



Arthroscopic Incomplete Rotator Cuff Repair With Patch Augmentation Using Acellular Dermal Matrix Allograft

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Abstract: Arthroscopic rotator cuff repair has been shown promising clinical outcomes. However, large to massive rotator cuff tears are difficult to completely repair with appropriate tension because of their size or poor tissue quality. An incomplete repair using the “hybrid technique” is one of way to solve this problem by maximizing the contact area between the tendon and the footprint of greater tuberosity. Additionally, the acellular dermal matrix patch augmentation has emerged as an adjuvant technique to enhance the biomechanical properties to promote healing of the repaired construct. This Technical Note describes arthroscopic incomplete rotator cuff repair using the “hybrid technique” with acellular dermal matrix patch augmentation.

Arthroscopic rotator cuff repair (ARCR) is the treatment of choice for rotator cuff tears (RCTs). Despite advancements in surgical techniques, large to massive RCTs remain challenging because of partial footprint coverage and poor tissue quality, resulting in inferior outcomes and retear rates up to 30%.^{1,2} To address this issue, Jeong et al.³ proposed an incomplete repair using a “hybrid technique” that maximizes the contact area between the tendon and the greater tuberosity (GT) footprint. The authors reported more satisfactory clinical outcomes in cases of incomplete repair compared to partial repair of large to massive RCTs.³

Recently, ARCR with patch augmentation has emerged as a technique for promoting the healing of

repaired tendons and providing the mechanical support.⁴⁻⁷ Among the various sources of patches, human acellular dermal matrix (ADM) allograft has revealed favorable clinical and radiologic outcomes,⁷⁻¹¹ with lower retear rates compared to xenografts.^{12,13} This patch augmentation is indicated for patients who are expected to have an incomplete coverage or a high risk of retear based on preoperative magnetic resonance imaging^{14,15} and intraoperative evaluation (Table 1).

However, ARCR with patch augmentation is technically challenging due to several difficulties, such as delivering the patch, securing it in the proper location, managing multiple sutures, and extended surgical time. Although several articles have reported relatively simplified techniques,¹⁶⁻²¹ we report a systematic and consistent surgical technique to achieve a firm fixation of the patch on the incompletely repaired tendon (Table 2). Thus, this article describes a combined technique of incomplete repair³ and patch augmentation using the ADM allograft.

Surgical Technique

Our detailed surgical technique can be seen in Video 1.

Incomplete Rotator Cuff Repair Using a “Hybrid Technique”

The patient is placed in lateral decubitus position. Standard posterior, anterior, anterolateral, and posterolateral portals are created (Fig 1), and

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Table 1. Indications and Contraindications of Arthroscopic Incomplete Rotator Cuff Repair With Acellular Dermal Matrix Patch Augmentation

Relative Indications	Relative Contraindications
Preoperative MRI	
Large to massive tear size	Severe atrophy of ISP
Occupation ratio of SSP <40%	Fatty infiltration of ISP ≥ Goutallier grade 3
Fatty infiltration of SSP > Goutallier grade 2	
Intraoperative evaluation	
Poor tendon tissue quality	Coverage defect on the GT footprint over 1 cm
Coverage defect on the GT footprint within 1 cm	
Perioperative factors	
Revision rotator cuff repair	Active inflammation/infection
Young age for whom arthroplasty is not considered	Glenohumeral osteoarthritis
	Old age >75 years

GT, greater tuberosity; ISP, infraspinatus; MRI, magnetic resonance imaging; SSP, supraspinatus.

glenohumeral joint and subacromial spaces are thoroughly examined. If subscapularis is torn, it is repaired first. If necessary, capsular release, acromioplasty, biceps tenotomy, or tenodesis is performed prior to examination of rotator cuff. To mobilize the remnant rotator cuff, complete bursectomy and adhesiolysis, complete release of coracohumeral ligament, anterior interval slide, and complete detachment of the superior capsule from the glenoid can be performed. If the anterior portion of the supraspinatus fails to be reduced to its original footprint, then the incomplete repair with patch augmentation is performed (Table 1).

