, 2020; accepted February 7, 2021.*

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*2212-6287/201985*

*https://doi.org/10.1016/j.eats.2021.02.009*

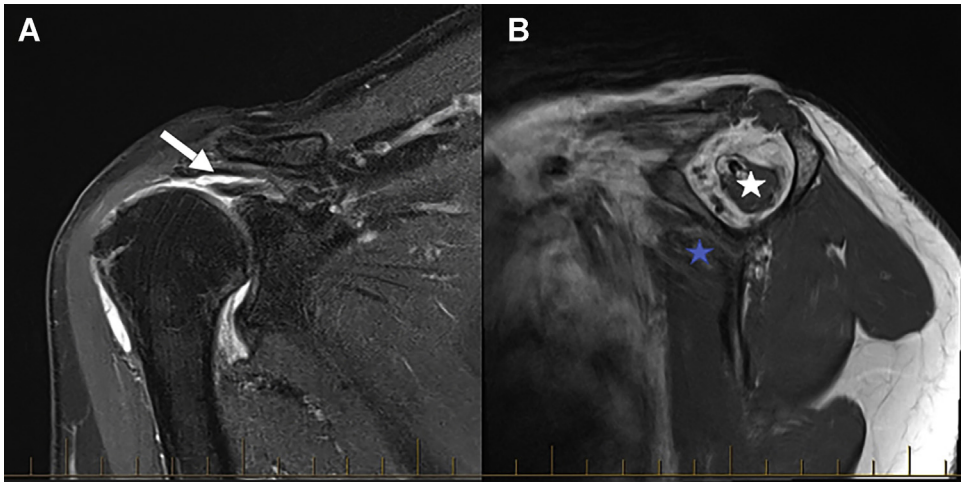


**Fig 1.** (A) Preoperative T2-weighted coronal MRI scan of a right shoulder demonstrating a supraspinatus tendon tear retracted to the level of the glenoid (end of tendon indicated by white arrow). (B) Preoperative T1-weighted sagittal MRI demonstrating grade 3 fatty infiltration of the supraspinatus (white star) and grade 1 fatty infiltration of the infraspinatus (blue star). (MRI, magnetic resonance imaging.)

## Indications and Setup

Our technique of muscle advancement and rotator cuff repair is primarily indicated in a relatively young and active patient with retracted supraspinatus and/or infraspinatus tendon tears that cannot be reduced to their anatomical footprint on the greater tuberosity by conventional means. This is similar to the indications proposed for a superior capsular reconstruction and latissimus dorsi or lower trapezius tendon transfer. Tears that are retracted to the level of the glenoid can be safely mobilized and repaired to their anatomical footprint under minimal tension (Fig 1 A and B). Relative contraindications to muscle advancement and tendon repair include static proximal humeral head migration with pseudoparalysis of the shoulder and revision rotator cuff tear with a short tendon stump length (<15 mm).

Under general anaesthesia with an interscalene block, the patient is placed in a beach-chair position using an open-backed shoulder positioner table attachment with head support (T-Max; Smith & Nephew, Andover, MA). The involved extremity is placed in a pneumatic arm holder (SPIDER2; Smith & Nephew). Surgical preparation to the midline posteriorly is performed and draping of the entire ipsilateral half of the back allows easy access to the medial border of the scapula (Fig 2 A and B).

A low arthroscopic pump pressure is maintained to minimize soft-tissue swelling while allowing

