

Arthroscopic Superior Capsular Reconstruction With Biceps Autograft: Snake Technique



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Abstract: Many options have been developed to treat irreparable massive cuff tears. Superior capsular reconstruction has been reported as one of the treatment options for relatively young patients with irreparable massive cuff tear. However, this original technique has a disadvantage of requiring a tensor fascia lata autograft. It requires another incision at the lateral thigh and can be a cause of thigh pain. This article describes our modified technique for arthroscopic superior capsule reconstruction using the biceps autograft to preserve the long head of the biceps tendon anchors to the glenoid labrum (the snake technique).

Introduction

The treatment of massive irreparable rotator cuff tears is a challenge to shoulder surgeons.¹⁻³ There are many treatment options, such as conservative treatment,⁴ arthroscopic debridement and biceps tenotomy,^{5,6} rotator cuff partial repair,⁶⁻⁸ patch augmentation,⁹⁻¹² reverse total shoulder arthroplasty,¹³⁻¹⁵ and superior capsular reconstruction.¹⁶⁻²⁰ Superior capsular reconstruction is a good treatment option for relatively young patients with irreparable massive cuff tear because the superior capsule is the superior restraint to proximal migration of the humeral head.²¹ However, the superior capsular reconstruction technique requires the additional surgical procedure of tensor fascia lata autograft harvesting from the lateral thigh or using a dermal allograft.^{17,19} The technique described here is an

arthroscopic reconstruction of the superior capsule with the biceps tendon autograft preserving the long head of the biceps tendon (LHBT) anchors to the labrum. We called it the snake technique because the reconstructed superior capsule resembles a snake (Video 1).

Surgical Technique

Preoperative Workup

The indications for the snake technique are irreparable massive rotator cuff tears (supraspinatus tear and/or infraspinatus tear and/or subscapularis tear), normal attachment of the LHBT to the glenoid labrum or <20% partial tear of the LHBT, good deltoid muscle, and minimal/no glenohumeral arthritis (Fig 1, Table 1). It is important to check the quality of the LHBT anchors to the labrum with the use of preoperative magnetic resonance imaging or magnetic resonance arthrography (Fig 2).

Patient Position and Diagnostic Arthroscopy

The patient was positioned in the beach-chair table with arms externally rotated and 30° abducted and fixed with the use of a padded arm sleeve (STAR sleeve; Arthrex, Naples, FL) while under general anesthesia. Suprascapular nerve block was added to help the immediate postoperative pain control and initial rehabilitation process.

Posterior viewing portal was made approximately 2 cm medial and 2 cm inferior to the posterolateral corner of the acromion. A standard 30° arthroscope (Arthrex) was introduced, and an anterior portal was

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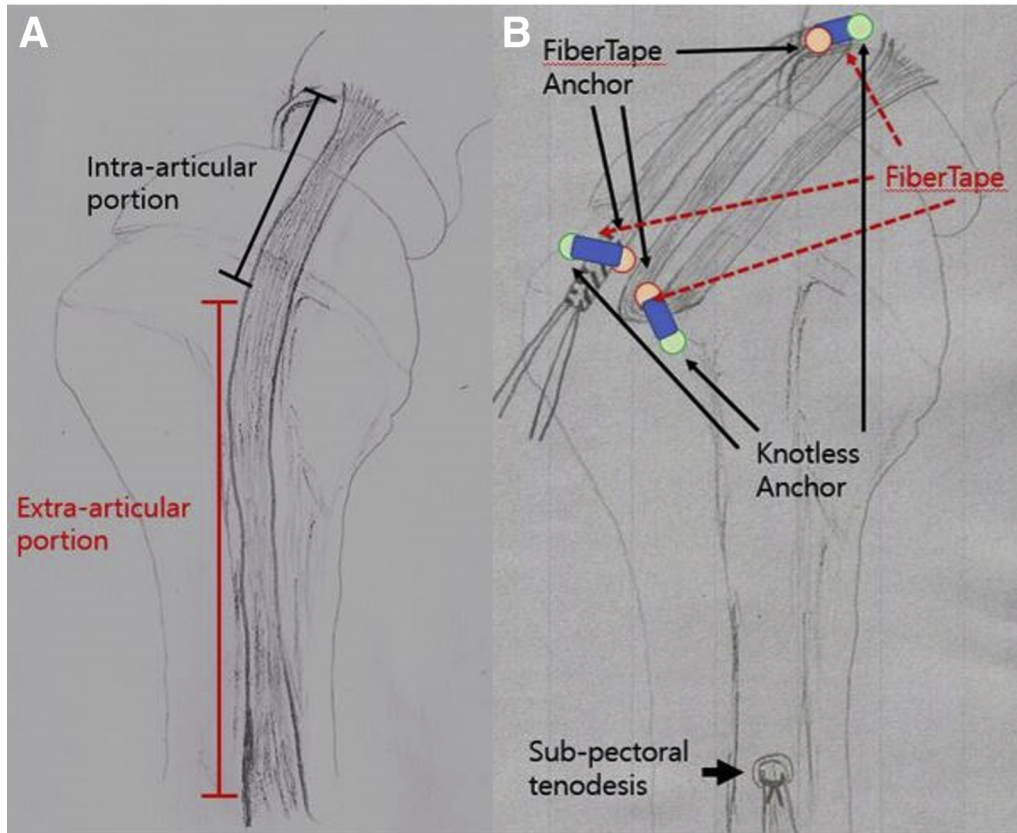


