Anterior Cable Reconstruction Using the Biceps Tendon in Retracted Anterior L-Shaped Rotator Cuff Tears

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Abstract: Repair of a retracted anterior L-shaped rotator cuff tear is challenging because of the lack of mobilization of the torn tendon and destruction of the rotator cable. Restoring the anterior rotator cable decreases gap formation of the repaired tendon, leading to maintenance of the repair integrity of the anterior supraspinatus tendon. This Technical Note introduces the surgical technique of anterior cable reconstruction using the proximal biceps tendon for a retracted anterior L-shaped rotator cuff tear.

Characteristic of anterior L-shaped rotator cuff tears are a retracted supraspinatus to the glenoid level combined and a relatively preserved infraspinatus tendon. A degenerated anterior margin of the supraspinatus tendon and frayed tissue involving the rotator interval induce lack of mobilization and hinder stable anatomic reduction without tension. The conventional repair technique for anterior L-shaped rotator cuff tear involves fixation of the supraspinatus on the footprint and margin convergence repair between the retracted torn tendon edges of the supraspinatus and infraspinatus in a side-to-side manner. However, undue tension is applied to the retracted supraspinatus tendon when placed on the footprint, which might lead to retear.

Anterior L-shaped rotator cuff tear usually begins from the anterior edge of the supraspinatus, disrupting the rotator cable. The rotator cable that extends from the anterior margin of the supraspinatus to the posterior border of the infraspinatus tendon acts as a “suspension bridge.” A tear involving the rotator cable may cause the loss of stress-shield capability, and increased strain may be associated with further tear propagation. Therefore, it is important to restore the anterior attachment of the rotator cable to maintain the integrity of repaired tendons and improve clinical outcomes. This Technical Note introduces rotator cuff repair combined with anterior cable reconstruction using the proximal biceps tendon for an anterior L-shaped tear (Video 1).

Surgical Technique

Preoperative Evaluation
The rotator cuff tear pattern is recognized by preoperative magnetic resonance imaging and confirmed during arthroscopic surgery. An anterior L-shaped rotator cuff tear is defined as a tear that is longer in the medial-to-lateral direction than in the anterior-to-posterior direction, with exposure of the biceps tendon (Fig 1A, B).

Patient Position and Arthroscopy Portals
The patient is placed in the lateral decubitus position after general anesthesia combined with interscalene block. The operative arm is placed in 30° abduction and 20° forward flexion. Diagnostic arthroscopy is performed with a 30° arthroscope through a standard posterior viewing portal and anterior working portal. The status of the intra-articular portion of the biceps tendon is examined during the diagnostic arthroscopy.
The arthroscope is moved to the subacromial space through the posterior portal, and a lateral portal is created for the main working portal. A posterolateral portal is made on the posterior edge of the torn tendon as the main viewing portal. The adhered tissue and adhesive capsule around the retracted supraspinatus tendon are debrided to release the tendon. The footprint is completely exposed and decorticated with a burr. An additional small incision is made on the lateral border of the acromion to insert suture anchors.

**Reconstruction of the Anterior Cable by Biceps Tenodesis**

To reconstruct the anterior portion of the rotator cable, a proximal biceps tendon after tenotomy and 2 triple-loaded suture anchors are needed. The optimal positions of the suture anchors are decided based on the mobility of the infraspinatus tendon (Fig 2A, B). A medial anchor (Healix Advance BR; Depuy Mitek, Raynham, MA) is placed at the anterior border of the infraspinatus on the cartilage junction, where the infraspinatus can move anteriorly and sit on the footprint without undue tension (Fig 3A, B). Biceps tenodesis is performed with 2 pairs of strands from medial anchor, wrapping around the tendon (Fig 4A). During medial tenodesis, the arm should be in external rotation to reduce the strain that may lead to limitation of motion. One suture knot is made at the anterior side of the tendon, and the other is made posterior to the tendon. Two pairs of strand remnants after tenodesis and a pair of strands that is not used for tenodesis are passed through the infraspinatus and supraspinatus tendon at an appropriate point, preparing side-to-side repair on the tenodesed biceps tendon (Fig 4B, C).