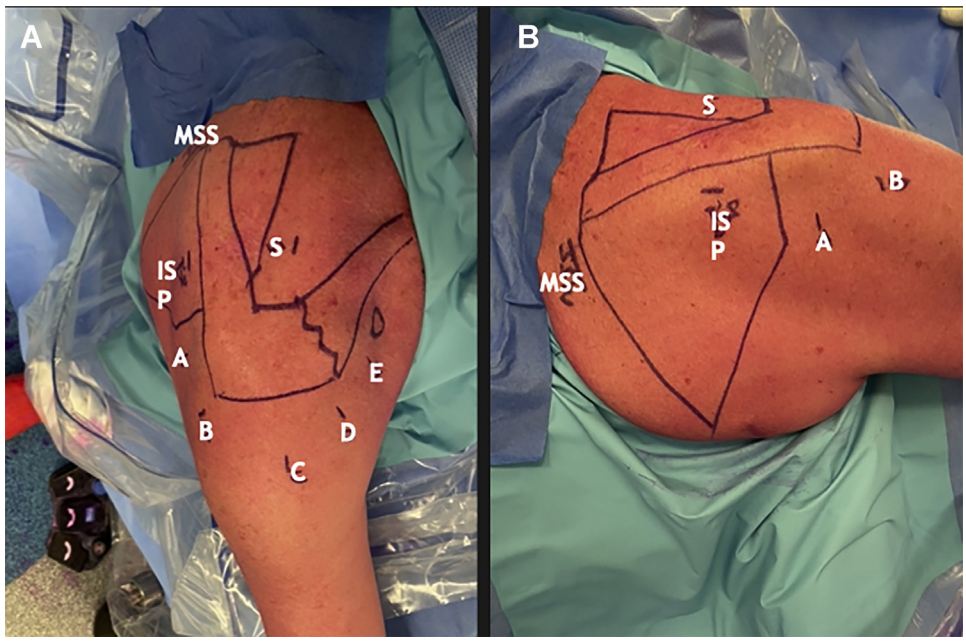


**Fig 2.** To perform an all-arthroscopic muscle advancement of a retracted posterosuperior rotator cuff tear, the patient is positioned in beach chair position using an open-backed shoulder positioner table attachment and draped allowing surgical access to the midline posteriorly. (A) Superior view of the right shoulder demonstrating surface anatomy and arthroscopy portals used (Typical portals used include A, B, C, D, E, S, ISP and MSS portals). (B) View of the posterior shoulder surface anatomy and arthroscopy portals used. The medial scapular spine (MSS) portal is made 2 cm medial to the medial angle of the scapular spine allowing detachment of the medial insertion of both the supraspinatus and infraspinatus muscles to facilitate maximal lateral excursion of each tendon.

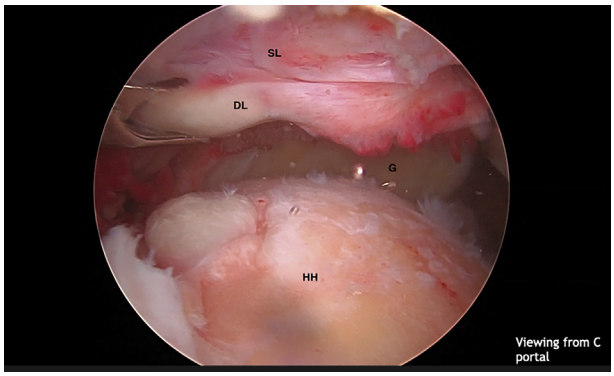


**Fig 3.** Arthroscopic image of a right shoulder viewing from the C portal demonstrating a retracted tear of the posterosuperior rotator cuff tendons (supraspinatus and infraspinatus) to the level of the glenoid. The deep layer and superficial layer of the supraspinatus tendon are defined and the mobility of the tendon for repair to its humeral footprint is assessed using an. arthroscopic grasper. Here, the tendon cannot be reduced to the humeral head. (DL, deep layer; G, glenoid; HH, humeral head; SL, superficial layer.)

arthroscopic visualization. Bleeding is reduced by adding 1 gram of adrenaline to each bag of arthroscopic fluid and INVOS (Medtronic, Minneapolis, MN) cerebral perfusion monitoring is applied to allow a safe, low systolic blood pressure throughout.

## Diagnostic Arthroscopy, Subacromial Decompression, Acromioclavicular Joint Excision, and Management of Long Head of Biceps or Subscapularis Tendon Pathology

We use a 30° angled arthroscope throughout the procedure. Arthroscopic portals used are indicated in Figure 2 A and B. From the C portal, the subacromial bursa is accessed and subacromial bursectomy is performed, instrumenting through a posterior portal (A). The coracoacromial ligament is released from the anterior acromion medially to the acromioclavicular joint and an acromioplasty is performed for access. Working through the E portal, the acromioclavicular joint is typically excised to allow dissection medially to the supraspinous fossa. The remainder of the coracoacromial ligament is debrided to identify the coracoid process and define the conjoint tendon anteriorly. The brachial plexus is identified anterior to the subscapularis muscle and care is taken not to debride medially to the coracoid process to avoid injury. The rotator interval tissue and coracohumeral ligament is excised to identify the anterior edge of the supraspinatus tendon.