Fig 1. (A) The snake technique uses both intra-articular and extra-articular portions of the long head of the biceps tendon, preserving biceps tendon anchors to the glenoid labrum. (B) Diagram of the snake technique.

made. Diagnostic arthroscopy was performed to examine the glenohumeral joint, the articular side of the supraspinatus tendon, the subscapularis tendon, and the integrity of the LHBT. If the quality of LHBT anchor to the glenoid labrum was not good enough to perform the snake superior capsular reconstruction or the LHBT was partially torn $>20\%$, we chose a different treatment option.

The arthroscope was moved into the subacromial space through the posterior portal to examine the subacromial space. A lateral portal was made approximately 4 cm lateral to the anterolateral corner of the acromion. Bursectomy was performed with a shaver (Arthrex) through the lateral portal and then through the posterior portal. An acromioplasty and a coracoacromial ligament release were performed with the shaver (Arthrocare; Smith & Nephew, Andover, MA) and a burr (Arthrex) if needed. The arthroscope was

moved through the lateral portal, a bursectomy was performed, and a portal of Wilmington (viewing portal) was created.



Fig 2. Preoperative T2-weighted oblique-coronal magnetic resonance (MR) images from a 61-year-old male. It shows massive retracted cuff tear (arrowhead) and intact attachment of the long head of the biceps tendon to the glenoid labrum (arrow).

Table 1. Indications for the Snake Technique

Irreparable supraspinatus and/or infraspinatus tears
Severe shoulder pain with failed conservative management
Good quality of the long head of the biceps tendon anchors to the glenoid labrum (normal or $<20\%$ partial tear)
Minimal to no glenohumeral arthritis

