Technical Note

Advancement of Rotator Cuff With Trapezius Reinforcement: An Alternative Surgical Technique for Treatment of Massive Irreparable Posterosuperior Rotator Cuff Tears

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Abstract: Massive irreparable rotator cuff tears represent a marked challenge for shoulder surgeons, particularly in younger patients with a high level of activity, when a reverse shoulder arthroplasty is not a valuable option. Since massive tears have traditionally been attributed to high retear rates, numerous alternative procedures have been proposed such as partial repair, various tendon transfers, superior capsular reconstruction, or repair with different patch augmentation techniques. In recent years, muscle advancement of the rotator cuff, which used to be a historical procedure, has been emphasized again, with several studies reporting promising clinical and structural outcomes for the treatment of irreparable rotator cuff tears. In this technical note, we describe an alternative technique: advancement of the rotator cuff with trapezius reinforcement. This technique includes muscle advancement of the supraspinatus and infraspinatus muscles and an additional augmentation of the infraspinatus muscle using the lower trapezius tendon to enhance the muscular component of the final repair construct and to achieve higher postoperative strength outcomes in massive irreparable posterosuperior rotator cuff tears.

Management of massive rotator cuff tears (MRCTs) is challenging, especially for young and active patients who are not suitable candidates for reverse shoulder arthroplasty. Due to high failure rates of arthroscopic rotator cuff repair (ARCR), numerous alternatives have been proposed, including partial repair, superior capsular reconstruction, tendon transfers, or different patch augmentations. Another alternative procedure is muscle advancement, first described in 1965,[1] which includes lateral advancement of the supraspinatus (SSP) muscle. Modifications of this procedure have been developed in the following years,[2] including arthroscopic-assisted[3,4] and all-arthroscopic[5,6] techniques.

Fundamentally, muscle advancement provides higher mobility of the retracted tendon and allows for a "tension-free" repair, which significantly increases the likelihood of successful healing. In this technical note, we describe an alternative technique: advancement of the rotator cuff with trapezius reinforcement (ARC-TR). We hypothesized that with this technique, strength of the advanced infraspinatus (ISP) muscle could be increased due to an augmentation effect provided by the lower trapezius (LT) tendon.

Surgical Technique

Indications and contraindications are listed in Table 1. The surgical technique is presented in Video 1, and a step-by-step description of the technique is provided in Table 2.

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Table 1. Indications and Contraindications for Advancement of the Rotator Cuff With Trapezius Reinforcement Procedure

Indications	Contraindications
Young (<70 years of age) patients with high level of physical activity	Coexisting "irreparable" subscapularis tear
Massive posterosuperior rotator cuff tears (involving both supraspinatus and infraspinatus tendons, with or without extension to the teres minor tendon)	Significant glenohumeral arthritis
Severe medial retraction of the rotator cuff without sufficient mobilization to perform a "tension-free" repair	Rotator cuff tear arthropathy with marked static proximal humeral head migration
Any degree of muscle fatty infiltration	

Surgical Setup

This procedure is performed under general anesthesia with the patient positioned in a beach-chair position. The head and neck are stabilized using a dedicated head holder. An open-backed operating table is recommended. A pneumatic arm holder is optional. The patient is draped, leaving the entire scapula uncovered to allow easier access to the medial scapular margin (Fig 1).

Arthroscopic Rotator Cuff Release

Five routine arthroscopic portals (posterior and posterolateral portals as viewing portals and anterior, anterolateral, and lateral portals as working portals) are used. Subscapularis tears are addressed and repaired to ensure anterior force couple. Then, a thorough

Table 2. Step-by-Step Description and Key Points of the Procedure

Technical Step of the Procedure	Key Points of the Step
Anesthesia and patient positioning	• General anesthesia; interscalene nerve block is preferable for postoperative pain control. • Beach-chair position; head and neck are stabilized with a head holder. Pneumatic arm holder is optional. • The patient is draped with entire scapula and ipsilateral half back left uncovered.
Diagnostic arthroscopy	• Evaluate for chondral, labral, biceps, and subscapularis pathologies. • Tenotomy or tenodesis of the long head of the biceps in case of tendonitis. • Repair subscapularis tear if needed.
Subacromial decompression and rotator cuff release	• Comprehensive subacromial and intra-articular release of the rotator cuff. • Release of the coracohumeral ligament from its attachment to the coracoid process is beneficial to increase the mobility of the supraspinatus tendon. • Intra-articular cuff release is performed using an arthroscopic rasp between the undersurface of the rotator cuff and glenoid. • Care must be taken with the suprascapular nerve at this stage.
Assessment of rotator cuff mobility	• If tendon excursion is not enough to perform a "tension-free" repair, pass a traction suture through the most retracted portion of the cuff.
Harvesting of lower trapezius tendon	• A 5-cm horizontal skin incision. Just 1 cm inferior to the scapular spine, along 1 cm medial to 4 cm lateral to the medial edge of the scapular spine. • After subcutaneous dissection, identify the fat area that marks the lower border of distal part of the lower trapezius tendon. • Detachment of tendinous insertion of the lower trapezius to the scapular spine. Dissection of the lower trapezius tendon medially. • Superior border of the tendon marks the interval between the lower and middle trapezius muscles. • Caution is warranted during deep dissection since the accessory nerve lies 2 cm medial to the medial edge of the scapula, on the undersurface of the lower trapezius muscle. • Lateral end of the lower trapezius tendon is secured with sutures using a Krackow configuration after achieving a satisfactory release and tendon mobility.
Advancement of rotator cuff muscles	• A broad and blunt periosteal elevator is used. • Avoid intramuscular penetration of the elevator. Care must be taken to elevate the muscles subperiosteally. • Medial superficial fascial continuity between rotator cuff muscles and rhomboids should be maintained intact.
Arthroscopic rotator cuff repair	• Mobility of rotator cuff tendons is reassessed following muscle advancement. • Conventional arthroscopic transosseous-equivalent repair is performed after achieving enough cuff mobility to totally cover the footprint without tension.
Lower trapezius reinforcement to infraspinatus	• The arm is externally rotated and slightly elevated during this step. • Suture limbs from the lower trapezius tendon are sutured to the superficial fascia and muscle belly of the upper portion of the infraspinatus. • Superficial fascia of the infraspinatus is thick and firm, which provides a strong suture fixation.