Our preference is to perform long head of biceps tenodesis in the bicipital groove using 1 or 2 all-suture anchors (2.9-mm, Juggerknot; Zimmer Biomet, Warsaw, IN) as an onlay technique, securing the tendon using multiple lasso loops. Partial- or full-thickness subscapularis tears are repaired.

**Table 1.** Sequential Steps of Supraspinatus and Infraspinatus Muscle Releases and Advancement

| | |
|---|---|
| Step 1 | Suprascapular nerve identification and release in the suprascapular notch |
| Step 2 | Intra-articular releases |
| Step 3 | Supraspinatus muscle release from supraspinous fossa |
| Step 4 | Infraspinatus muscle release from infraspinous fossa |
| Step 5 | Release of medial scapular insertion of supraspinatus and infraspinatus muscles and lateral muscle advancement |

## Assessment of the Supraspinatus and Infraspinatus Tendons

Debridement of abnormal supraspinatus and infraspinatus tendon back to healthy tendon is performed. Care is then taken to define the deep and superficial delaminated layers, as each layer needs to be reduced and fixed within the repair construct (Fig 3).

An arthroscopic grasper is used to assess mobility of the retracted tendons and a spectrum of sequential releases are performed arthroscopically, assessing tendon mobility and the need for further, more extensive muscles releases and advancement after each step.

## Supraspinatus and Infraspinatus Muscles Release and Advancement

Five sequential steps are performed depending on the degree of tendon retraction (Table 1).

### Step 1: Suprascapular Nerve Identification and Release

Tension-free release of the supraspinatus and infraspinatus muscles from their respective scapular fossae requires identification of the suprascapular neurovascular pedicle and suprascapular nerve (SSN) release at the suprascapular notch to prevent traction injury

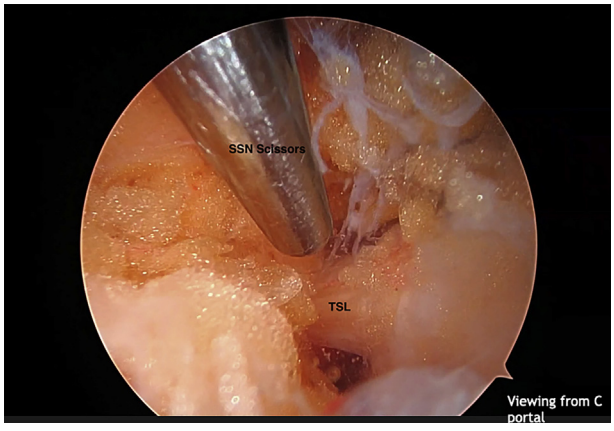


**Fig 4.** Arthroscopic image of a right shoulder viewing from the C portal. While one is performing lateral advancement of the posterosuperior rotator cuff muscles to repair a retracted tear, an SSN release is performed to prevent traction injury to the nerve. First, the suprascapular nerve scissors (SSN scissors) are introduced from the S portal and the TSL is identified. The suprascapular nerve is found under the TSL. (SSN, suprascapular nerve; TSL, transverse scapular ligament.)

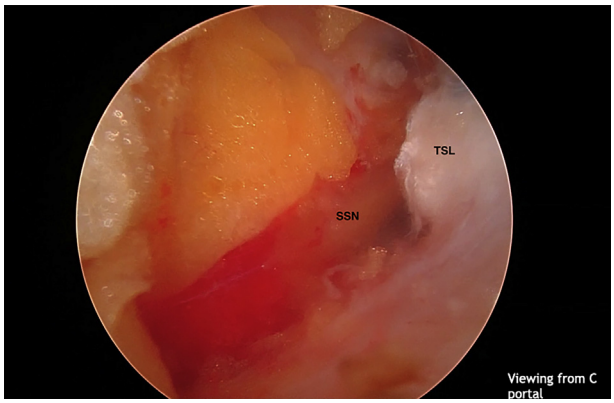


**Fig 5.** Arthroscopic image of a right shoulder viewing from the C portal after release of the SSN. The SSN scissors are introduced through the S portal and positioned under the TSL. The TSL is then released using the SSN scissors to free the SSN and vessel. (SSN, suprascapular nerve; TSL, transverse scapular ligament.)

when advancing the supraspinatus muscle laterally.[8] Under direct vision, the S portal is established immediately superior to the scapular spine in line with the suprascapular notch, allowing retraction of the supraspinatus muscle and identification of the SSN and adjacent vascular structures. Medial to the coracoclavicular ligaments the transverse scapular ligament is identified at the suprascapular notch (Fig 4). Suprascapular nerve scissors (DePuy Mitek, Raynham, MA) are inserted through the S portal and used to cut the transverse ligament, freeing the SSN and vessel (Fig 5). The SSN is then followed and identified as it passes distal to the spinoglenoid notch.