The anteromedial anchor (Healix; Dupuy Mitek) is inserted at 5 mm medialized from the humeral articular margin in the GT, and the anterior portion of supraspinatus tendon is repaired using a single-row repair. The posteromedial anchor (Healicoil; Smith & Nephew) is inserted just lateral to the humeral articular margin on the GT, and the posterior supraspinatus and infraspinatus tendons are repaired using double-row repair technique (Fig 2).

Preparation for the Patch Augmentation

This surgical technique involves 5 traction sutures (anteromedial, medial, posteromedial, anterolateral, and posterolateral corner) with 1 pair of sutures for additional compression to ensure proper positioning and engagement of the patch onto the repaired tendon. Using a Accu-pass (Smith & Nephew) through the anterior portal, the anteromedial traction suture is first

passed through the upper portion of the subscapularis and pierced out through the anterior portion of the supraspinatus. The medial traction suture is inserted through the Neviaser portal and placed in between the supraspinatus and infraspinatus. Posterior tied sutures of the incomplete repair are used as the posteromedial traction sutures. Additional compression suture of the patch is applied with a Mason-Allen suture of the incomplete repair. When finishing incomplete repair and placement of the traction sutures, the size of overall construct and the distance between each traction

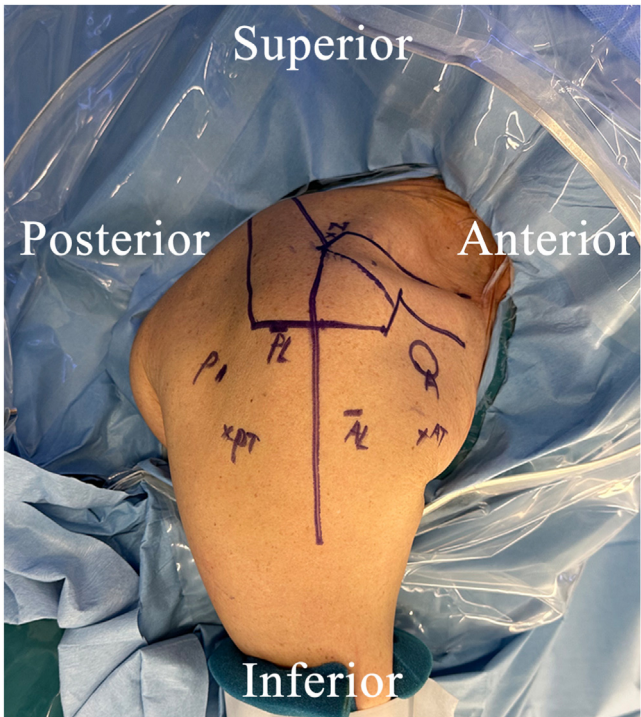


Fig 1. Outside lateral photo of the right shoulder in the lateral decubitus position with arthroscopy portals established. (a) P, posterior portal. (b) A, anterior portal. (c) AL, anterolateral portal. (d) PL, posterolateral portal. (e) PT, posterior traction portal. (f) AT, anterior traction portal. (g) N, Neviaser portal.

Table 2. Advantages and Disadvantages

Advantages
Improved biological integrity of repair construct
Enhanced mechanical property of repair construct
No additional anchor insertion is required
Can be applied to any size or type of primary repair
Disadvantages
Increased operation time
Technically challenging to manage sutures