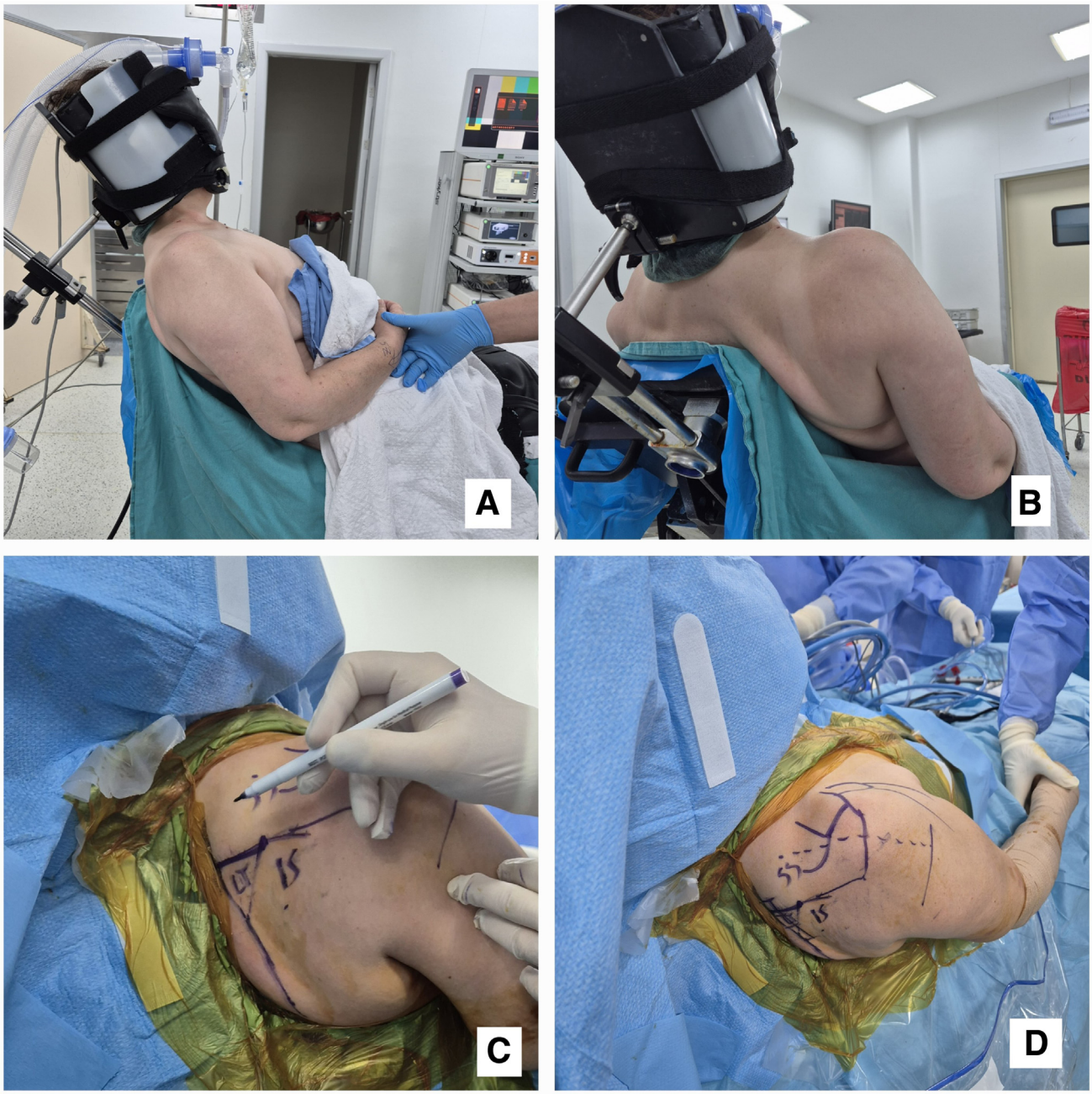

Fig 1. Patient positioning and surgical setup. The patient is positioned in a beach-chair position on an open-backed operating table. (A, B) The head and neck are stabilized using a dedicated head holder. The patient is draped, leaving the entire scapula uncovered, allowing easy access to the medial scapular margin. (C, D) Surgical landmarks are marked using a surgical marking pen.

subacromial decompression is performed to clearly expose the tear. The rotator cuff is meticulously released on bursal and articular sides to increase the mobility of torn tendons. Articular side release is performed between the undersurface of the rotator cuff and glenoid using an arthroscopic rasp (Fig 2). Care must be taken during this step to avoid damaging the suprascapular nerve (SSN) due to its close proximity, and an arthroscopic rasp should not be advanced more than 2 cm. An arthroscopic grasper is then used to assess the excursion of the rotator cuff (Fig 3). If the mobility of the rotator cuff is not enough to reduce the

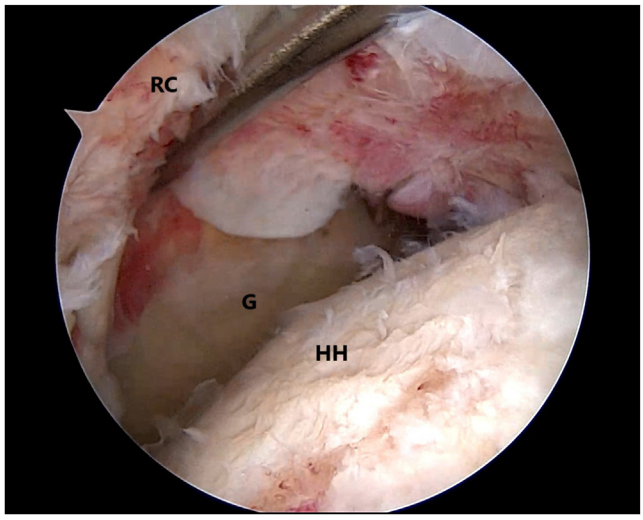

Fig 2. Arthroscopic view of the right shoulder from the posterolateral viewing portal showing intra-articular release of the rotator cuff. The patient is in the beach-chair position. An arthroscopic rasp is inserted between the undersurface of the rotator cuff and the superior glenoid to release retracted rotator cuff tendons. (G, glenoid; HH, humeral head; RC, rotator cuff.)

tendon onto the footprint without tension, a traction suture is passed at the edge of the mostly retracted cuff portion (Fig 4).

Lower Trapezius Harvest

The technique, previously described by Elhassan et al.,[7] is used for LT tendon harvesting. A 5-cm-long horizontal skin incision, 1 cm inferior to the scapular spine, along 1 cm medial to 4 cm lateral to the medial edge of the scapular spine, is performed (Figs 5 and 6). After dissecting subcutaneous tissue, a triangular fat area is identified, which is located just below the lateral border of the LT. Tendinous insertion of the LT to the scapular spine is detached (Fig 7), and the LT tendon is medially dissected from surrounding fascial tissues following the superior border of the tendon (Fig 8). This interval represents the border between middle and lower trapezius muscles. Superficial dissection can be performed safely; however, the accessory nerve is located approximately 2 cm medial to the medial scapular edge on the undersurface of the LT muscle. Therefore, deep dissection should be carried out with caution to avoid any damage to the accessory nerve.

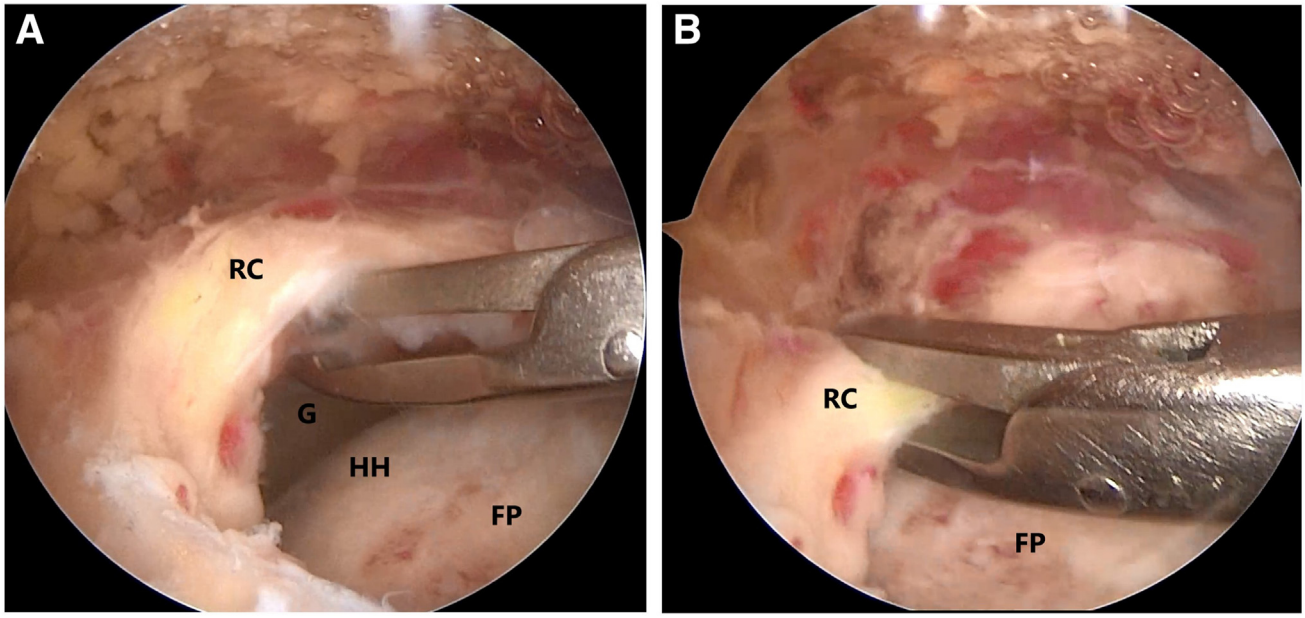

Fig 3. Arthroscopic views of the right shoulder from the posterolateral viewing portal showing the excursion of torn rotator cuff tendons. The patient is in the beach-chair position. (A) The rotator cuff is retracted to the level of the glenoid margin. (B) The insufficient mobility of the rotator cuff is shown despite the subacromial and intra-articular release by pulling with a grasper. (FP, footprint; G, glenoid; HH, humeral head; RC, rotator cuff.)