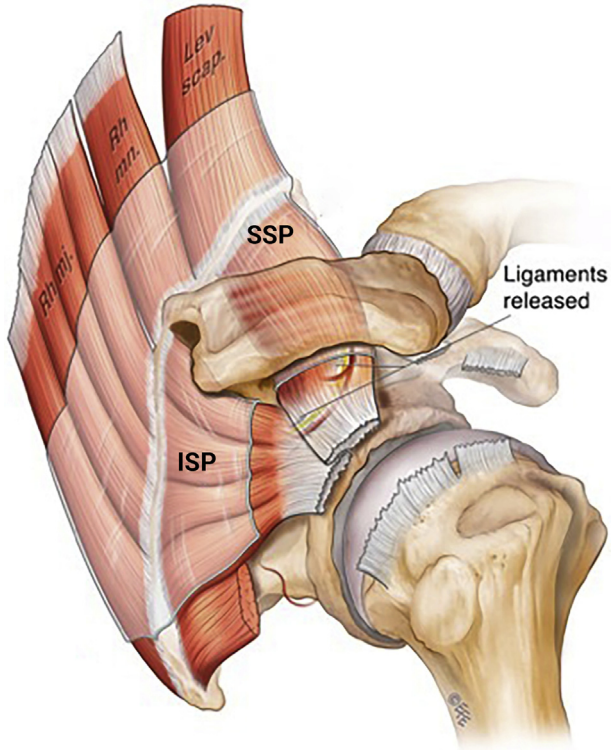


**Fig 6.** Illustration of a right shoulder demonstrating the interval between the supraspinatus (SSP) and infraspinatus (ISP) tendons that is identified just lateral to the scapular spine. The SSN and vessel are found under the musculotendinous junction at this point and protected before elevation of the SSP and ISP muscles from their respective scapular fossae. (SSN, suprascapular nerve.)

### Step 2: Intra-Articular Releases

Viewing through the C portal and interchangeably using a soft tissue shaver and radiofrequency coblation through D and posterolateral (B) portals, tissue between the anterior edge of the supraspinatus and the coracoid is released (ensuring excision of the coracohumeral ligament). Capsular attachments underneath the supraspinatus and infraspinatus tendons are released from the glenoid. Typically, the tissue peels off the superior glenoid before reaching the supraglenoid tubercle. The downslope of the tubercle houses the SSN in a pad of fat; care is taken not to injure the nerve. A complete 360° capsulotomy is performed to allow mobilization of the humeral head as often the inferior capsular contracture accompanies a longstanding cuff tendon rupture. The labrum is left attached to the glenoid rim.

### Step 3: Supraspinatus Muscle Release From Supraspinatus Fossa

Bursal tissue overlying the supraspinatus and infraspinatus muscles is removed to identify the scapular spine and the interval between these muscles (Fig 6). Under direct vision, the supraspinatus muscle is elevated from the supraspinatus fossa. Viewing from

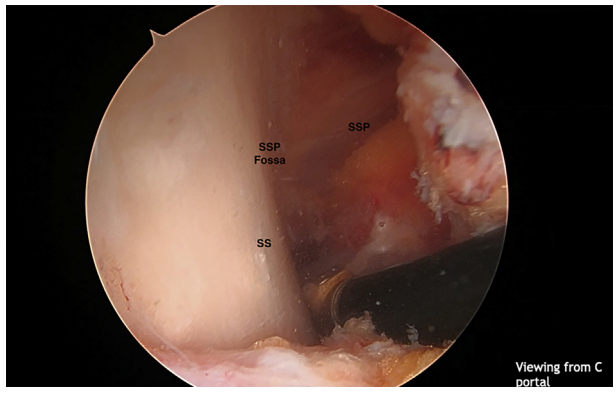


**Fig 7.** Viewing medially from the lateral C portal in a right shoulder, the supraspinatus muscle is elevated sharply from its bony fossa on the scapula to facilitate lateral tendon advancement. A coblator is introduced through the D portal and slid down the scapular spine under the supraspinatus to elevate the muscle. A separate retractor is introduced through the S. portal retracting the supraspinatus muscle (not in view). (SS, scapular spine; SSP, supraspinatus; SSP fossa, supraspinatus fossa.)

