Technical Note

Arthroscopic Acromiograft for Large-to-Massive Rotator Cuff Tears: A Rescue Technique for Restoring Shoulder Stability

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Abstract: A large-to-massive rotator cuff tear is a complicated disease for an orthopedic surgeon to get the best results and prevent complications like retears or progression to arthropathy. Although there are several surgical options for managing these tears, there is still no gold standard treatment. The key point in the solution would be preventing the upward migration of the humeral head to create a biomechanically stable joint to promote rotator cuff healing. In this article, we introduced a technique called an acromiograft, in which the allograft is attached to the undersurface of the acromion.

Introduction

A wide variety of surgical techniques, such as partial repair, biceps augmentation, tendon transfer, and superior capsular reconstruction, have been introduced as treatment methods for large-to-massive cuff tears.[1-5] The reason why there are so many options is that it is difficult to treat it completely, and there is no gold standard treatment method for massive cuff tears yet.

Recently, the superior capsular reconstruction (SCR) technique was introduced and is gaining popularity.[6] Even though the clinical outcomes of SCR were reported to be favorable,[6,7] it is a technically difficult and time-consuming procedure with donor site morbidity.[8] Moreover, graft failure on the humeral side has been reported due to greater stress with movement and greater abrasion via acromiohumeral contact.[9]

As a countermeasure against these problems, the arthroscopic biceps rerouting (BR) technique was introduced as a new method for large-to-massive cuff tears without harvesting an autograft, which was originally named in situ SCR.[10] A cadaveric biomechanical study showed that BR restored shoulder stability in patients with large-to-massive cuff tears, in which superior humeral translation was significantly decreased by the BR method compared to the partial repair of large-to-massive cuff tears.[11] The preliminary outcome of this technique is satisfactory.[12] However, if the long head of the biceps is not healthy enough for rerouting because of severe tendinopathy or partial tear, this technique cannot be used.

To address this shortcoming, this study proposed another rescue technique. On the basis of the

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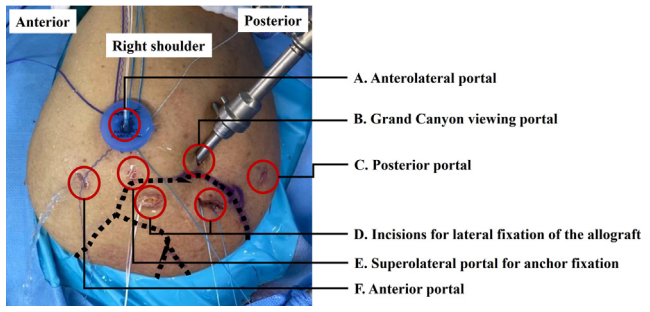

Fig 1. Portals and incisions in the lateral decubitus position. (A) anterolateral portal. (B) Grand canyon viewing portal. (C) Posterior portal. (D) Incisions for lateral fixation of the allograft. (E) Superolateral portal for anchor fixation. (F) Anterior portal.

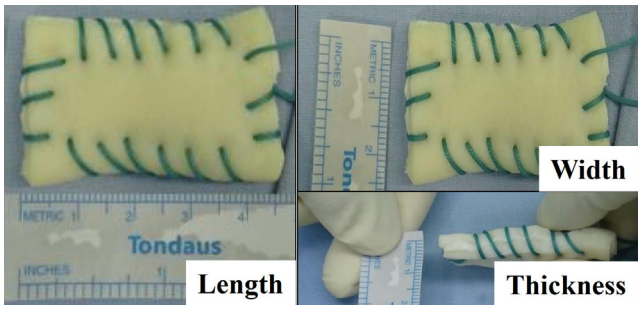

Fig 2. Prepared human acellular dermal matrix. We fold it 4 cm wide and 2 cm long, and about 6 mm thick using nonabsorbable sutures.

biomechanical principle of creating a functioned shoulder with a downward humeral head,[6] it is a technique to pile the allograft down under the acromion rather than pile it up on the greater tuberosity of the humerus. This Technical Note describes the arthroscopic fixation of the allograft to the bottom of the acromion for large-to-massive cuff tears. We named this technique an acromiograft.

Surgical Technique (Video 1)

Patient Positioning

The patient was prepared in a routine manner, in the lateral decubitus position on a beanbag under general endotracheal anesthesia. The position of the arm was placed at 30° to 40° abduction and 15° to 20° forward flexion. Ten to 15 pounds of traction was applied using an arm sleeve.