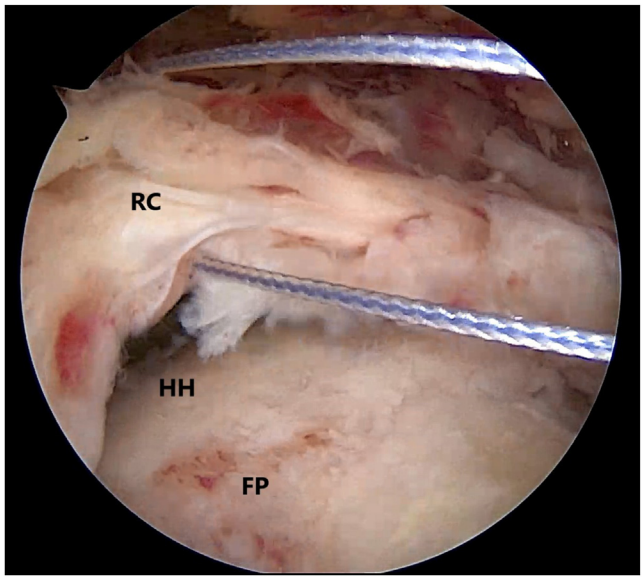

Fig 4. Arthroscopic view of the right shoulder from the posterolateral portal showing the traction suture passed through the rotator cuff at the edge of mostly retracted portion of the supraspinatus tendon. The patient is in the beach-chair position. (FP, footprint; HH, humeral head; RC, rotator cuff.)

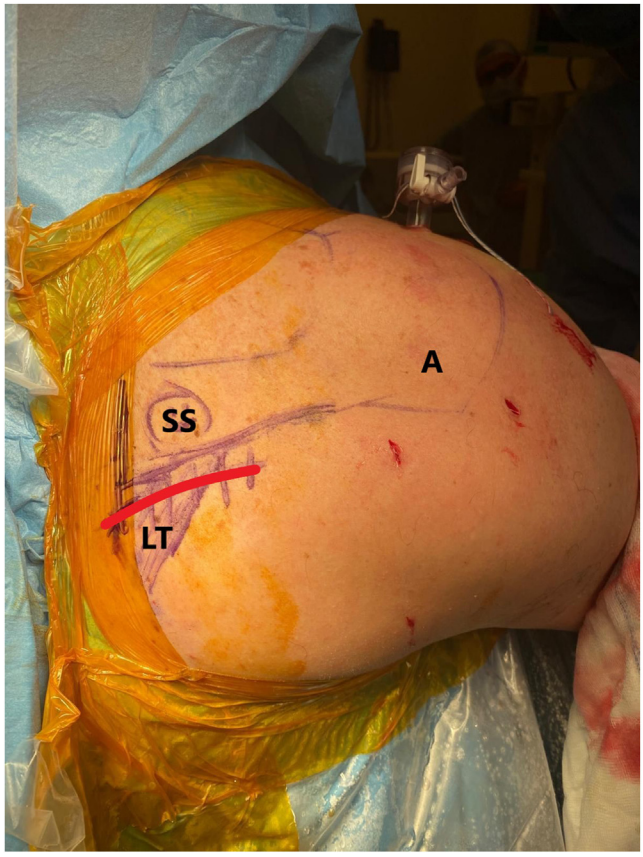

Fig 5. Intraoperative view of the right shoulder showing a skin incision for the lower trapezius harvest. Red line represents the skin incision. (A, acromion; LT, lower trapezius; SS, scapular spine.)

Care must be taken not to damage the fascial continuity between the ISP and rhomboid muscles. After releasing the LT tendon, sutures in a Krackow configuration using a No. 2 braided nonabsorbable suture (FiberWire; Arthrex) are placed at the distal end of the LT tendon, and the harvested tendon is secured (Fig 9).

Advancement and Repair of the Rotator Cuff

Muscle bellies of the ISP and SSP are elevated using a broad and blunt periosteal elevator from their respective scapular fossae (Figs 10-12). Care must be taken to elevate the muscles subperiosteally and to avoid intramuscular penetration of the elevator. One key point of this step is to maintain the medial fascial attachment between rotator cuff muscles and rhomboids. Advancement of the ISP and SSP can be observed and adjusted by a gentle pull from the traction suture (Fig 13).

The mobility of the rotator cuff is reassessed arthroscopically, and the muscles are further elevated until sufficient mobility is achieved. When the rotator cuff totally covers the footprint without undue tension, ARCR is performed using a knotless transosseous-equivalent repair technique with 2 medial row anchors (Corkscrew FT Anchor; Arthrex) and 2 knotless lateral row anchors (SwiveLock; Arthrex) (Fig 14).

Reinforcement of the Infraspinatus With the Lower Trapezius

After achieving a secure, "tension-free" repair with muscle advancement, the arm is externally rotated and slightly elevated. This is the optimum position to perform the reinforcement with adequate LT and ISP tension. Then, the LT tendon is sutured to the upper part of the ISP muscle belly, superficial fascia, and deep periosteum using the remaining limbs of Krackow sutures (Figs 15 and 16). ISP muscle has a thick and firm superficial fascia in this area, which provides a strong and durable fixation.

Postoperative Rehabilitation

Immobilization in an abduction sling is performed for 6 weeks after surgery. Passive shoulder range of motion (ROM) exercises are initiated at the second postoperative week. At the sixth postoperative week, active-assisted ROM exercises are initiated until full ROM is achieved. After the 12th postoperative week, rotator cuff, deltoid, and periscapular muscle strengthening exercises are performed.

Discussion

Muscle advancement has been recently emphasized by several authors for the treatment of MRCTs with various technical modifications of the procedure.[2-5] Current knowledge regarding the outcomes of this procedure is limited; however, available data suggest