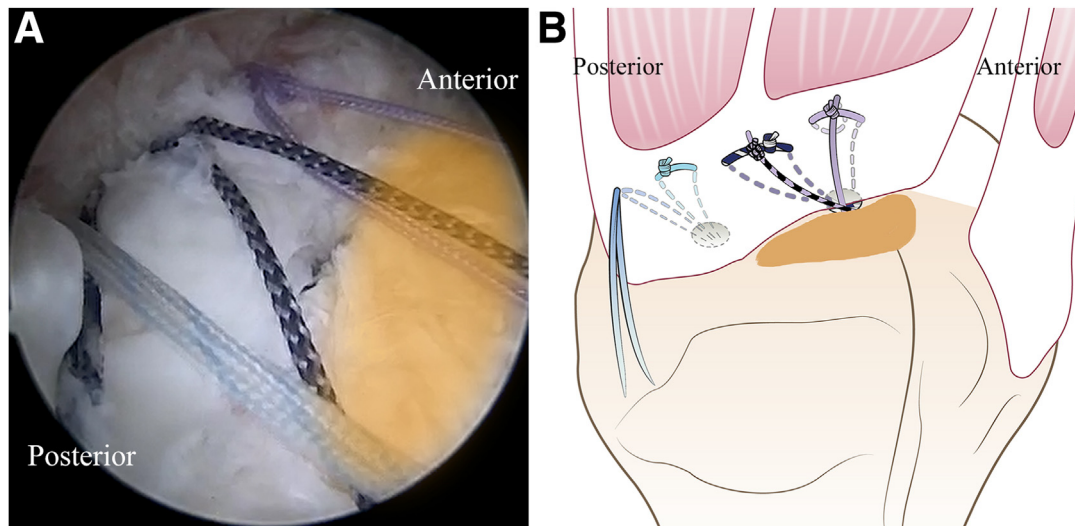


Fig 2. Incomplete rotator cuff repair using the “hybrid technique.” (a) Arthroscopic photo of the right shoulder in the lateral decubitus position viewed from the posterolateral portal of the incomplete repair construct. (b) Schematic image of incomplete rotator cuff repair in the right shoulder. Note that there is a coverage defect (orange) on the anterior portion of the greater tuberosity footprint and medialized anterior portion of the supraspinatus. Anterior portion of the supraspinatus tendon is repaired using a single-row repair with a modified Mason-Allen suture (purple) and Mason-Allen sutures.

sutures are measured using an arthroscopic ruler (Arthrex).

The ADM patch (Bellacell; 3 × 4 cm; HansBiomed) is prepared on the side table (Fig 3). The anterolateral and posterolateral traction sutures are placed using a spinal needle and secured using a “Megaknot” technique (Video 1). Then, the distance between each traction suture is marked using a pen. Using a free strand, a relay strand is applied into the patch to shuttle the

Mason-Allen suture of the incomplete repair in the later procedure (Fig 4).

Insertion of the Patch

Additional small anterior and posterior traction portals are created for proper tensioning during the patch delivery (Fig 1). A large cannula (Kii Optical; Applied Medical) is engaged to make the path for the patch. Then, the sutures that need to be passed through the