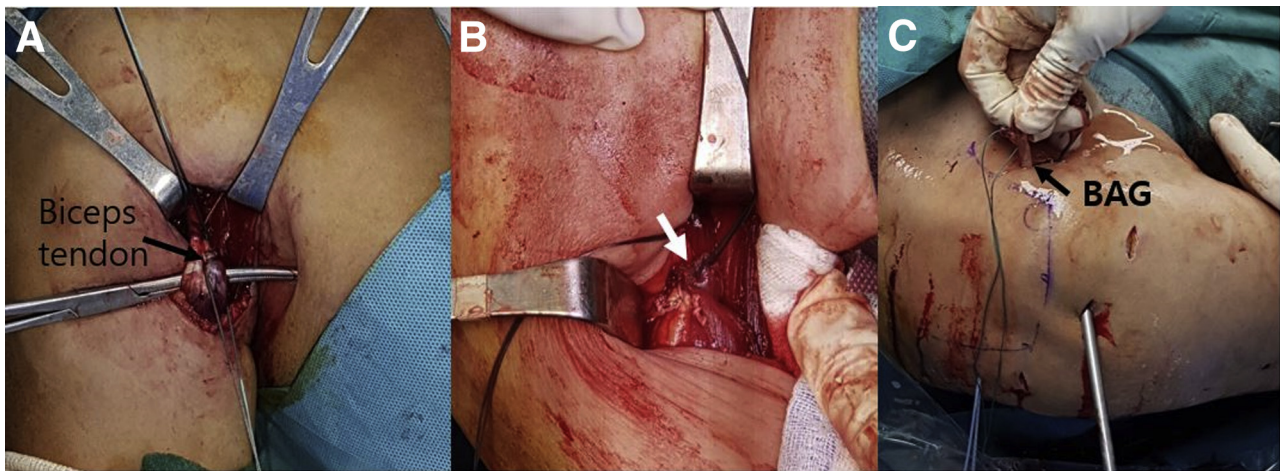


Fig 3. Harvesting of biceps autograft (BAG) and open subpectoralis tenodesis. (A) Running-locking sutures above and under biceps tendon. (B) Subpectoralis biceps tenodesis (arrow) performed with the 5.5-mm Corkscrew FiberTape anchor (Arthrex). (C) BAG was pulled through the shoulder joint.

Open Subpectoralis Biceps Tenodesis and Biceps Autograft Preparation

After confirmation that the quality of the LHBT was sufficient, an approximately 3-cm longitudinal skin incision was made at the inferior border of the pectoralis major tendon and anteromedial aspect of the humerus. The subcutaneous tissues were dissected with use of an electrical cautery device (Megadyne; Ethicon, Somerville, NJ). Dissection was directed to the humerus medially so as not to touch the neurovascular structure. We identified the LHBT through palpation of the bicipital groove. The snake technique requires approximately 14 cm of the LHBT. We decided the biceps autograft (BAG) length based on the tenotomy level. Running-locking sutures (Ethibond Excel; Ethicon) were placed above and under the biceps tenotomy level, and then biceps tenotomy was performed. Subpectoralis biceps tenodesis was performed with the 5.5-mm Corkscrew FT anchor (Arthrex). We performed finger sweeps through the bicipital groove from the subpectoralis tenotomy area to the subacromial space. While pulling the BAG in the distal direction, we peeled the surrounding soft tissue including the mesotendon attached to the BAG with the use of our fingers and a curved Metzenbaum scissor.

The arthroscope was placed at a viewing portal, and the wire-passer was inserted from the anterior portal along the biceps groove into the subpectoralis biceps tenodesis site. Next, the BAG was retrieved and moved from the subpectoralis lesion to the subacromial space by using the wire-passer or Ethibond suture (Fig 3). The diameter and length of the harvested BAG were measured with the use of a ruler. The fixation position of the BAG on the greater tuberosity of the humerus was determined by considering the rotator cuff defect size and the diameter and length of the BAG.

An additional posterior portal (posteromedial [PM] portal) was created approximately 2 cm medial to the posterior portal, and an additional anterior portal (anteromedial [AM] portal) was created approximately 2 cm medial to the anterior portal (Fig 4). The posterosuperior glenoid and greater tuberosity of the humerus bone beds were decorticated for BAG attachment by using a shaver and burr. The anterosuperior labrum where the LHBT anchors to the glenoid labrum was left intact. We used a laser-marked probe (Arthrex) to measure the anterior-to-posterior and medial-to-lateral cuff tear sizes, diameter of the LHBT, and length of the intra-articular portion of LHBT through the anterior portal and the viewing portal (Fig 5).

Next, 8.25-mm × 7-cm cannulas (Arthrex) were inserted in the AM, PM, and lateral portals to facilitate instrumentation. A Neviaser portal was created, and a 5.5-mm SwiveLock anchor with attached swedged FiberTape (Arthrex) was placed percutaneously