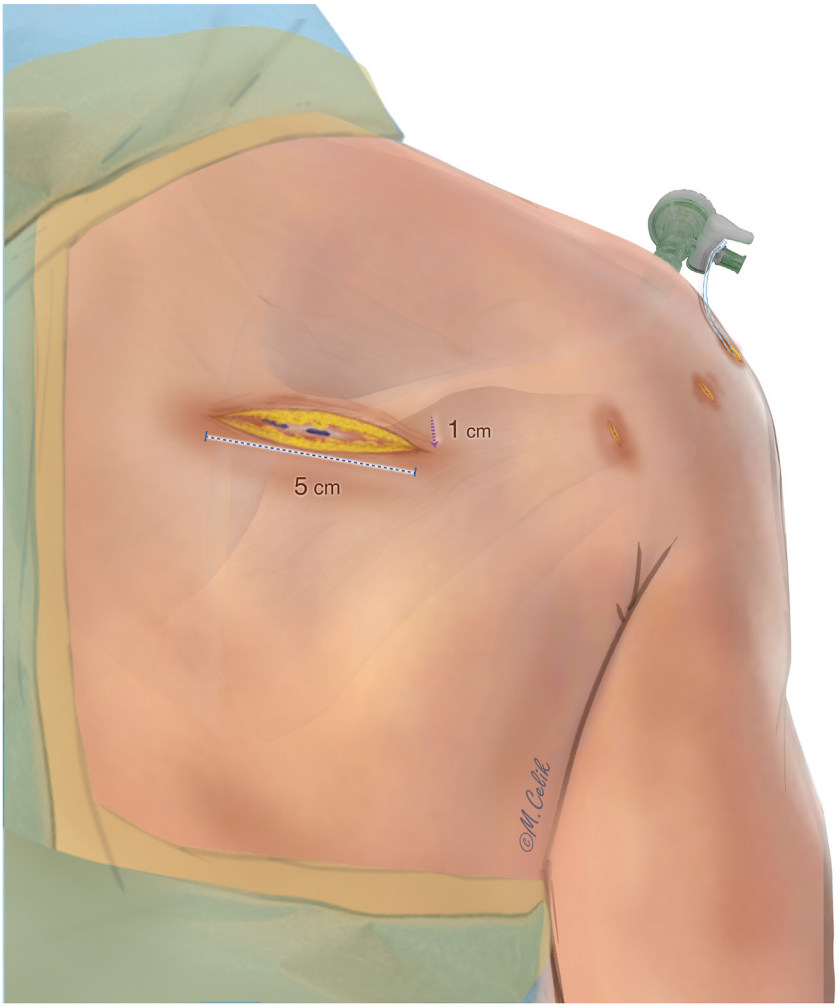

Fig 6. Illustration showing the skin incision for lower trapezius tendon harvesting on a right shoulder. The skin incision is horizontal and 5 cm long, located 1 cm inferior to the scapular spine, and extends from 1 cm medial to 4 cm lateral to the medial edge of the scapular spine.

promising results. Yokoya et al.[3] reported comparable clinical outcomes between ARCR and repair with muscle advancement, but the muscle advancement group showed significantly higher postoperative abduction strength, a higher acromiohumeral interval, and lower retear rates (23.1% vs 52.4%). However, their findings did not show any significant benefit of muscle advancement in terms of external rotation strength. Another study by Morihara et al.[4] reported results of arthroscopic-assisted muscle advancement in irreparable MRCTs. Their findings showed a similar retear rate (23.5%) with significant improvement in clinical outcomes. The authors indicated significant improvement in the strength component of the Constant-Murley score. However, even though the difference was insignificant, postoperative strength was relatively lower when preoperative fatty infiltration was grade 4 in at least one of the rotator cuff muscles compared to the patients with fatty infiltration grade 3 or less.

Muscle advancement offers the possibility of performing a "tension-free" repair with full coverage of the footprint, thus having a high likelihood of tendon-bone healing. However, even though successful tendon-bone healing is achieved, due to weak, degenerated rotator cuff muscles with high grades of fatty infiltration, it is likely that postoperative strength outcomes would be relatively unsatisfying, according to the findings of

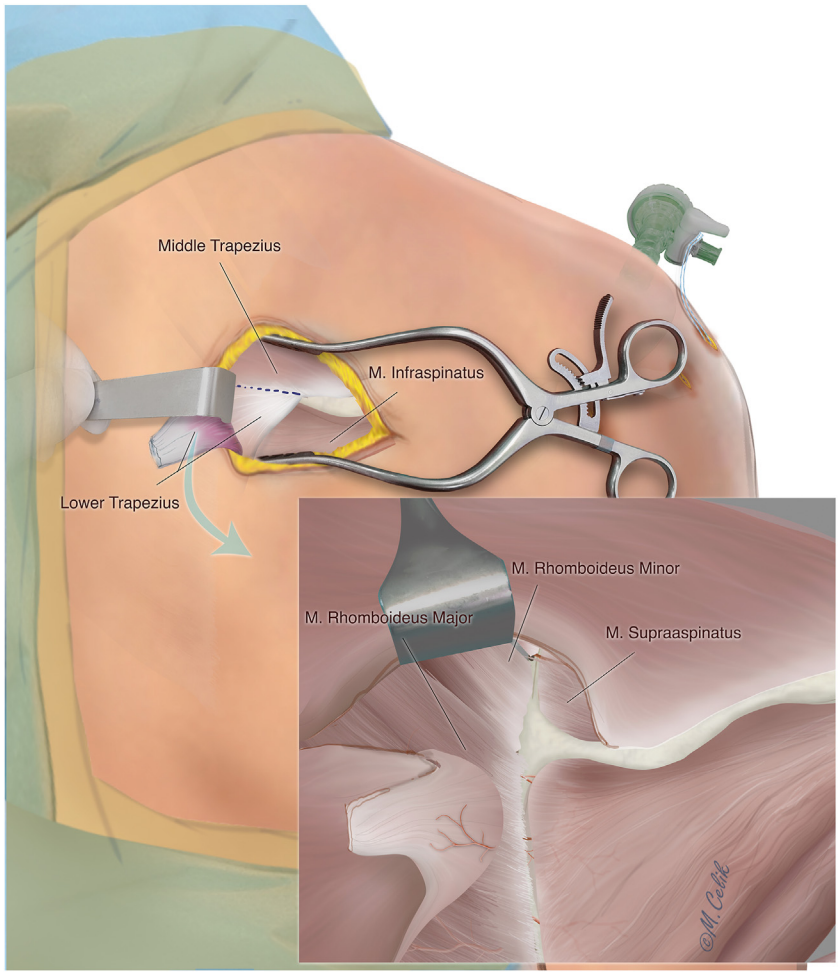

Fig 7. Illustration showing the detachment of the lower trapezius tendon from its insertion on the medial portion of the scapular spine.