The lateral anchor (Healicoil PK; Smith & Nephew, Andover, MA) is inserted at the lateral margin of the footprint (Fig 5A). The point should be where the anteriorly moved infraspinatus and distal portion of tenotomized biceps can lie together. After the lateral anchor is inserted, 1 strand is penetrated through the distal end of the biceps tendon. Then biceps tenotomy is performed with an electrocautery device at the...
Fig 3. A medial anchor is inserted on the medial cartilage junction where the infraspinatus can move anteriorly without undue tension. Half of paired strands are passed underneath the tendon through the anterior portal to prepare the biceps tenodesis. (A) Arthroscopic view from the posterolateral portal of the right shoulder. (B) Schematic view. Abbreviations: BT, biceps tendon; H, humeral head; IS, infraspinatus tendon.

Fig 4. Arthroscopic view from the posterolateral portal of the right shoulder. (A) Using 2 pairs of strands, wrapping tie is performed for medial biceps tenodesis. (B) Two pairs of strand remnants after tenodesis and a pair of strands that is not used for tenodesis passed through the infraspinatus and supraspinatus tendon at an appropriate point, preparing side-to-side repair on the tenodesed biceps tendon. (C) Schematic view of the procedure. Abbreviations: BT, biceps tendon; H, humerus head; IS, infraspinatus tendon; SS, supraspinatus tendon.

Fig 5. Arthroscopic view from the posterolateral portal of the right shoulder. (A) A lateral anchor is inserted where the anteriorly moved infraspinatus and distal portion of tenotomized biceps can lie together. (B) One strand is penetrated through the distal portion of the biceps tendon. Biceps tenotomy is performed at the proximal portion of the transverse humeral ligament. The distal part of the biceps is firmly fixed after tying the passed strand. Before fixation, half of 2 paired strands are passed underneath the tendon through the anterior portal. (C) Schematic view of the procedure. Abbreviations: BT, biceps tendon; IS, infraspinatus tendon; IT, rotator interval tissue.
proximal portion of the transverse humeral ligament to obtain enough length to cover the exposed footprint. The distal part of the biceps is firmly fixed after tying the passing strand (Fig 5B, C). Two strands of the remaining 2 pairs of strands are passed underneath the bicep tendon and through the anterior rotator interval tissue unless the tissue is thin. Abbreviations: BT, biceps tendon; IS, infraspinatus tendon; IT, rotator interval tissue.

Reduction of the Torn Tendon and Final Fixation

Using strands derived from the medial anchor, which already passed the tendons, the supraspinatus tendon is tied with the infraspinatus on the tenodesed biceps tendon with a 1-by-1 approach in a side-to-side suture manner. The retracted supraspinatus tendon sits on the biceps tendon without undue tension. The strands from the lateral anchor also are tied with the infraspinatus tendon to the tenodesed biceps, if possible, together with the rotator interval tissues (Fig 6). Suture bridge fixation can be performed using additional knotless anchors (Multifix S Ultra; Smith & Nephew) for better configuration and firm fixation. Finally, the proximal portion of the infraspinatus tendon is sutured with the supraspinatus tendon on the biceps tendon, and the distal portion of the infraspinatus tendon is repaired with the biceps tendon and the rotator interval tissue unless the tissue is thin (Fig 7A, B). The tenodesed biceps tendon acts as the anterior part of the rotator cable and reinforces rotator cuff repair by suturing the torn cuff with the biceps tendon (Table 1).

Rehabilitation

All patients are required to wear an abduction brace for 1 month. Passive range of shoulder motion is allowed below the waist level on the first day of the operation, when pain is tolerable. Passive range of motion exercise and strengthening exercise are gradually started at 1 month, and strengthening exercise is begun 3 months postoperatively.

Discussion

Biceps augmentation in a different direction or partial repair has been introduced as a surgical repair technique for anterior L-shaped rotator cuff tear. Jeon et al.4 compared biceps augmentation that was performed to cover the cuff footprint in the anterior-to-posterior

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direction by cutting the tendon insertion and partial repair for an anterior L-shaped rotator cuff tear. Despite improved postoperative shoulder function, the retear rate of the 2 techniques was not significantly different (32% in biceps augmentation vs 39% in partial repair). One of the reasons for retear might be poor healing potency between the supraspinatus tendon and biceps tendon in the side-to-end manner and undue tension of the torn supraspinatus tendon that was forcibly pulled to the medial footprint.