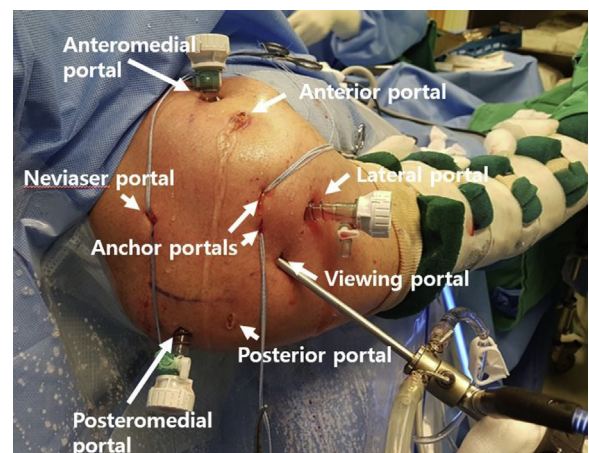


Fig 4. Portals used in the snake technique.

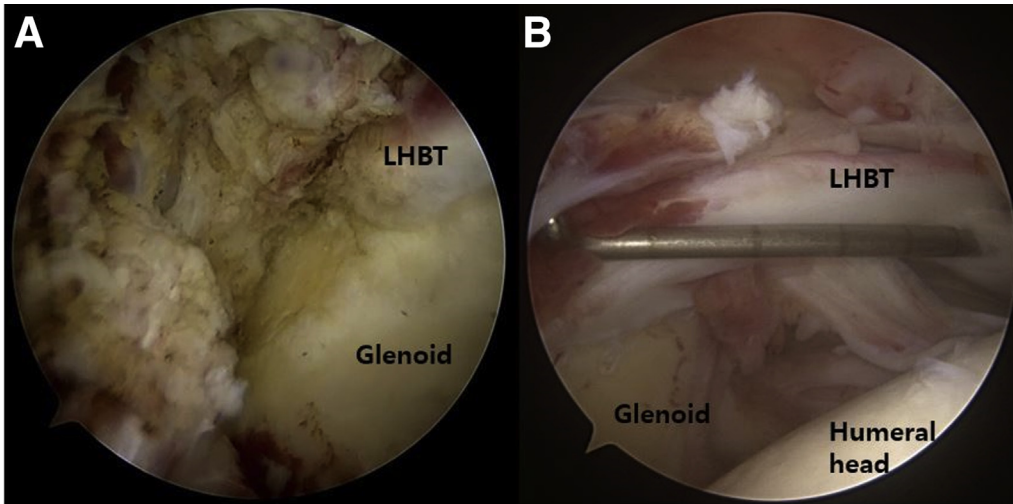


Fig 5. (A) Posterosuperior glenoid was decorticated with a burr. The long head of the biceps tendon (LBHT) condition must be checked before superior capsular reconstruction. (B) Laser-marked probe was used to measure anterior-to-posterior and medial-to-lateral cuff tear size, diameter of the LHBT, and length of intra-articular portion of LHBT.

through a Neviaser portal on the PM lesion of the glenoid. If the size of the glenoid bone was not large enough to insert a 5.5-mm SwiveLock anchor with attached swedged FiberTape, we used an all-suture anchor (2.8-mm Q-FIX; Smith & Nephew) (Fig 6). Through anchor portals, we placed 2 SwiveLock 5.5-mm anchors with attached swedged FiberTape into the lateral margin of the footprint of the greater tuberosity of the humerus both anteriorly and posteriorly.

First Bundle (Fixation on Anterior Portion of the Greater Tuberosity of the Humerus)

The distal part of the harvested BAG was pulled to the subacromial space. A 5.5-mm SwiveLock anchor with attached swedged FiberTape was inserted by using an anchor portal. The first bundle of the BAG was affixed at the greater tuberosity of humerus by using inserted FiberTape and a knotless anchor (5.5-mm SwiveLock; Arthrex) while

pulling the BAG in the lateral direction (Fig 7A). If the fixation was insufficient, we used additional sutures with FiberWire loaded together with a 5.5-mm SwiveLock anchor and attached swedged FiberTape (Fig 7B). After fixation, we checked that the tension of the first bundle was correct and that the attachment of the LBHT to the glenoid labrum was not detached from the glenoid.