Portal Placement and Examination of the Glenohumeral Joint and Subacromial Space

A standard posterior portal is used for viewing, and an anterior portal is placed between the anterolateral edge of the acromion and the tip of the coracoid after checking with the spinal needle, which is suitable for working on the glenohumeral joint. A routine examination is done for detecting subscapularis tendon tears and bicep or labral lesions. After examining the glenohumeral joint, we switched the arthroscope to the subacromial space through the Grand Canyon viewing portal. Then, we make the anterolateral portal in line with the extension of the anterolateral edge of the acromion. A bursectomy is done by an arthroscopic shaver (Advantage Turbo; ConMed, Largo, FL). We measure the anteroposterior tear size and amount of retraction of the torn supraspinatus and determine the tear pattern (Fig 1).

We repair the torn supraspinatus tendon before performing the acromiograft. Medialization is performed about 8−10 mm from the footprint of the tendon. We prepare a bone bed for the repaired tendon using an arthroscopic burr (5.5-mm spherical burr; ConMed) and are careful not to damage the area where the anchor suture would be placed. In the case of delaminated tears, a separate double-row repair or bridge repair is performed. In the case of a massive rotator cuff tear that cannot be covered by the remaining cuff tissue, a partial repair is possible.

Preparation of the Bone Bed of the Undersurface of the Acromion and Allograft and Fixation

To ensure clear visualization, complete bursectomy and soft tissue removal are performed using an electrocautery device (vapor suction electrodes; Depuy Synthes Mitek, Raynham, MA) and a shaver in the subacromial space. After that, we perform skeletalization and decortication of the bone bed of the undersurface of the acromion with an arthroscopic burr (5.5-mm spherical burr; ConMed).

We use a human acellular dermal matrix (Bellacell HD; Hanscare, Seoul) as a spacer to attach under the acromion. We fold and make it 4 cm wide and 2 cm long, and about 6 mm thick to maximize its role as a spacer under the acromion (Fig 2). It is stitched not to

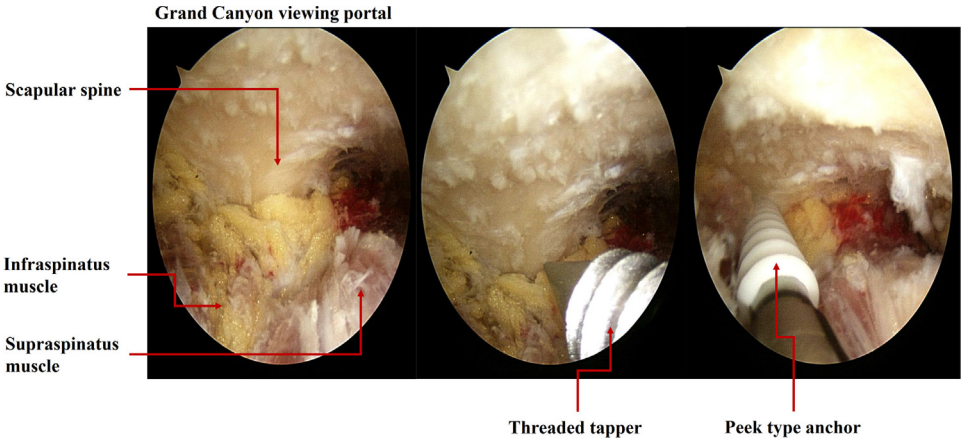

Fig 3. Posteromedial anchor fixation for the medial side of the allograft. We use PEEK type anchor on the scapular spine. A tapping is required as the bones in this area are very hard. And care should be taken not to damage the infraspinatus branch of the suprascapular artery and nerve.