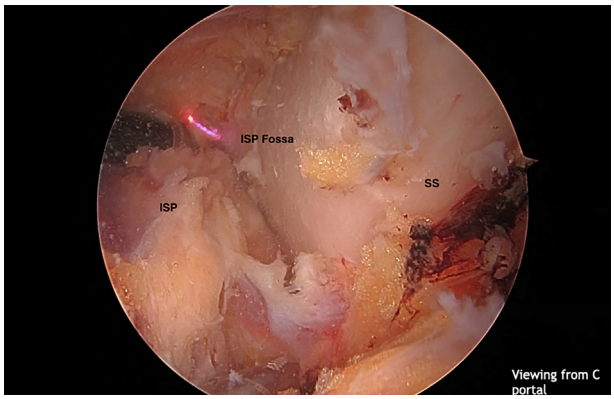


**Fig 8.** In a right shoulder viewing medially from the lateral C portal, the infraspinatus muscle is elevated sharply from its bony fossa on the scapula. A coblator is introduced through the ISP portal and slid down the scapular spine from above to elevate the infraspinatus muscle. (ISP, infraspinatus; ISP fossa, infraspinatus fossa; SS, scapular spine.)

the C portal and using the D and S portals interchangeably to instrument and retract, the muscle is peeled of the bone sharply using a labral elevator, Cobb elevator or coblation. Typically, the instrument is slid down the scapular spine into the fossa under the muscle, freeing it along its length (Fig 7). A second labral elevator from an anterior percutaneous portal helps retract the released supraspinatus muscle and keep the muscle under a degree of tension allowing a cleavage plane to be created to elevate the muscle off its bony origin.

### Step 4: Infraspinatus Muscle Release From Infraspinatus Fossa

The same technique is then performed to release the infraspinatus muscle from its fossa, this time viewing from the C portal and instrumenting through the A, B, and ISP portals. An additional ISP portal is created 7 cm medial to the posterior Acromial tip. This is the working portal for the infraspinatus muscle release. An elevator or coblator is slid down the inferior aspect of the scapular spine under the infraspinatus muscle liberating it off the bone (Fig 8).

After steps 1-4 are completed, tension-free tendon excursion and coverage of the cuff footprint is evaluated. If sufficient tension free length is attained no further releases are required. However, if the cuff cannot be restored to the footprint further releases are performed.

### Step 5: Release of Medial Scapular Insertion of Supraspinatus and Infraspinatus Muscles and Lateral Muscle Advancement

Complete release of the supraspinatus and infraspinatus muscles from their medial scapular attachments is performed, leaving the superficial attachments of each muscle to overlying rhomboids and deltoid fascia. A vertical 2-cm portal is made just medial to the medial angle of the scapular spine (the medial scapular spine portal) (Fig 9). Care is taken not to go more medial to avoid injury to the spinal accessory nerve, typically found 4 cm medial to this point. A Cobb elevator is used to bluntly dissect and completely free the supraspinatus medial attachment superior to the scapular spine and infraspinatus inferior to the spine (Fig 10A). Leaving only the superficial fascial attachments intact, the supraspinatus and infraspinatus