Second Bundle (Fixation on the Glenoid)

A 5.5-mm SwiveLock anchor with attached swedged FiberTape was inserted into the posterior glenoid through the Neviaser portal. We inserted it into the medial side of the glenoid as far as possible. The distal part of the BAG was pulled through a PM portal. While we were maintaining the graft tension through a PM portal, the BAG was fixed using FiberTape and a knotless anchor (Swivelock; Arthrex) at the articular surface margin of the glenoid through the posterior

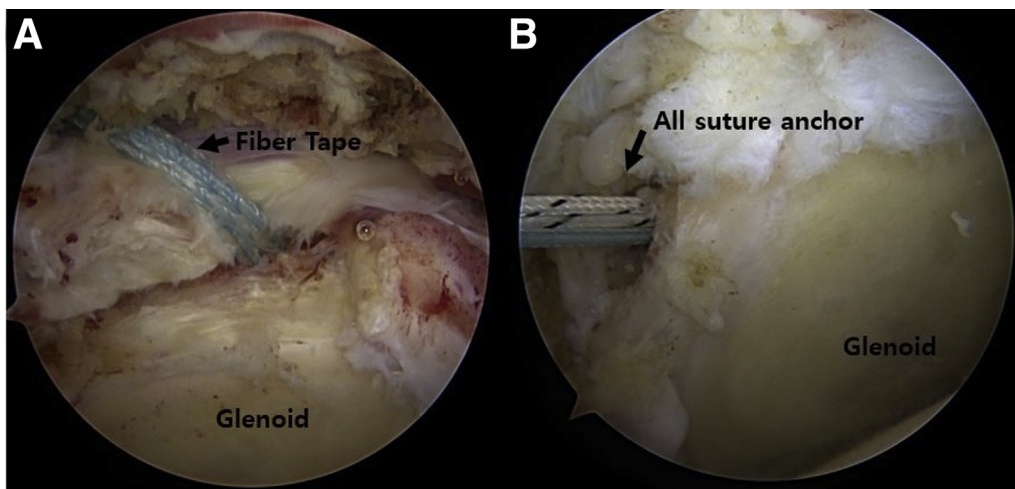
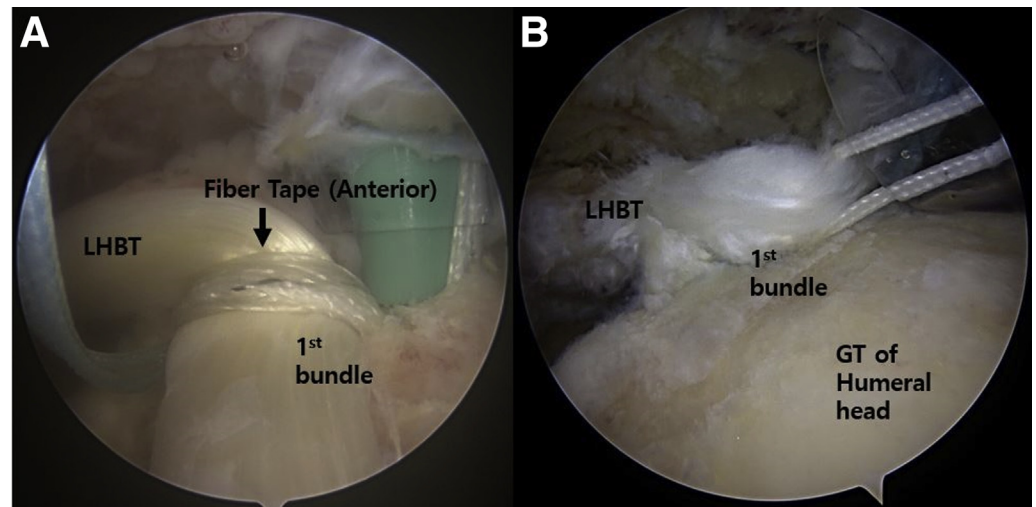


Fig 6. (A) Glenoid preparation and a 5.5-mm SwiveLock anchor with attached swedged FiberTape. (B) If glenoid was too small to insert a 5.5-mm SwiveLock anchor, we used an all-suture anchor.

Fig 7. First bundle. (A) FiberTape and knotless fixation. (B) Additional suture.



portal. If the glenoid was too small or too weak to insert 5.5-mm SwiveLock anchor with attached swedged FiberTape, we used an all-suture anchor (Fig 8).