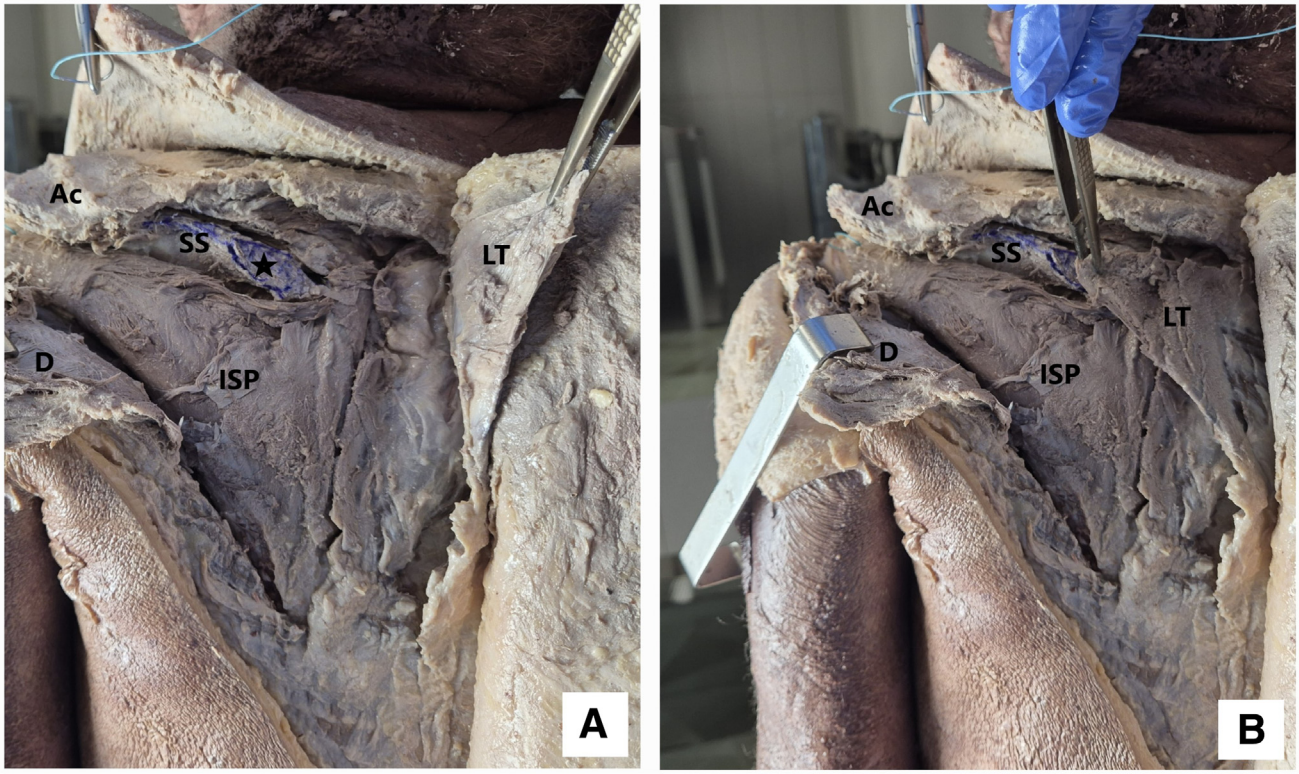

Fig 8. (A, B) Cadaveric demonstration of a left shoulder showing the detachment of the lower trapezius tendon from its insertion on the scapular spine (black star). The lower trapezius tendon is held with surgical forceps. (Ac, acromion; D, deltoid; ISP, infraspinatus; LT, lower trapezius; SS, scapular spine.)

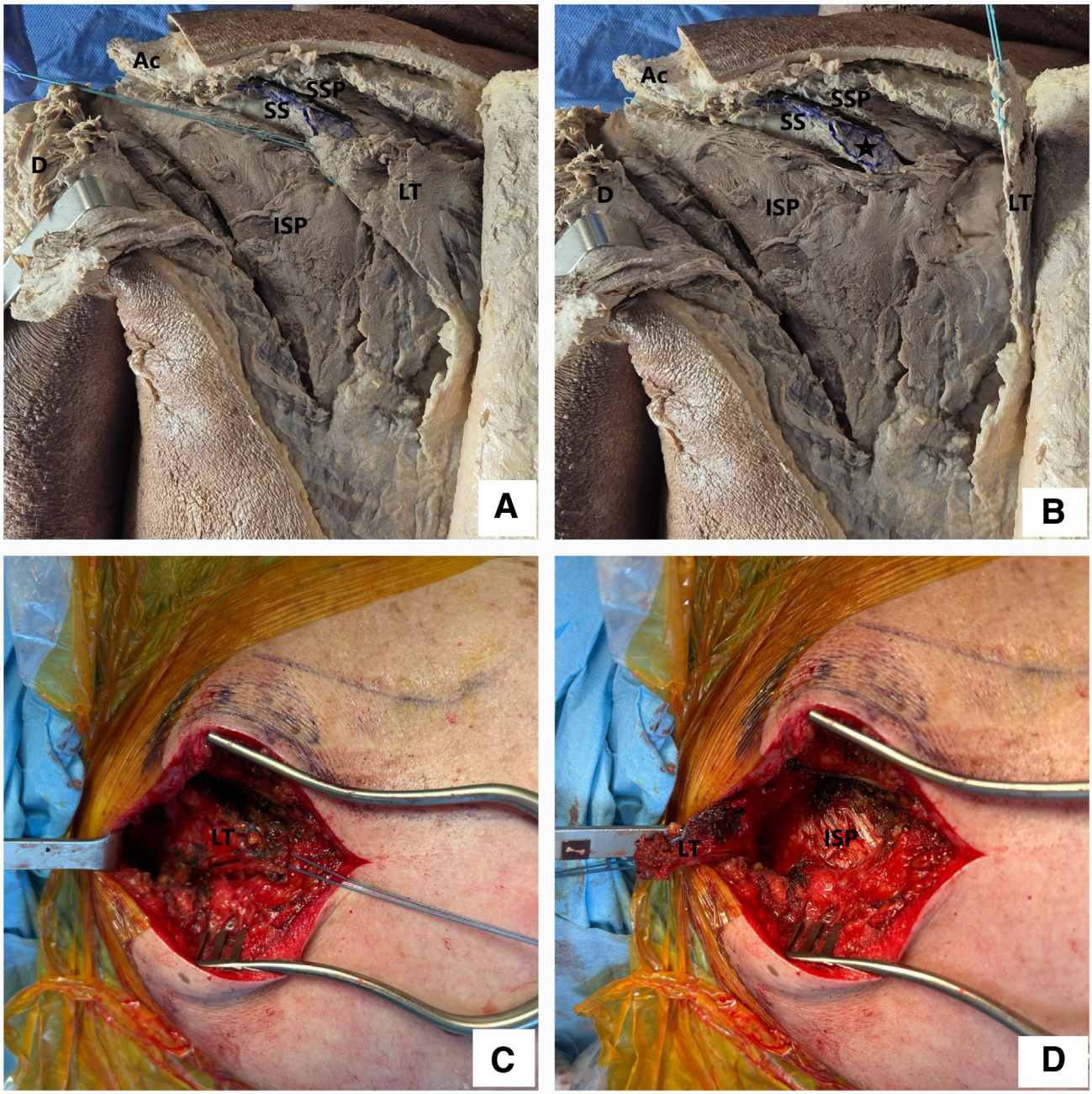

Fig 9. Cadaveric demonstration of a left shoulder (A, B) and intraoperative views of a right shoulder (C, D) showing the Krackow sutures placed at the distal end of the lower trapezius tendon to secure the harvested tendon. Black star indicates the insertion site for the lower trapezius tendon. (Ac, acromion; D, deltoid; ISP, infraspinatus; LT, lower trapezius; SS, scapular spine; SSP, supraspinatus.)

previously mentioned studies.[3,4] This situation caused us to ask how we could obtain higher postoperative strength and led us to search for alternative solutions. The LT tendon has already been proposed as a valuable option for tendon transfer in the treatment of posterosuperior MRCTs by Elhassan et al.[7] due to its similar line of pull, excursion, and tension with the ISP. We therefore hypothesized that the LT tendon could also be used to augment the ISP muscle and enhance the functional muscular unit of the final repair construct, and subsequently, postoperative external rotation strength could be increased following muscle

