Technical Note

Arthroscopic Extreme Medialized Repair for Massive Rotator Cuff Tear: Resection of Cartilage and Subchondral Bone Over the Top of the Humeral Head

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Abstract: Rotator cuff repair is a widely performed surgery. Its purpose is to improve shoulder function, fix tendons to bones, restore anatomical structure, and prevent the progression of rotator cuff tear arthropathy and associated muscle degeneration. However, in large and massive tears, the tension imposed during repair becomes too high. Medialized repairs have been reported for cases of rotator cuff tear, but they are difficult to perform. We report on ex-medialization that used common portals and instruments to remove the osteochondral and subchondral bone, reduce humeral head volume, and suture the tendon extremely medially. Compared to a common medialized repair, this procedure reduces tension on the rotator cuff to be sutured. The goal of this technique is to restore functional anatomy, reduce the rate of retear, prevent the progression of rotator cuff muscle atrophy and fatty degeneration, and to improve muscle strength by allowing the repair of rotator cuff tears (Goutallier grade 2 or higher) to the humeral head, which have conventionally been challenging.

Introduction

Massive rotator cuff tears are reported to occur in 40% of all rotator cuff tears.[1] In addition, the rate of retear after surgery is high, and recovery of functional anatomy is difficult in some cases.[2-5] Therefore, alternative procedures have been previously described in the literature.[6-10] However, these procedures fall short when it comes to adequately restoring anatomical reconstruction and have the potential to lead to progressive muscle atrophy of the rotator cuff that is not repaired to the humeral head. Moreover, these procedures are both highly invasive and complex. We propose ex-medialization as a viable option for large and massive tears that are difficult to repair to a footprint, cases of retear, and rotator cuff tears of Goutallier grade 2 or higher. Ex-medialization includes two important features: 1) resection of the upper part of the humeral head enables a reduction of the volume, thereby, facilitating the upward lifting of anterior and posterior rotator cuff tendons, and 2) extreme medialized repair can be performed by placing anchors on the innermost surface of the greatly reduced upper surface of the humeral head to reduce tension on the repaired tendon. These two features enable the repair of rotator cuff tears that were previously difficult to suture. Suturing all tendons to the humeral head prevents the progression of muscle atrophy and fatty degeneration of the rotator cuff muscles. (Fig 1, Video 1).

All study participants provided informed consent, and the study design was approved by an ethics review board. The identity of the patients has been protected.

Surgical Technique

Diagnostic Arthroscopy and Intra-Articular Debridement

With the patient in the lateral position, the arm is tractioned with a 4-kg weight in ~30° of flexion and 40° of abduction. Through the posterior portal, the condition of the articular cartilage, rotator cuff tears,

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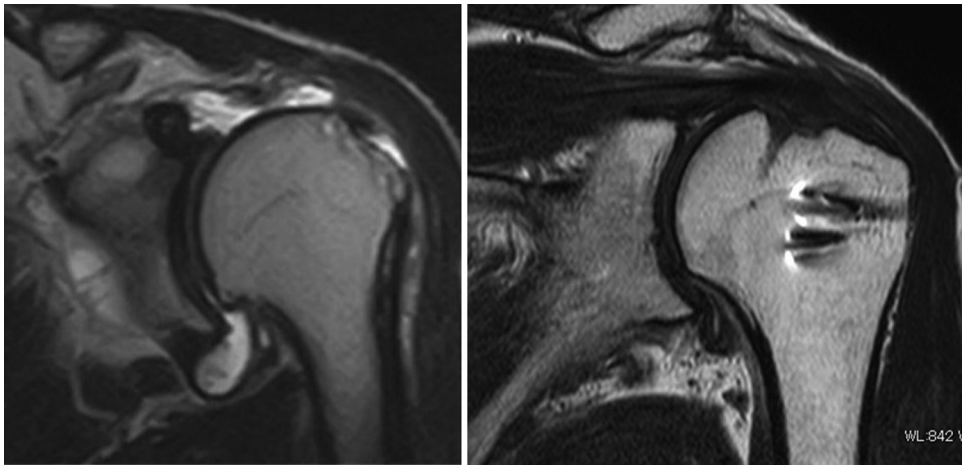