Third Bundle (Fixation on Posterior Portion of the Greater Tuberosity of the Humerus)

If it is not sufficient to restore a superior capsule with 2 bundles, we made a third bundle. A 5-mm SwiveLock anchor with attached swedged FiberTape was inserted into the greater tuberosity of the humerus posteriorly considering the second bundle position. The remainder of the BAG was pulled through the lateral portal, and we applied the appropriate tension during fixation of the BAG using FiberTape and a knotless anchor. If the BAG was not long enough for knotless fixation, a single stitch was performed (Fig 9A). After performing superior capsular reconstruction, remnant rotator cuff partial repair was performed to the posterior reconstructed superior capsule (Fig 9B). The stability of the reconstructed superior capsule was checked using a probe (Table 2).

Postoperative Care

Postoperatively, the patient was treated by our hospital's massive cuff repair protocol. After surgery, the patient was applied with shoulder abduction brace immediately. The patient was restricted with shoulder joint motion and because we performed open subscapularis biceps tenodesis in all patients, even passive motion of the elbow was prohibited during the entire brace application period. Passive motion was started 6 to 8 weeks postoperatively after removal of the brace. Active range of motion typically started after 12 weeks, and external rotation strengthening exercises started after 16 weeks.

Discussion

The superior capsule is a static stabilizer of the glenohumeral joint.^{20,22} The absence of a superior capsule causes superior migration of the humeral head and accelerates cuff tear arthropathy.²⁰ Mihata et al.¹⁹ reported use of a superior capsular reconstruction

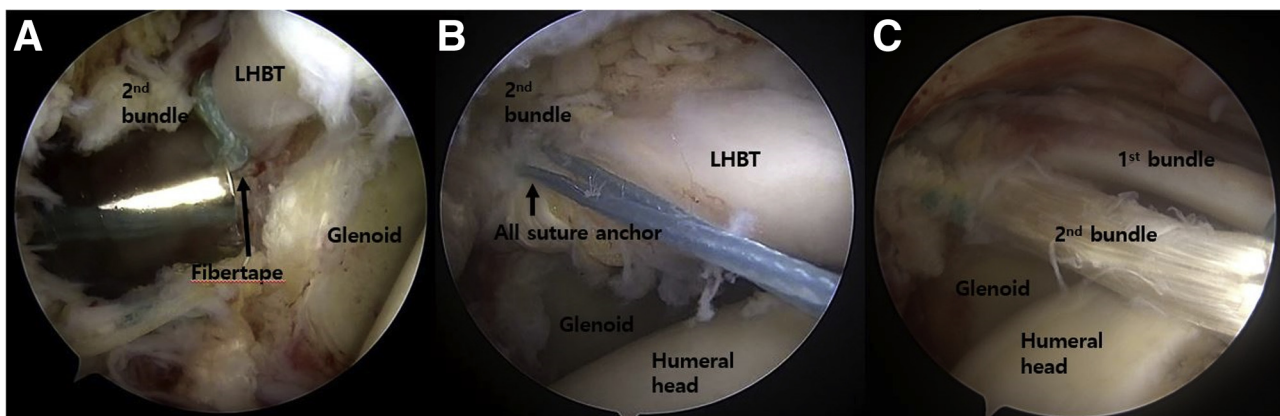


Fig 8. Second bundle. (A) FiberTape and knotless fixation. (B) All-suture anchor fixation. (C) If it was sufficient to restore a superior capsule with 2 bundles, we made 2 bundles only.