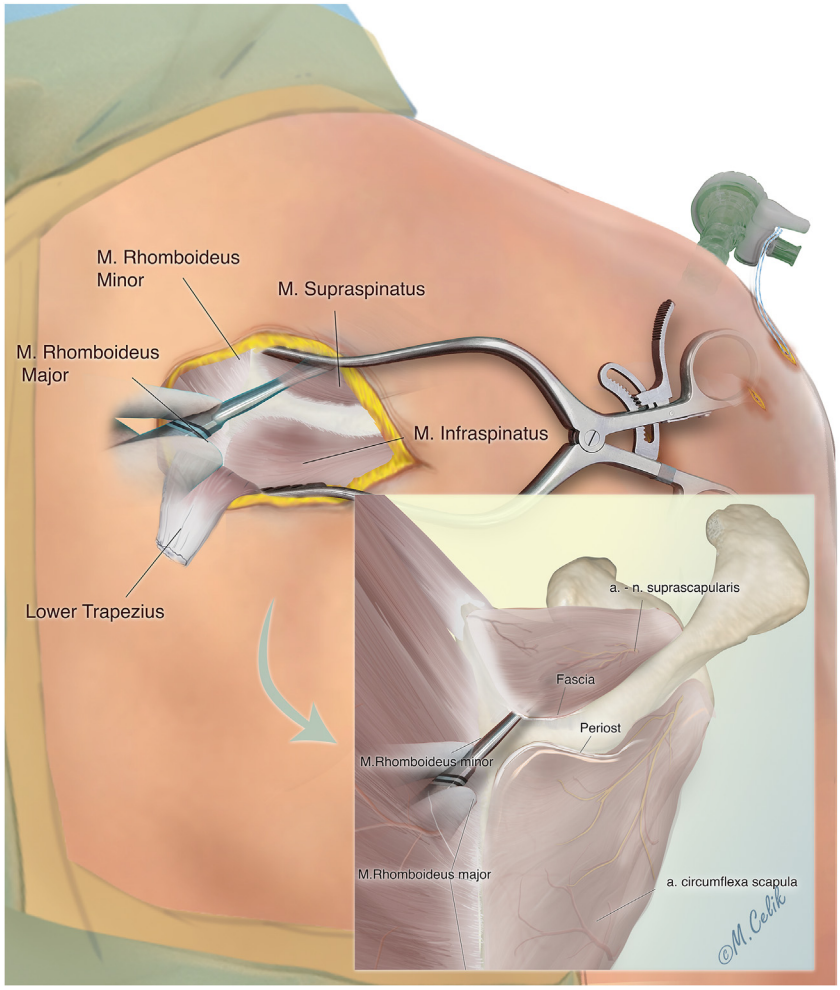

Fig 10. Illustration showing the advancement of supraspinatus muscle using a periosteal elevator inserted subperiosteally.

advancement. Moreover, the ARC-TR procedure has also several advantages. It is technically less demanding, and a shorter surgical duration is needed compared to LT transfer. It is cost-effective since no tendon grafts, additional implants, artificial biomaterials, or patch grafts are needed. It can easily be performed in a single incision combined with muscle advancement. No additional preoperative preparation is needed, and intraoperative decision-making for ARC-TR can easily be done when a satisfactory ARCR is not possible (Table 3).

One possible drawback of this procedure is the likelihood of SSN damage during advancement of the SSP and ISP muscles. Therefore, arthroscopic release of the

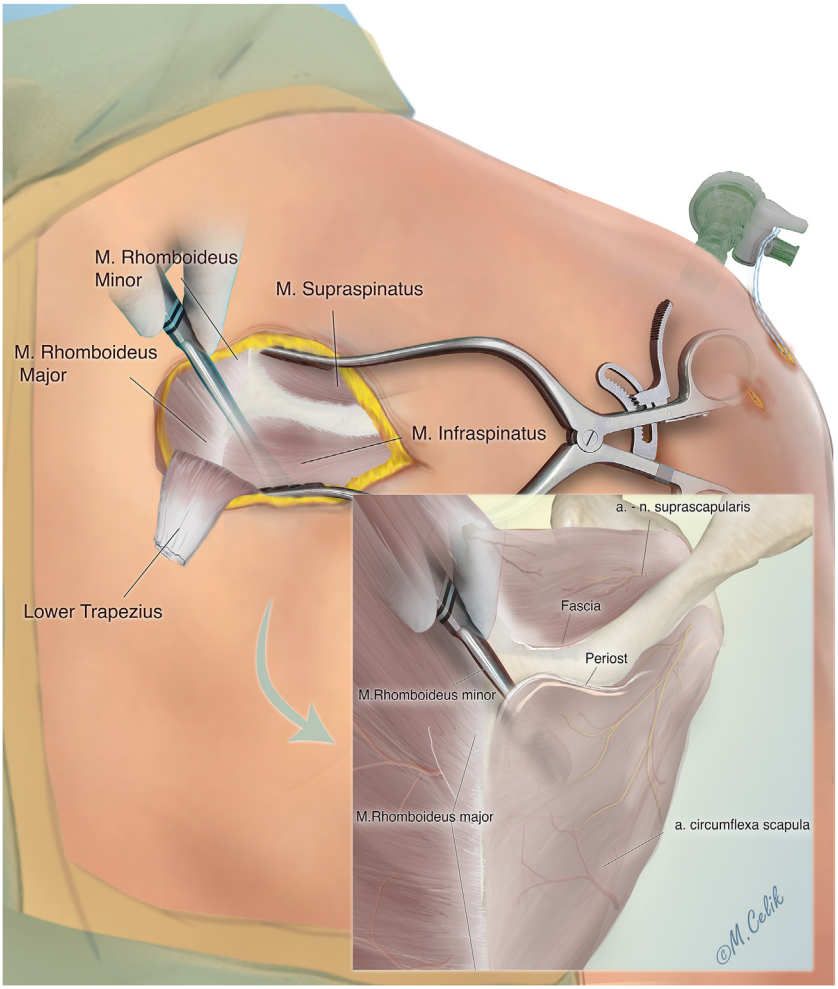

Fig 11. Illustration showing the advancement of the infraspinatus muscle using a periosteal elevator inserted subperiosteally.

transverse scapular ligament was recommended to avoid SSN palsy in previous reports.[3-5] However, we think that routine release of the SSN is not essential as it would increase surgical duration, but it can be performed optionally. We think that the key step to avoid SSN palsy is to elevate the SSP and ISP from their relevant fossae "subperiosteally," taking care to avoid intramuscular penetration of the elevator, which could damage the nerve. Second, as previously reported by Warner et al.,[8] damaging the fascial continuity between rotator cuff muscles and rhomboids would increase lateral advancement distance of rotator cuff muscles and eventually cause compression of the SSN by drastically changing the path of the nerve. As long as the fascial continuity between rhomboids and rotator cuff muscles is preserved, excessive lateral excursion of the rotator cuff and thus SSN palsy can be avoided.

In summary, the described technique offers a different perspective for the treatment of MRCTs. We think that ARC-TR would provide higher postoperative strength compared to previously described muscle advancement procedures. However, clinical results and possible advantages of this technique are bound to be confirmed by future clinical studies.