Fig 1. Coronal T2-Weighted Magnetic resonance imaging of the left shoulder before and after the ex-medialization procedure. Left: before surgery; right: after surgery.

and biceps tendon are assessed (Fig 2, portal). Mobility and the extent of the rotator cuff tear are confirmed. The area between the deep layer of the rotator cuff and the joint capsule should be released. The coracohumeral ligament should also be released. Additionally, the circumference of the coracoid process, and the rotator interval should be released. If the labrum is thickened or avulsed, it is removed. In older patients and/or in the presence of a degenerative biceps tendon, a tenotomy is indicated. Generally, a tenodesis is performed in patients <50 years.

Acromioplasty and Release of the Rotator Cuff

The subacromial bursa is viewed through the posterior portal. Subsequently, the coraco-acromial ligament is detached using electrocautery from the anterolateral portal. Then, the position of field of view is changed to a posterior lateral aspect, and the bone spur of the acromion is resected using a burr. If necessary, release of the subacromial bursa, periarticular bursa, and adhesions on the superior surface of the rotator cuff are performed with an electrocautery and shaver. Furthermore, the coracohumeral ligament and peri-coracoid process are also released. The junction between the supraspinatus and subscapularis tendons remains preserved, while the detachment is performed (Fig 3). If the rotator cuff can be repaired at the greater tuberosity, the usual suture technique is performed. If not, preparation should be made to perform an ex-medialization.

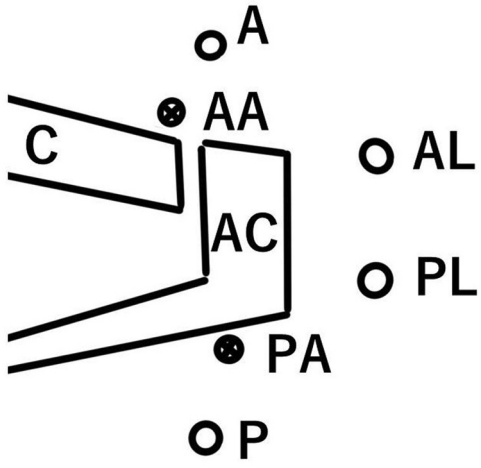

Fig 2. Portal placement for right shoulder viewed from above. AA, anterior anchor portal; AC, acromion; A, anterior portal; AL, anterolateral portal; C, clavicle; P, posterior portal; PL, posterolateral portal; PA, posterior anchor portal.

Resection of the Upper Part of the Humeral Head

Resection of the bone from the upper surface of the humeral head is performed using a burr or chisel (Fig 4, A and B). The cartilage and bone of the humeral head are resected at the thickest (~5−10 mm) point at the top of the humeral head. The cancellous bone is completely exposed. Because the medial cartilage is difficult to remove in the abduction position, the arm is placed in adduction. If the outer corner of the greater tuberosity is shaved too much, the threads may become embedded in the bone when performing the suture bridge procedure. After resection, the greater tuberosity is often shaved to at least 3 cm medial to the lateral edge (Fig 4, A and B). Shaving reduces the size of the humeral head, in addition to improving the downward view of the subscapularis and infraspinatus tendons (Fig. 4, C and D). We have attempted to reduce the rotator cuff again. Ensure that the rotator cuff can be securely placed and sutured to the area where the bone was resected. Even if the supraspinatus tendon is still difficult to repair, it can be sutured to the humeral head by raising the infraspinatus and subscapularis tendons (Fig 5).