In a previous biceps augmentation technique, the biceps tendon lies in the anterior-to-posterior direction; in our technique, the biceps tendon lies relatively in the medial-to-lateral direction, which has several advantages (Table 2). First, it is possible to repair the retracted supraspinatus tendon on the tenotomized biceps tendon instead of on the footprint to reduce tension, which may lead to an increase in the healing rate. Suturing the retracted supraspinatus tendon to the relatively preserved infraspinatus tendon could also decrease the retear rate. As a side-to-side repair with the adjacent tendon is an important factor in force transmission, a side-to-side suture of the supraspinatus and infraspinatus may be worthwhile to restore the integrity of the reconstructed rotator cuff tendon.

Other advantages of tenodesis of the biceps tendon in the medial-to-lateral direction are suturing the infraspinatus tendon together and minimizing the exposed rotator cuff footprint. Lastly, this technique reconstructs the anterior rotator cable using the biceps tendon in a rotator cuff tear normalized the superior migration of the humeral head and subacromial contact pressure. A cadaveric study of tears of the anterior rotator cable resulted in increased gapping and abnormal strain distributions, supporting the important role of the rotator cable.

### Table 1. Surgical Steps with Pearls and Pitfalls

| Surgical Step                              | Pearls                                                                 | Pitfalls                                                                 |
|-------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Analyzing the tear pattern with an arthroscope | Infraspinatus tendon is relatively preserved; moves anteriorly without undue tension | May confuse large-to-massive tear and proceed to superior capsular reconstruction or tendon transfer |
| Insertion of a medial anchor              | Optimal position of the medial anchor is the anterior border of the infraspinatus on the cartilage junction where the infraspinatus moves as anteriorly as possible without undue tension | Insertion of an anchor with an internally rotated shoulder joint may increase the risk of retear and limit shoulder motion |
| Tenodesis of the proximal portion of the biceps tendon | Two pairs of strands wrapping around the biceps tendon make tenodesis stronger | Penetrating the tendon is not recommended because of the possibility of longitudinal tear of the biceps |
| Tenotomy of the biceps tendon             | Pull out the extra-articular portion of biceps tendon by grasper to obtain enough length of the tendon | Should consider the length of the footprint before tenotomy to avoid failure of distal tendon |
| Insertion of a lateral anchor             | The point should be where the anteriorly moved infraspinatus and distal portion of tenotomized biceps can lie together | Far laterally inserted anchor may not be appropriate for tenodesis of the distal portion of the biceps tendon |
| Tenodesis of the distal portion of the biceps tendon | One strand should penetrate the biceps for fixation to prevent sliding or migration of the tenodesed tendon | Inadequate penetration may result in longitudinal tear of the biceps tendon |
| Reduction of tendon and fixation          | Before passage of the strand to the torn tendon, prereduction by a grasper should be performed to confirm the anatomic configuration of the tendon | Reduction of the torn tendon may result in dog-car or bird-beak deformities |

The biceps tendon must be intact to apply this technique. Tenotomy of the biceps can cause a cosmetic issue because of distal bulging of the biceps muscle. Anterior mobilization of the infraspinatus may cause disruption of the balanced force couples of the rotator cuff. A complicated procedure relative to simple repair...
of the rotator cuff, this technique may cause difficulty for surgeons.

**Conclusion**

The tenodesed proximal biceps tendon can act as the anterior part of the rotator cable and reinforce rotator cuff repair by suturing the torn cuff together. Anterior cable reconstruction using the biceps tendon is considered a surgical option for patients with retracted anterior L-shaped rotator cuff tears.

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**Table 2. Advantages and Disadvantages**

| Advantages                                                                 | Disadvantages                                                                                                                                      |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Use of a reliable infraspinatus tendon, which is relatively less torn      | Degeneration or absence of the biceps tendon cannot be indicated                                                                             |
| Suturing the retracted supraspinatus on the biceps tendon without undue tension | Because of tenotomy of the biceps tendon, cosmetic issues can occur with retrieval of the tendon distally                                      |
| Suturing the supraspinatus tendon to the relatively preserved infraspinatus tendon to decrease the retear rate | Relatively complicated procedure compared with the simple side-to-side repair technique                                                         |
| Tenodesis can be applied in the desired position by biceps tenotomy as much as the infraspinatus can be mobilized anteriorly | May interrupt the force couple of shoulder biomechanics by moving the infraspinatus tendon anteriorly                                              |
| Technically easier than superior capsular reconstruction or tendon transfer |                                                                                                |

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