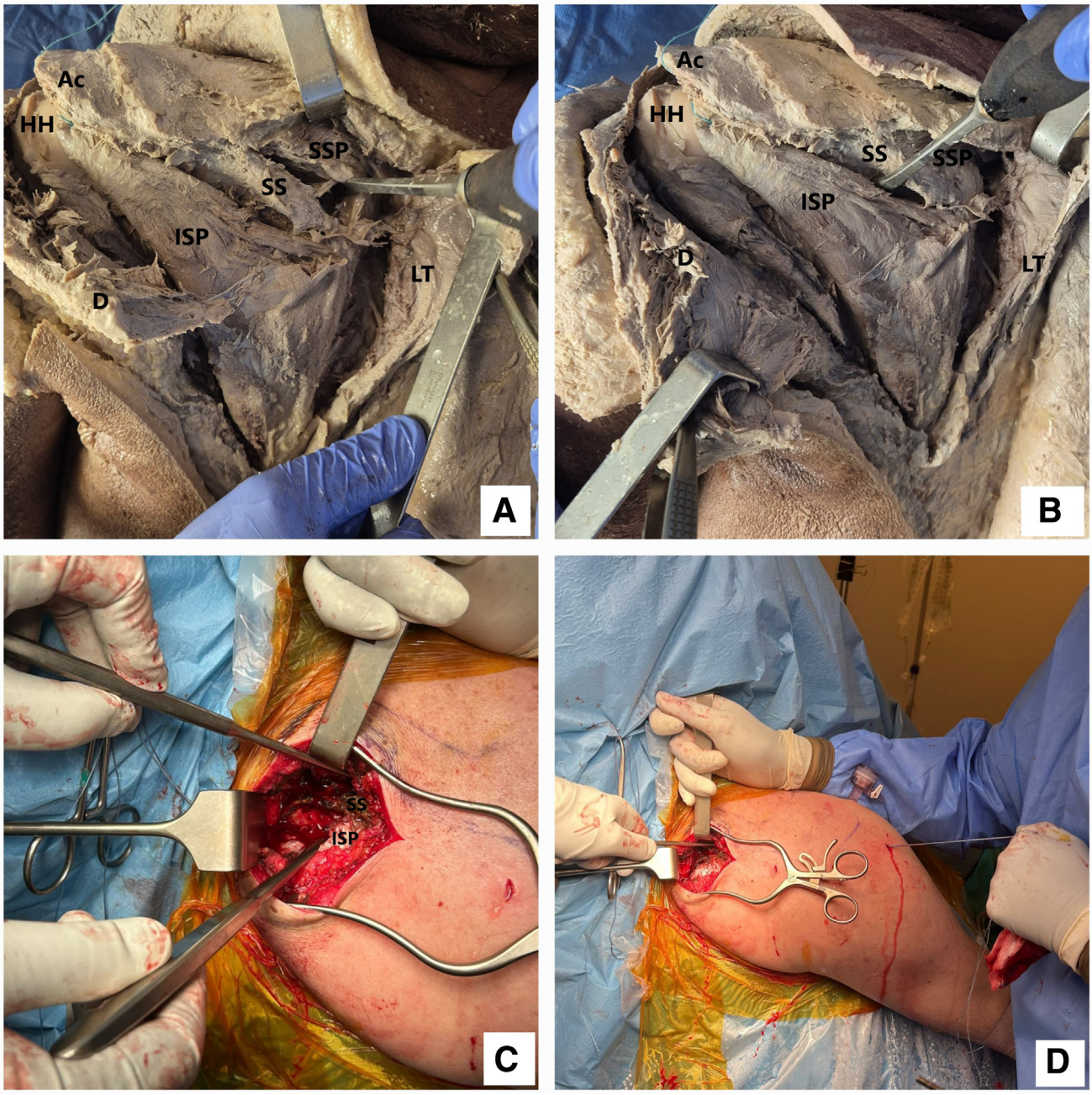

Fig 12. Cadaveric demonstration of a left shoulder showing the advancement of the supraspinatus (A) and infraspinatus (B) muscles using a periosteal elevator inserted subperiosteally to their relevant fossae. (C) Intraoperative view of a right shoulder showing 2 elevators inserted underneath the supraspinatus and infraspinatus muscles for muscle advancement. (D) The degree of muscle advancement is observed and assessed by pulling the traction sutures. (Ac, acromion; D, deltoid; HH, humeral head; ISP, infraspinatus; LT, lower trapezius; SS, scapular spine; SSP, supraspinatus.)

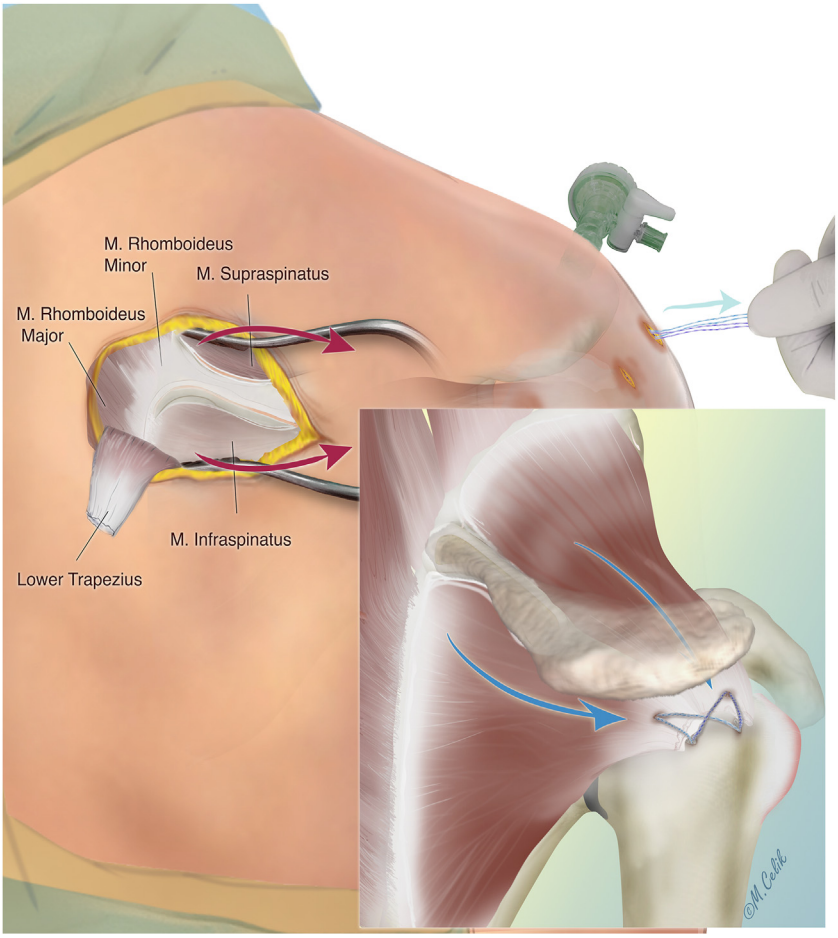

Fig 13. Illustration showing the assessment of muscle advancement by pulling the traction sutures. After obtaining sufficient mobility with muscle advancement, the rotator cuff repair is performed.

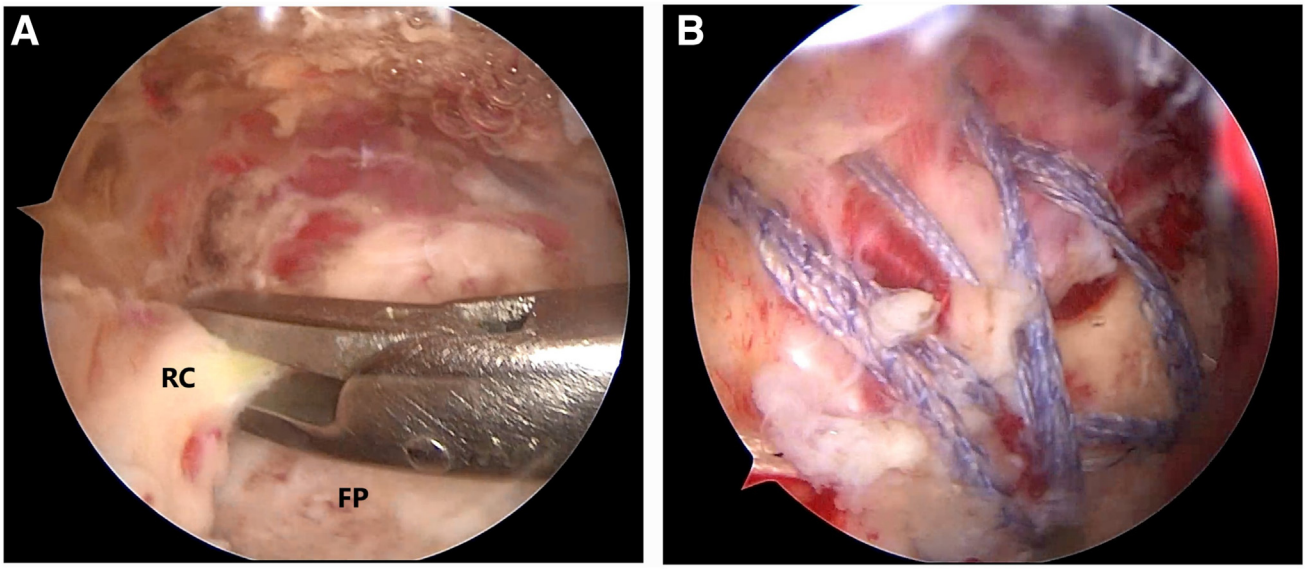

Fig 14. Arthroscopic views of a right shoulder from the posterolateral portal. The patient is in the beach-chair position. (A) Tendon excursion is not sufficient before muscle advancement to cover the footprint. (B) Rotator cuff repair is performed, and the footprint is completely covered without tension following muscle advancement. (FP, footprint; RC, rotator cuff.)