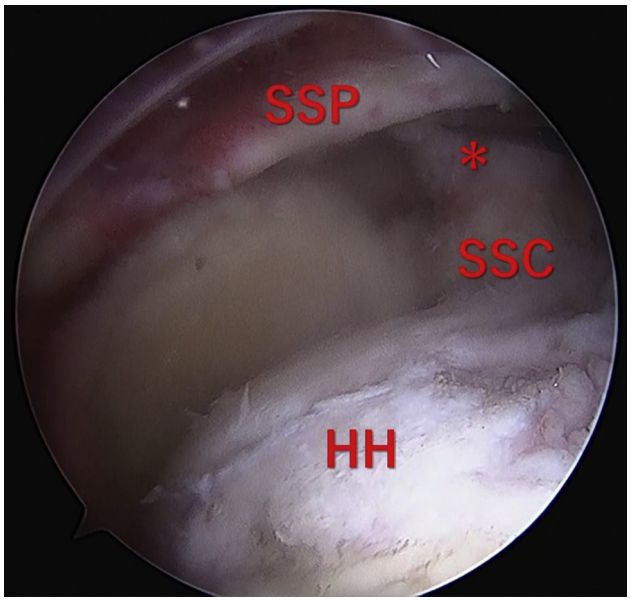

Fig 3. The junction between the supraspinatus and subscapularis tendons of the right shoulder from posterolateral view. HH: humeral head; SSC: subscapularis; SSP: supraspinatus. The asterisk (*) denotes the junction between the SSP and the infraspinatus.

Insertion of Suture Anchor

Anchors are inserted into the medial margin of the medialized footprint (subchondral bone area). Anchors are then inserted in the area of the humeral head where the cancellous bone is exposed. The portals, into which anchors are inserted, are specifically placed, and include an anterior clavicle portal and a posterior superior portal (Fig 2). The anterior anchor is easier to insert using the anterior clavicle portal, while the posterior anchor is easier to insert using the posterior superior portal. It should be noted that the central anchor is the most difficult to insert; therefore, it should be inserted by adjusting the position of the arm for rotation. If a screw-type anchor is challenging to insert, insertion is made easier by using a metal guided anchor (Iconix 2.3; Stryker, San Jose, CA).

Tendon Repair and Suture Bridge

Sutures are passed through the rotator cuff using a suture grasper EXPRESSEW III Flexible Suture Passer (DePuy Mitek, Raynham, MA). The key is to identify the deep layers of the rotator cuff that are retracting inward and pass the suture through both the superficial and deep layers. From our experience, lifting the