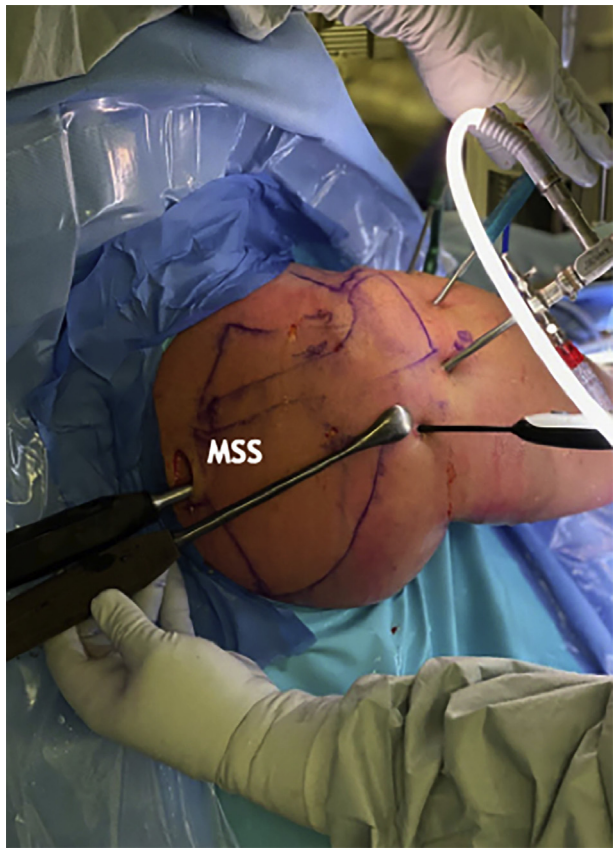


**Fig 9.** Posterior view of a right shoulder. To facilitate maximum lateral excursion of the supraspinatus and infraspinatus tendons allowing a tension-free rotator cuff repair, the medial attachment of each muscle is released from the medial border of the scapula. The medial scapular spine (MSS) portal is created making a 2-cm vertical incision medial to the medial angle of the scapular spine. The portal is made no more than 2 cm medial to the medial angle to avoid injury to the spinal accessory nerve, typically found 4 cm medial to the medial angle. From this portal, a Cobb elevator can be inserted to bluntly dissect off the medial attachment of the supraspinatus muscle superior to the scapular spine and the medial attachment of the infraspinatus muscle inferior to the scapular spine. Here, the Cobb elevator has been introduced laterally under the infraspinatus muscle to ensure a full release from the bony fossa.

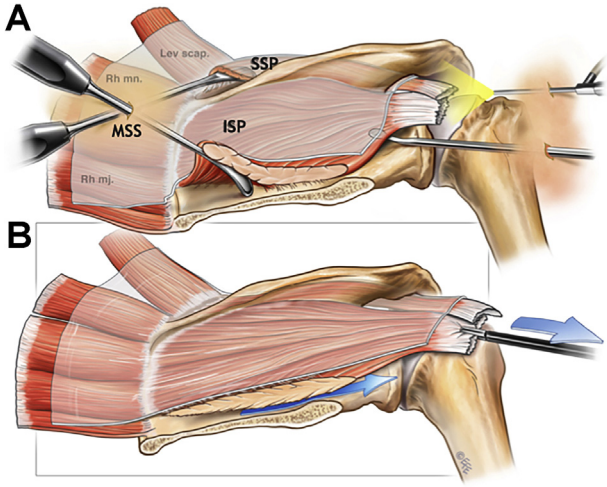


**Fig 10.** (A) Drawing of the posterior scapula in a right shoulder showing full elevation of the supraspinatus (SSP) and infraspinatus (ISP) muscles from the scapula using a Cobb elevator through the medial scapular spine (MSS) portal. (B) The superficial fascial attachments of the supraspinatus and infraspinatus muscles are left intact and the muscles can then be advanced laterally up to 4 to 5 cm, facilitating a tension-free rotator cuff repair in the presence of a retracted posterosuperior tear.

muscles can then be advanced laterally up to 4 to 5 cm (Fig 10B).

### Rotator Cuff Repair

Following muscle release and advancement, a double-row rotator cuff repair is performed. Typically, 2 or 3 medial row anchors are inserted just lateral to the humeral articular cartilage (5.5-mm PEEK Quattro X; Zimmer Biomet). Sutures are passed through the deep layer using a Lasso loop technique[10] (Fig 11A), as well as the superficial layer and tied medially. Sutures from the medial anchors are then taken to 2 lateral anchors (5.5-mm PEEK Quattro Link Knotless; Zimmer Biomet), using a suture bridge configuration to compress the tendons to the anatomical footprint on the greater tuberosity (Fig 11B and 12 A and B).

### Postoperative Rehabilitation

The patient is placed into a brace with 60° of abduction for 8 weeks (Ottobock; 50A10 Omo Immobil, Duderstadt, Germany) and begins our standardized rotator cuff repair rehabilitation programme under physiotherapist supervision.