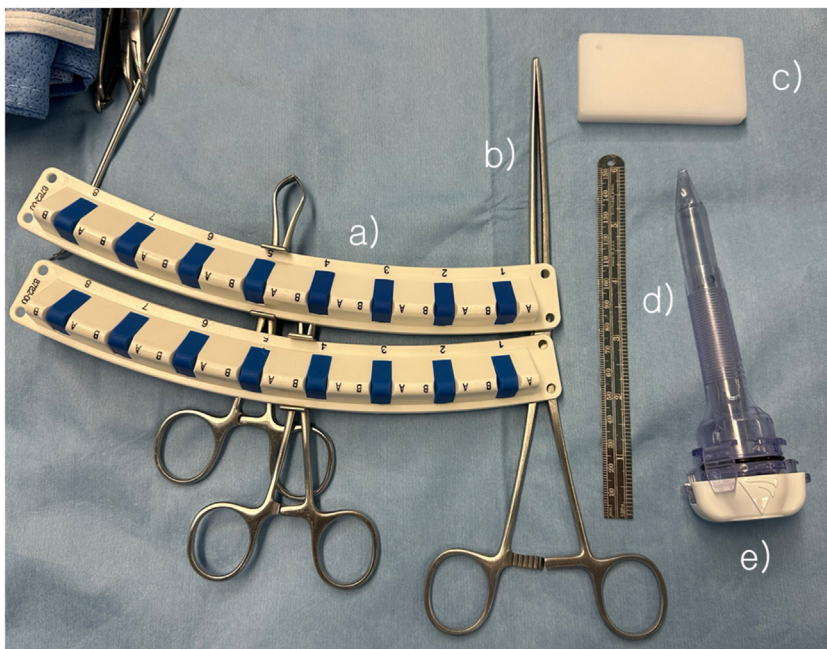


Fig 3. Instruments for patch augmentation. (a) Suture retaining bar (Koros). (b) Bowel forceps. (c) Stand for a patch. (d) Ruler. (e) Cannula (Kii Optical; Applied Medical).

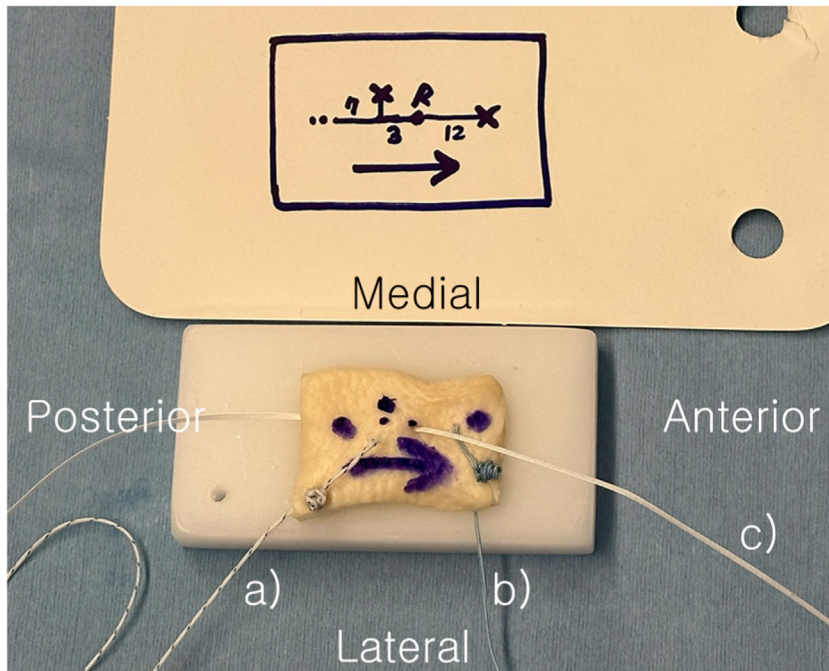


Fig 4. Preparation of patch augmentation. (a) Posterolateral traction suture. (b) Anterolateral traction suture. (c) Relay suture to shuttle the Mason-Allen suture of incomplete repair. Note that pen marking (blue color) indicates the intended passing point.

patch are pulled out and aligned first (Fig 5). The anteromedial and medial traction sutures are passed through the patch using an anterograde suture passer