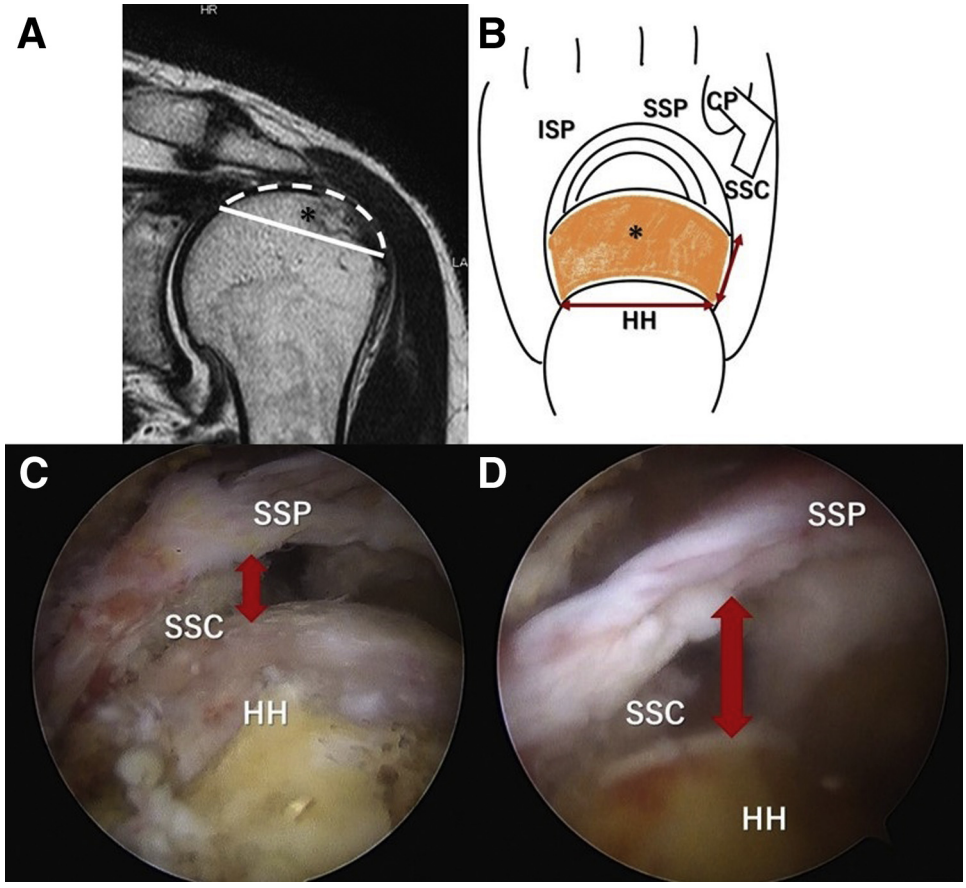

Fig 4. Depiction of the shaving area of the humeral head for extreme medialization. After shaving, improvement of the downward view of SSC. (A) Coronal T2-weighted magnetic resonance imaging of the shaving area of the left shoulder. (B) Shaving area of the right shoulder from the lateral view. (C) Before shaving view of the left shoulder from the posterolateral portal. (D) After shaving view of the left shoulder from the posterolateral portal. CP, coracoid process; HH, humeral head; ISP, infraspinatus; SSC, subscapularis; SSP, supraspinatus. An asterisk (*) denotes the shaving area.

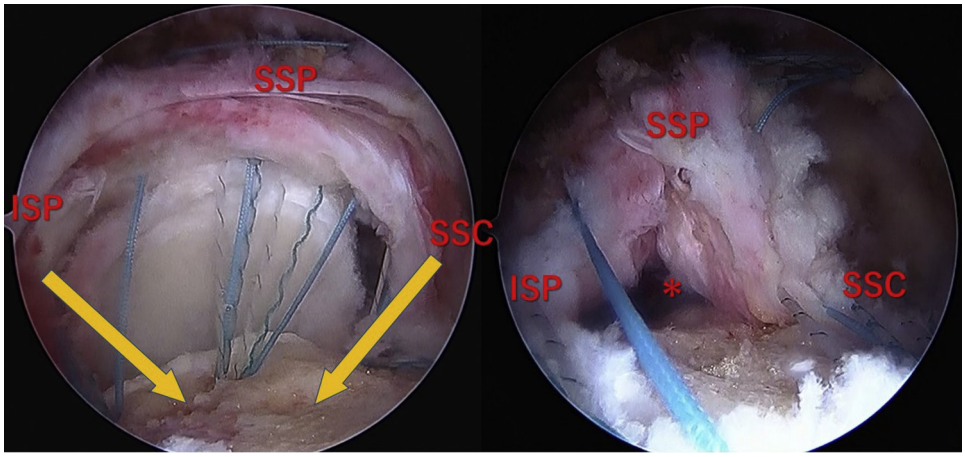

Fig 5. Image of the right shoulder from posterolateral view during suturing. Suture the infraspinatus tendon and subscapularis tendon first, lifting each above the humeral head. In this way, the supraspinatus tendon is loosened and easy to suture. Left: Before suturing; right: after suturing of SSC and ISP. ISP, infraspinatus; SSC: subscapularis; SSP, supraspinatus. An asterisk (*) denotes loosened SSP.