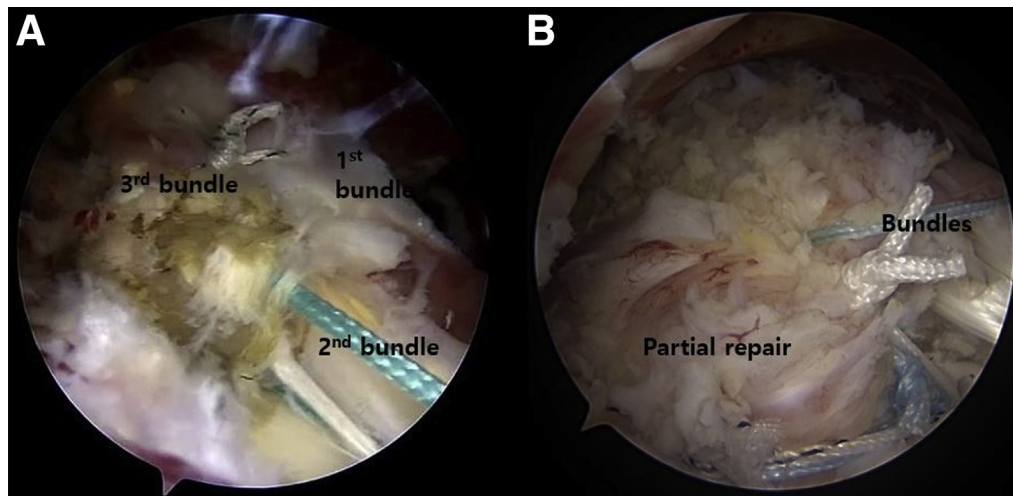


Fig 9. (A) Third bundle fixation. If the long head of the biceps tendon was not sufficient for FiberTape and knotless fixation, single-row repair was performed. (B) Partial repair was performed to posterior reconstructed superior capsule.

technique with tensor fascia lata autograft to restore the normal restraint to superior translation that leads to deficient rotator cuff. This technique is especially good for relatively young irreparable massive cuff tear patients in that it has few complications and it is possible to switch to a salvage procedure such as reverse

total shoulder arthroplasty when retear or reoperation is needed. However, this technique has the disadvantage of requiring tensor fascia lata autograft harvesting and donor site morbidity such as lateral thigh pain.¹⁶⁻²²

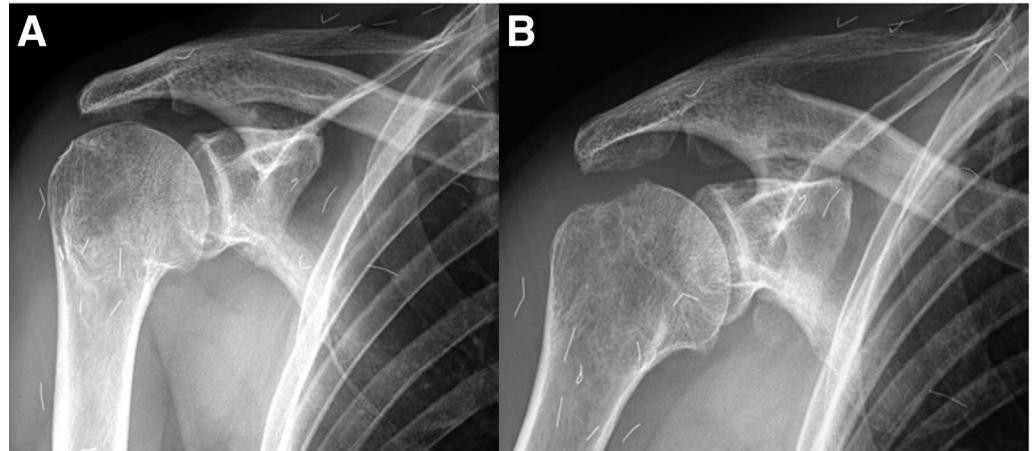
Many surgeons have tried to use the LHBT to treat patients with irreparable massive cuff tear. Sano et al.²³