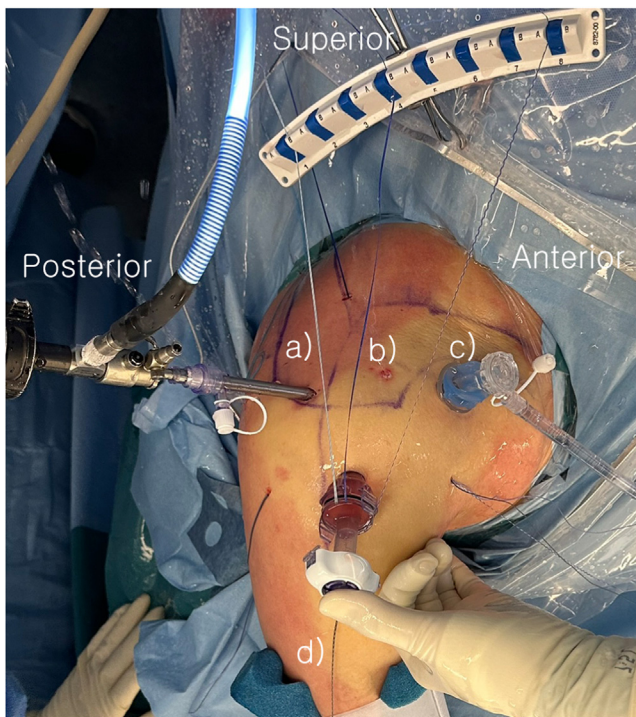


Fig 5. Aligned sutures before being passed through the patch. Outside photo of the right shoulder in the lateral decubitus position with (a) posteromedial traction suture from the incomplete repair, (b) medial traction suture from the Neviaser portal, (c) anteromedial traction suture from the anterior portal, and (d) Mason-Allen suture from the incomplete repair to be shuttled.

(Scorpion; Arthrex) and secured using the “Megaknot” technique. The posteromedial traction sutures are also passed through the patch separately, and a knot pusher is engaged (Fig 6). As the patch is delivered into the joint, a knot pusher is used to push the patch, and anteromedial and medial traction sutures are pulled simultaneously (Fig 7). After placing the patch, anterolateral and posterolateral traction sutures are pulled out through the anterior and posterior traction portal, respectively, and pulled to avoid folding the patch. Finally, Mason-Allen sutures of the incomplete repair are passed through the patch by shuttling with a relay strand (Table 3).

Fixation of the Patch and Completion of Suture Bridge Repair

The anteromedial and medial traction sutures are secured on the rotator cuff directly. Two knotless suture anchors (SwiveLock; Arthrex) are loaded with sutures from the incomplete repair and the patch and then inserted laterally. Finally, the anterolateral and posterolateral traction sutures are replaced with extra sutures of lateral anchors by shuttle relay and fixed to the lateral anchor (Fig 8).

Postoperative Rehabilitation

Patients are instructed to wear an abduction brace for 6 weeks to immobilize the shoulder. After 6 weeks, passive range-of-motion (ROM) exercises are initiated. Active-assisted ROM exercises are started once the patient has fully recovered their passive ROM. Strengthening exercises are initiated 12 weeks after surgery.