superficial layer will almost always reveal a deep layer that is retracted. The most anterior and most posterior 1−3 threads may be passed through the superficial layer only. The threads are placed about 5 mm apart. Once all anchor threads have been passed, the suture bridge technique is performed, using two or three anchors if the tendon can be easily reattached to the medialized footprint. If the supraspinatus tendon is particularly inflexible, suture the infraspinatus tendon and subscapularis tendon first, while lifting each above the humeral head. In this way, the supraspinatus tendon is loosened, which allows it to be lifted, making it easier to repair (Fig. 5). In many cases, the ends of the sutured tendon do not completely cover the greater tuberosity because they are medialized and sutured (Fig 6). The postoperative MR image shows tissues that are continuous with the repaired rotator cuff in the area of the greater tuberosity that is not covered by the tendon.

Postoperative Protocol

Postoperatively, the shoulder is immobilized in a sling with an abduction pillow for 5−6 weeks. Passive rehabilitation begins 2 weeks after surgery, and active rehabilitation begins 7−8 weeks after surgery. Holding heavy objects and participating in sports can be initiated at 6 months postoperatively. We have performed this procedure countless times, and it has not resulted in a significantly limited range of motion, while ADL improved to a level of no interference (Fig 7). The pearls and pitfalls of the ex-medialization technique are shown in Table 1, and advantages and disadvantages are listed in Table 2.

Discussion

The advantages of ex-medialization are as follows: It is a simple procedure that can be performed using the same techniques and tools used in general arthroscopic rotator cuff repair. It allows for a wider range of surgical indications than conventional medialized repair and can be performed in the majority of cases. It also prevents the progression of rotator cuff tears and fatty degeneration of the rotator cuff muscles because the repair is more anatomically similar. Numerous studies

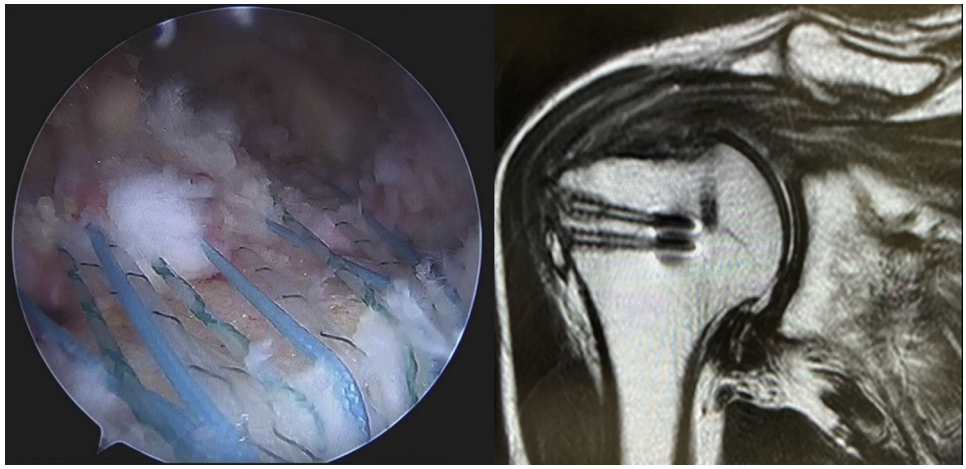

Fig 6. Left: Image of the right shoulder from posterolateral view after surgery. The ends of the sutured tendon do not completely cover the greater tuberosity. Right: Coronal T2-weighted magnetic resonance image of the right shoulder at 6 months postoperatively showing the rotator cuff covering the greater tuberosity.