Table 2. Surgical Key Steps With Pearls and Pitfalls

Key Steps	Pearls	Pitfalls
Diagnostic arthroscopy	Check the attachment of the long head of the biceps tendon to the glenoid labrum.	If >20% of the LBHT partial tear or <5 mm of the LBHT thickness, this technique cannot be performed with BAG.
Acromioplasty and coracoacromial ligament release, bursectomy	Bursectomy is performed enough to view entire cuff tear and glenoid.	
Humeral and glenoid bone bed preparation and anchors insertion	A spinal needle should be used to localize the portals. Bone bed should be debrided sufficiently.	If glenoid anchors are inserted too laterally, a fracture in the glenoid can occur.
Biceps tenodesis and Biceps autograft preparation	For graft passage, soft tissues around the biceps tendon should be completely released for easy BAG harvesting and passing into the shoulder joint.	If incision is made too medially, the musculocutaneous nerve can be injured. When performing biceps tenodesis, be careful not to cause a humerus shaft fracture when fixing the suture anchor. Be careful with the anchor malposition or pull out.
First bundle	The biceps should be fixed with the arm in neutral rotation at 30° of abduction. Shorten the operation time and maximize healing surface area with knotless fixation using FiberTape.	
Second bundle	Pull the BAG through a posteromedial portal and fix it with proper tension.	If the size of the glenoid bone is not large enough to insert a SwiveLock anchor, use an all-suture anchor.
Third bundle (if needed)	Pull the BAG through the lateral portal and fix it with tension.	If the length of the biceps autograft is not long enough for FiberTape knotless fixation, perform single-row suture.
Partial repair (if needed) and final inspection, portal closing	Do not apply too much tension when performing partial repair. If rotator cuff is not sufficiently mobile, try a partial repair at the greater tuberosity just posterior the third bundle.	Do not attempt to repair one bundle with another bundle.

BAG, biceps autograft; LBHT, superior capsular reconstruction.

Fig 10. (A) Preoperative and postoperative shoulder Rockwood view radiographs from a 61-year-old male. (A) Preoperative radiograph shows superior humeral head migration (Hamada classification grade II). (B) Postoperative radiograph shows inferior humeral head migration (5 to 13 mm) compared with preoperative radiograph.



reported the clinical outcomes using the LBHT as a patch graft. However, this kind of interposition technique differs from superior capsular reconstruction (SCR). Recently, Kim et al.²⁴ reported in situ SCR via LBHT rerouting. By rerouting the LBHT, the superior migration of the humeral head is restricted through the application of a downward force on the humeral head, and the LBHT itself forms part of the superior capsule, but it is difficult to reconstruct the complete superior capsule. In both studies, only the intra-articular part of the LBHT had used. However, we used not only intra-articular side but also the extra-articular side of the LHBT to obtain sufficient graft.

We demonstrated a new SCR technique in this report. We harvested an average 14-cm length (range 12 to 17 cm) of the BAG, which is long and thick (average 6.5 mm, range 5 to 10 mm) enough to make 2 or 3 bundles with our technique. LHBT can be taken easily during shoulder surgery, and it is unnecessary to prepare other parts of the body such as the hip and knee for autograft harvesting. This technique does not require additional incisions other than shoulder. Unlike dermal allografts, this is a BAG, so the risk of complications due to allografts such as postoperative infection is relatively low. One of the greatest advantages of the snake technique is that the size of reconstructed capsule can be modified by adjusting the number of bundles in the middle of the operation, thus reducing the operation time required for rotator cuff tear size measurements. In most cases, SCR was possible with 2 bundles, although occasionally 3 bundles were required.

Another advantage of the snake technique is that the BAG passage is easy. Mihata et al.¹⁹ recommended making autografts with a thickness of ≥ 8 mm, which is technically difficult to pass through the lateral portal. The total bundle thickness using BAG varies from 5 to 10 mm, but the graft passage is relatively easy because it is fixed by dividing each bundle. In addition, preservation of the LBHT anchors to the labrum will result in

a better proprioception and more favorable healing of the reconstructed superior capsule because the blood supply is maintained. Compared with preoperative radiographs, postoperative radiographs showed restored center of rotation of humeral head (Fig 10).

A limitation is that this technique requires a good-quality LBHT. This technique cannot be indicated in patients with $>20\%$ partial tear of biceps tendon itself or severe biceps tendinitis. We also excluded patients who had biceps tendon <5 mm thick. Thus, it is important to check the quality of anchors of LHBT with preoperative magnetic resonance imaging and physical examination.

We fixed each bundle with a knotless technique using FiberTape, which enabled strong fixation by pressing a wide cross section during a relatively short operation time. The snake SCR technique with BAG can be one of the useful surgical treatment options for irreparable massive rotator cuff tears.

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