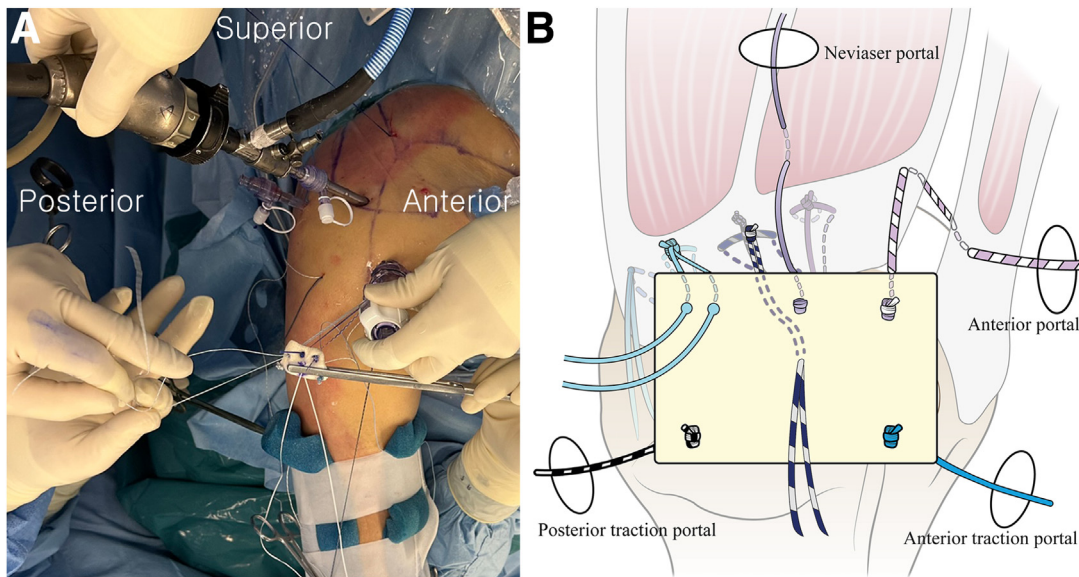


Fig 6. Suture passing into the patch. (a) Outside photo of the right shoulder in the lateral decubitus position. (b) Schematic image of the right shoulder for suture passing into the patch. Note that a knot pusher is engaged to the posteromedial traction sutures. The anteromedial and medial traction suture is passed through the patch using an anterograde suture passer (Scorpion; Arthrex) and secured using the “Megaknot” technique.

Discussion

Despite the overall success of ARCR on full-thickness RCTs,²² retear rates remain over 30% in large to massive rotator cuff tears. To address this issue, several

repair methods have been developed, including the incomplete repair using the “hybrid technique.”³ With the incomplete repair, the posterior portion of the GT can be covered, yet the anterior portion of the GT remains exposed.^{23,24} To address this limitation, ADM patch augmentation has been used to biomechanically enhance the integrity of the repaired tendon.

The ADM patch has shown its efficacy in integrating with the repaired tendon,^{5,25} increasing the thickness of the repaired tendon,²⁶ and improving the ultimate tensile failure load.²⁷ In clinical studies, Barber et al.⁸ reported superior clinical outcomes in patients who received the ADM patch augmentation compared to

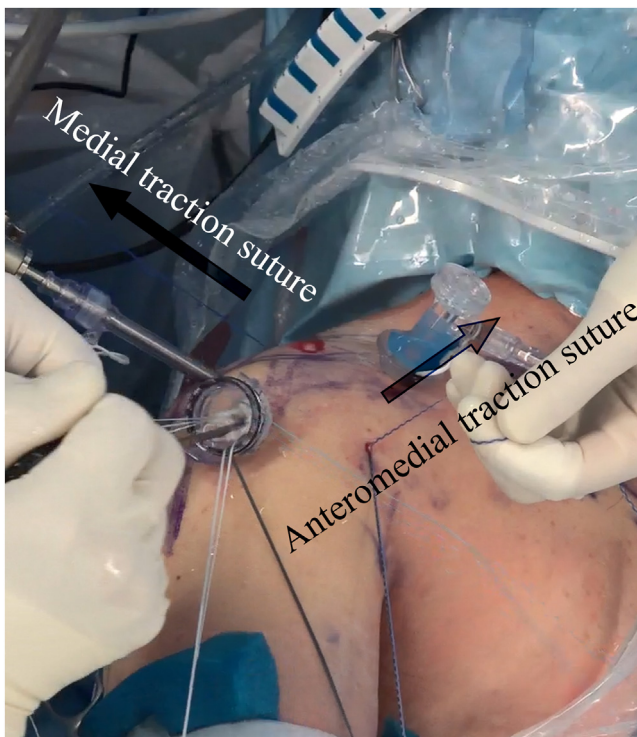


Fig 7. Insertion of the patch. Outside photo of the right shoulder in the lateral decubitus position showing the patch being pushed into the joint by the knot pusher and pulled by the anteromedial and medial traction suture at the same time.

Table 3. Pearls and Pitfalls

Pearls

- Appropriate subacromial bursectomy should be performed
- Proper mobilization of the rotator cuff is necessary to minimize defect
- Mark the patch with a marking pen to indicate its location
- Measure the distance between the sutures of primary repair and apply it to the patch
- Sutures passed through the patch should be properly aligned to avoid tangling before patch insertion
- Secure the patch to the lateral anchor without over-tensioning

Pitfalls

- Insufficient subacromial bursectomy can obstruct the visualization
- Inadequate mobilization can cause excessive tension
- Without any marking, it may be difficult to align the patch within the subacromial space
- Size mismatch between the patch and primary repair construct can cause the patch to fold
- If the sutures become entangled, the patch may be flipped over or secured incompletely
- Excessive lateral pulling of the patch can displace it laterally