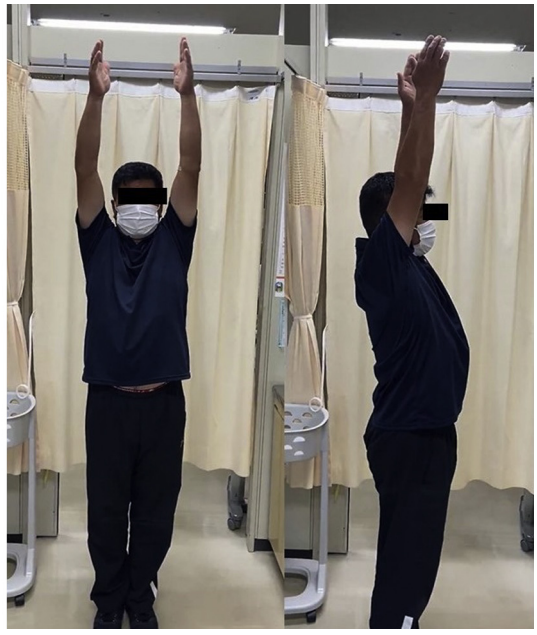

Fig 7. Image and ROM at two years postoperatively of the right shoulder. Left: Coronal T2-weighted magnetic resonance image. Right: Elevation angle of the shoulder.

have reported simple tension-free repair using the arthroscopic method of footprint medialization.[11-14] Our method reduces the tension on the rotator cuff by performing an extreme medialized repair. Furthermore, by reducing the size of the humeral head, we can raise the anterior and posterior tendons above the humeral head and reduce the tension on the supraspinatus tendon suture. This enables repair of rotator cuffs, which have previously been considered irreparable, owing to more progressive tendon retraction and fatty degeneration of the muscle.

Table 1. Pearls and Pitfalls of the Ex-Medialization Technique

Pearls
• It is necessary to release the coraco-humeral ligament between the rotator cuff and the joint capsule to increase the mobility of the tendon.
• Release of the coraco-acromial ligament and acromioplasty should be performed on Bigliani type 2 or 3 acromion.
• Extensive resection of the cartilage and subchondral bone of the humeral head is required to reduce the volume of the humeral head.
• The deep layer of the torn tendon needs to be located and threaded along with the superficial layer.
• If the supraspinatus tendon is still difficult to suture, it is easier to first suture the subscapularis and infraspinatus tendons by lifting them to the top of the humeral head, and then suture the supraspinatus tendon.
• The repaired tendon does not need to cover the entire greater tuberosity.
Pitfalls
• If the rotator cuff cannot be extracted beyond the glenoid fossa after a rotator cuff release, it cannot be repaired, and another technique must be performed.
• The patient should use an abduction sling to immobilize the shoulder postoperatively.

Ex-medialization is superior to partial repair, as complete repair of the rotator cuff is expected. It is superior to femoral fascia transfer and superior capsular reconstruction, as there are no problems with harvesting and using the transferred tendon, no fear of rupture of the transferred tendon, and it is closer to anatomical reconstruction. It is less invasive than reverse arthroplasty, and there is less risk of infection and revision. It is also less invasive than latissimus dorsi transfer and is more open to possibilities for anatomical reconstruction. The disadvantage is the reported limited range of motion; medialization of the supraspinatus tendon footprint by >10 mm decreased shoulder range of motion in cadaveric studies.[15-17] However, so far, our results have not demonstrated any such extreme

Table 2. Advantages and Disadvantages of the Ex-Medialization Method

Advantages
Simple technique using common portals and instruments
Decreasing the volume of the humeral head allows for better visibility of the anterior and posterior tendons.
The native cuff can be repaired with less tension.
Prevention of cuff muscle atrophy and fatty degeneration
Ability to consider other techniques (LD transfer, patch, and so on) is retained in case of failure.
Expanded indications compared to normal medialized repair (Goutallier $\geq$ 2)
Disadvantages
Limitation of range of motion
Cannot be applied in cases of severe glenohumeral joint arthritis
Repair may not be possible in the presence of significant rotator cuff muscle atrophy.

LD, latissimus dorsi.

restrictions. Regardless, we believe that this approach, with its emphasis on rotator cuff reconstruction, is an option for treating massive rotator cuff tears. We propose ex-medialization as a viable option for retear cases and fatty degeneration of Grade 2 (Goutallier classification) and above. Ex-medialization is a method for improving the functional anatomy of the rotator cuff.

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