## Discussion

MRCTs are associated with progressive muscle hypotrophy and medial tendon retraction over time. Anatomical tendon reduction may not be possible or result in increased tension at the repair site using traditional rotator cuff repair techniques, and the literature shows that chronic medial retraction and

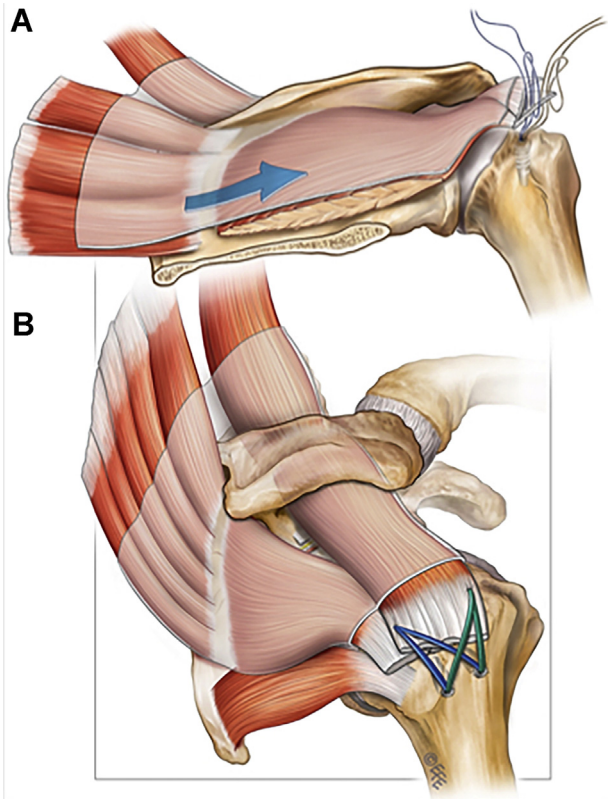


**Fig 11.** Drawing of a right shoulder demonstrating a double row rotator cuff repair following lateral muscle advancement. (A) Sutures are passed through the deep tendon layer using a Lasso loop technique, as well as the superficial layer and tied medially. (B) Sutures are then taken laterally using a suture bridge configuration to a lateral row of knotless anchors.

increased tension at the repair site significantly increase the risk of rerupture following tendon repair.[2-4,11] Shin et al.[3] found an overall retear rate of 58% in 83 patients undergoing supraspinatus repair and within the retear group there was a significant increase in mean preoperative tendon retraction of 20.4 mm compared with 11.7 mm in the intact repair group. For this reason, many proponents of alternative joint-sparing modalities to manage MRCTs, such as tendon transfers or superior capsular reconstruction, consider patients with tendon retraction to the level of the glenoid to have a functionally irreparable tear.[9]

The concept of releasing the entire supraspinatus muscle attachment from the scapula and advancing the muscle laterally was first proposed by Debeyre et al.[5] in 1965. However, they described an invasive open approach by performing an acromial osteotomy and there was a high rate of osteotomy nonunion reported. More recently, arthroscopically assisted techniques of muscle advancement of the posterosuperior cuff have been reported with low failure rates and significant functional improvements.[6,7] Morihara et al.[6] performed an arthroscopic-assisted muscle advancement in 34