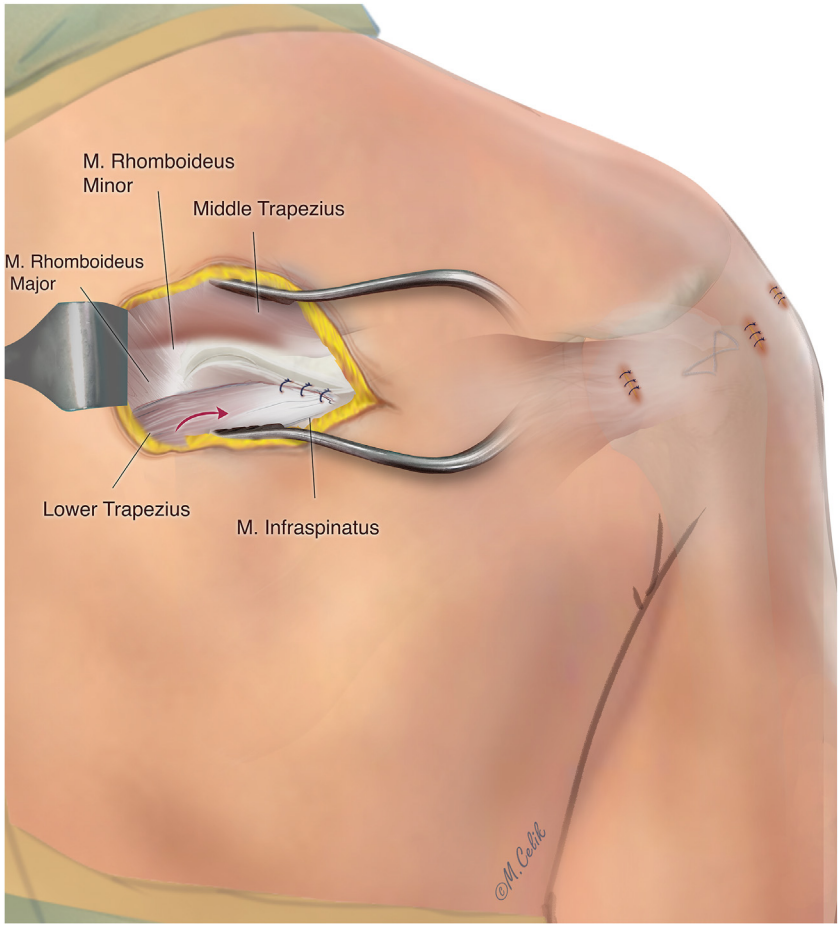

Fig 15. Illustration showing the reinforcement of the infraspinatus muscle with the lower trapezius tendon. The harvested lower trapezius tendon is sutured to the upper portion of the advanced infraspinatus muscle following rotator cuff repair.

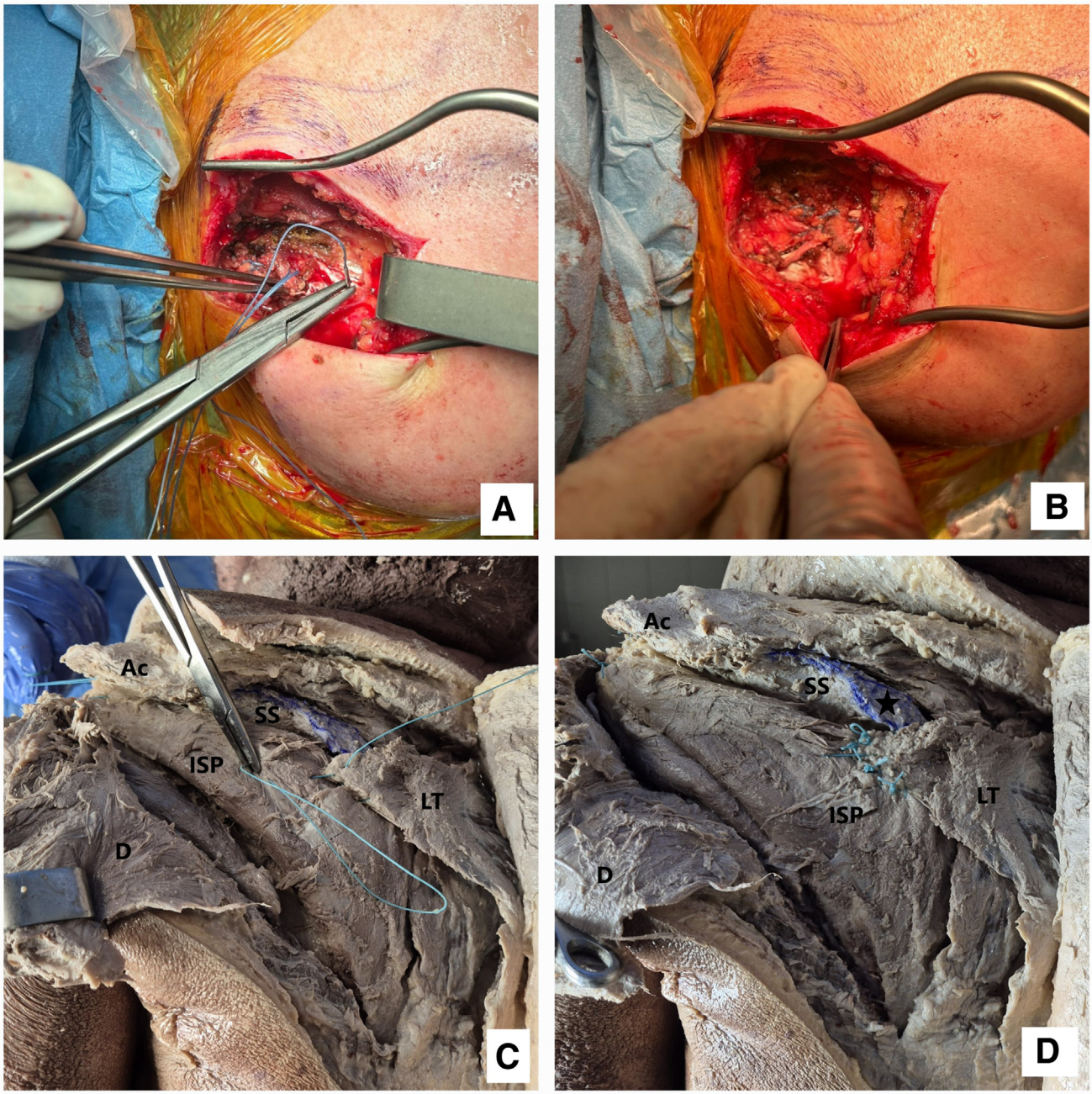

Fig 16. Intraoperative views of a right shoulder (A, B) and cadaveric demonstration of a left shoulder (C, D) showing reinforcement of the infraspinatus muscle with the lower trapezius tendon. The harvested lower trapezius tendon is sutured to the upper portion of the infraspinatus muscle. The thick superficial fascia of the infraspinatus muscle provides a strong suture fixation. Black star indicates previous insertion site of the lower trapezius tendon on the scapular spine. (Ac, acromion; D, deltoid; ISP, infraspinatus; LT, lower trapezius; SS, scapular spine.)

Table 3. Advantages and Disadvantages of the ARC-TR Procedure

Advantages	Disadvantages
Muscle advancement, lower trapezius harvest, and reinforcement of the infraspinatus using the lower trapezius tendon can be performed in a single incision.	Possibility of damaging the suprascapular nerve and accessory nerve.
Intraoperative decision change can easily be done in favor of ARC-TR when a satisfactory rotator cuff repair cannot be achieved without additional intraoperative preparation.	
No need for any additional implants, tendon grafts, patches, or artificial biomaterials.	
Technically less demanding and can be performed in a shorter duration compared to a lower trapezius transfer.	

ARC-TR, advancement of the rotator cuff with trapezius reinforcement.

Disclosures

All authors (K.B., K.Ş., M.Ç., A.B., M.K.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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