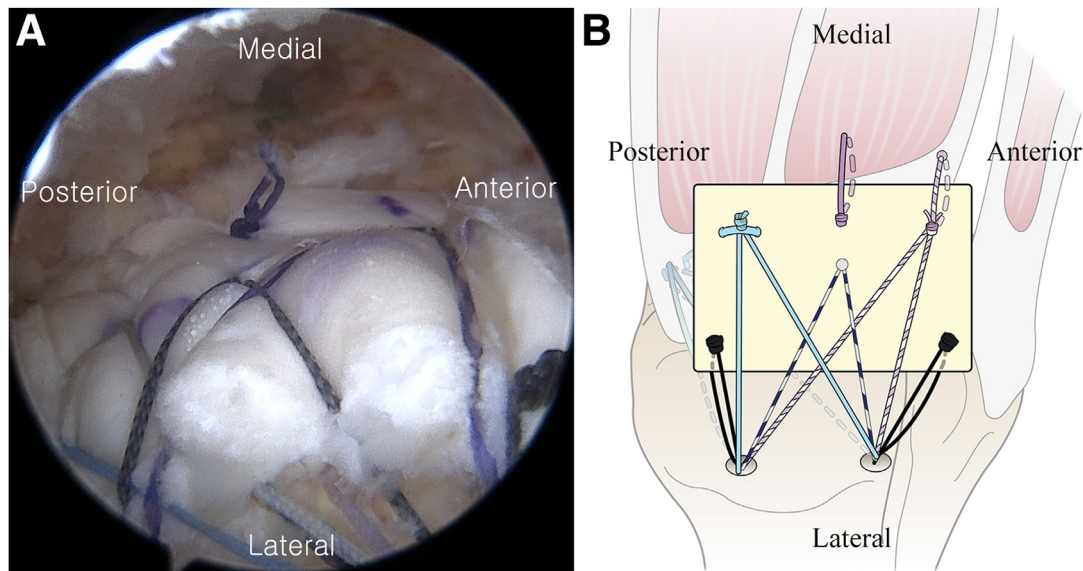


Fig 8. Final construct of rotator cuff repair with patch augmentation. (a) An arthroscopic photo of the right shoulder in the lateral decubitus position viewed from the posterolateral portal showing a well-fixed patch covering from the defect of the incomplete repair to the musculotendinous junction of the repaired tendon. (b) Schematic image of the final construct.

those who underwent rotator cuff repair (RCR) alone. Moreover, the incidence of retear was much lower than RCR alone,^{8,28,29} as well as other types of patches.^{12,13}

Despite the biomechanical advantages of RCR with patch augmentation, it has been considered a time-consuming and technically challenging procedure. Furthermore, the methods for patch fixation should be carefully considered because of its relation with initial stability and strength of the construct. In a biomechanical study, Jung et al.³⁰ evaluated the primary repair stability of RCR with patch augmentation using a xenologous dermal extracellular matrix according to patch fixation techniques in a cadaveric sheep model. The authors showed that the patch fixation technique with additional medial fixation to the patch and with lateral fixation using additional anchors showed the largest maximum force and functional limit.³⁰ The authors also reported that patch application without additional medial fixation to the patch weakened the repaired construct.³⁰ Using the patch augmentation technique described in this article, medial fixation of the patch on the repaired tendon, compression above the repair construct, and lateral fixation of the patch can be applied simultaneously without additional insertion of anchors.

Because of the independent nature of the procedure to the primary RCR, the patch augmentation technique described in this article can be applied to any other RCR techniques (Table 2). Incomplete repair with patch augmentation might be technically demanding, but this technique provides a reproducible and biomechanically enhanced construct for RCR with poor tendon quality

or large to massive size. Although long-term clinical outcome has not yet been reported, the authors' experience has shown that this procedure brings promising clinical outcomes.

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