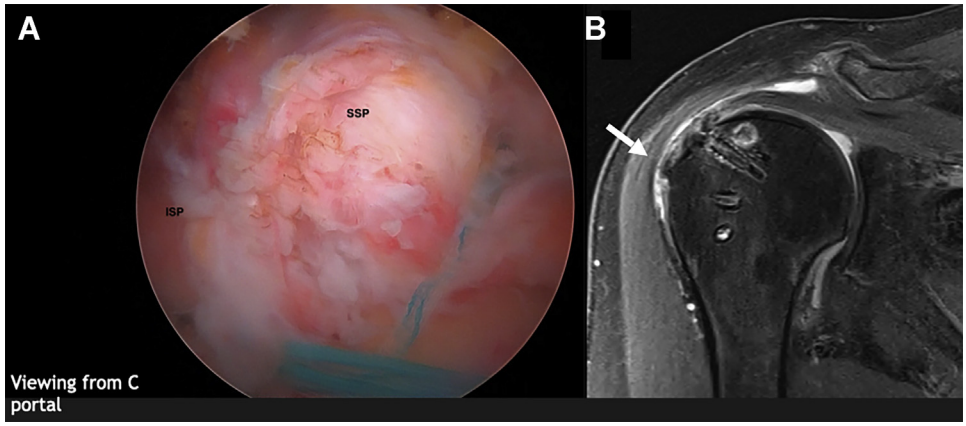


**Fig 12.** (A) Arthroscopic view of a right shoulder viewing through the C portal. Following lateral muscle advancement, the supraspinatus (SSP) and infraspinatus (ISP) tendons have been reduced over their anatomical footprint on the greater tuberosity and repaired. (B) Six-month postoperative T2-weighted coronal right shoulder magnetic resonance imaigng scan of the same patient shown in Figure 1, demonstrating healing of the supraspinatus tendon over its anatomical footprint (white arrow).

patients with MRCTs retracted to the level of the glenoid or further. At 2 years' follow-up, magnetic resonance imaging showed that 77% of tears were healed and there was a significant improvement in functional scores, with a mean Constant–Murley score of 70.8 for intact repairs.[6] Another recent study compared standard repair with an arthroscopically assisted muscle advancement in 47 patients with MRCTs. A significantly lower failure rate was reported in the muscle advancement group compared with standard repair (23.1% and 52.4%, respectively), as well as a significantly greater abduction strength in the muscle advancement group.[7]

Using our stepwise, all-arthroscopic technique the mobility of the tendons is assessed after each set of releases and progression to the next step is performed as necessary. By releasing the supraspinatus and infraspinatus muscles entirely from their scapular attachments and advancing the muscles laterally, we have been able to increase the lateral excursion of the torn tendons by 4 to 5 cm. This allows anatomical reduction and a tension-free repair of MRCTs with retraction to beyond the level of the glenoid, thus improving the potential for successful repair healing. For MRCTs, we feel it is important to identify the superficial and deep delaminated layers. Our technique of muscle advancement allows tension-free reduction of both these layers and we repair the deep layer using a Lasso loop technique.[10] The procedure is performed using an all-arthroscopic approach.

There are certain limitations to the use of this technique (Table 2). It requires advanced shoulder arthroscopy experience and knowledge of the relevant anatomy. Our contraindications to muscle advancement and tendon repair include static proximal humeral head migration with pseudoparalysis of the shoulder, moderate-to-advanced glenohumeral joint arthritis or previous failed MRCT repair with short tendon length.

Potential complications include scapula fracture during muscle elevation. The SSN must be identified and released at the suprascapular notch to prevent the risk of traction injury during lateral muscle advancement. There is also risk of injury to the spinal accessory nerve, but this is minimized by placing the medial scapular spine portal no more than 2 cm medial to the medial scapular angle.

There may be concerns over the biomechanical effects of fully releasing the rotator cuff muscles from their scapular attachments; however, our observation has been a good return of muscle power postoperatively. Fascial attachments to the overlying rhomboids and deltoid fascia are left intact, and presumed scarring and healing of muscle back to scapula fossa occurs. This is

**Table 2.** Advantages and Disadvantages of Performing All-Arthroscopic Muscle Advancement and Tension-Free Anatomical Rotator Cuff Repair

| Advantages | Disadvantages |
|---|---|
| • Tension-free anatomical repair of retracted MRCTs, improving potential for healing | • Requires advanced arthroscopic skills and knowledge of arthroscopic shoulder anatomy |
| • Healed tendon repair maximises clinical outcomes | • Risk of injury to SSN and spinal accessory nerves |
| • All-arthroscopic technique | • Risk of scapula fracture during muscle elevation |
| • Avoids other nonanatomic joint-sparing procedures, such as superior capsular reconstruction or tendon transfers | • Contraindicated in presence of static proximal humeral head migration, moderate to advanced glenohumeral arthritis or revision rotator cuff repair with short tendon length |

MRCTs, massive posterosuperior rotator cuff tears; SSN, suprascapular nerve.

akin to performing a Judet approach to address scapular fractures.

Our all-arthroscopic technique of muscle advancement allows anatomical reduction and a tension-free repair of chronic posterosuperior MRCTs with retraction up to and beyond the level of the glenoid. We believe that this will improve the rate of successful repair healing in this challenging group of patients, whom would often be deemed to have irreparable tears and offered alternative joint-sparing options.

## Acknowledgments

We thank Dr. Levente Efe for creating the artistic images and licensing the use in our article

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