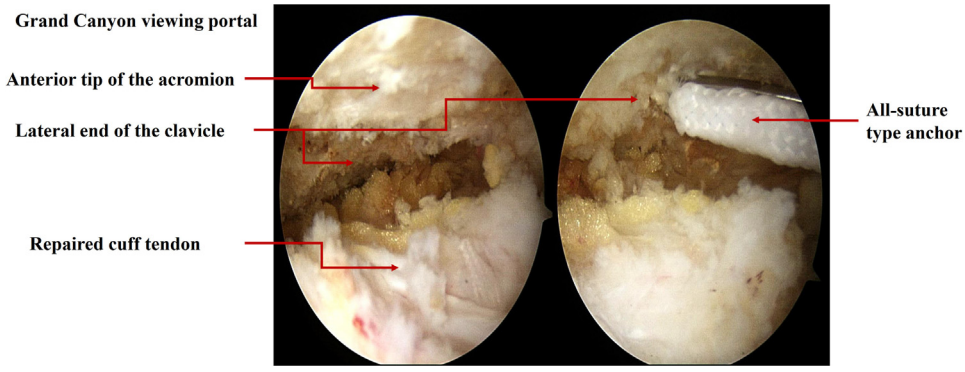

Fig 4. Anteromedial anchor fixation for the medial side of the allograft. We use all-suture type anchor on the end of the clavicle. The soft tissue under the acromioclavicular joint should be removed to obtain clear visualization and firm fixation of the anchor.

furl and also tagged anterolateral, posterolateral edge so that it will not turn over in the subacromial space.

To fix the allograft of the human acellular dermal matrix under the acromion, the medial side of the human acellular dermal matrix is fixed with two medial anchors. The lateral side of the dermal matrix is fixed with two fiber wires passing through the acromion. For the fixation of the medial side of the allograft, an anteromedial anchor (IconixSpeed, Stryker, Kalamazoo, MI) is fixed to the end of the clavicle, and a posteromedial anchor (Healicoil PK Suture Anchors, Smith & Nephew Endoscopy, Andover, MA) is fixed to the base of the scapular spine. When preparing the bone bed at the base of the scapular spine, care should be taken not to damage the infraspinatus branch of the suprascapular artery and nerve. Since the bones in this area are very hard, tapping is required before fixing the anchor (Fig 3). The anteromedial anchor will be placed under the surface of the lateral end of the clavicle, so the soft tissue under the acromioclavicular joint should be removed to obtain clear visualization and firm fixation of the anchor to the distal end of the clavicle (Fig 4). One of each thread from the anteromedial and posteromedial anchors on the medial side is withdrawn into the anterolateral portal. We pass it through holes 5 mm from the inner corner of each medial side of the allograft.

For the fixation of the lateral side of the allograft, we make a 1-cm skin incision at the front and rear of the

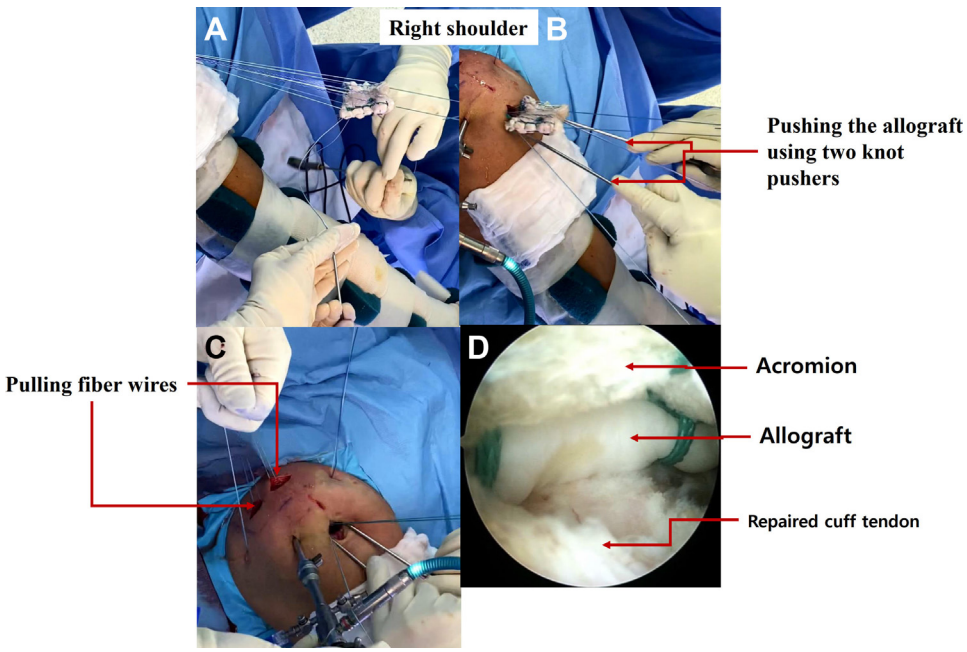

Fig 5. Pushing the allograft into the subacromial space. (A, B) We use a two-knot pusher to push down the allograft. (C) While pressing the knot pusher and pulling the thread pulled from the acromion side together, the allograft is inserted. (D) The allograft is attached to the undersurface of the acromion in the subacromial space.

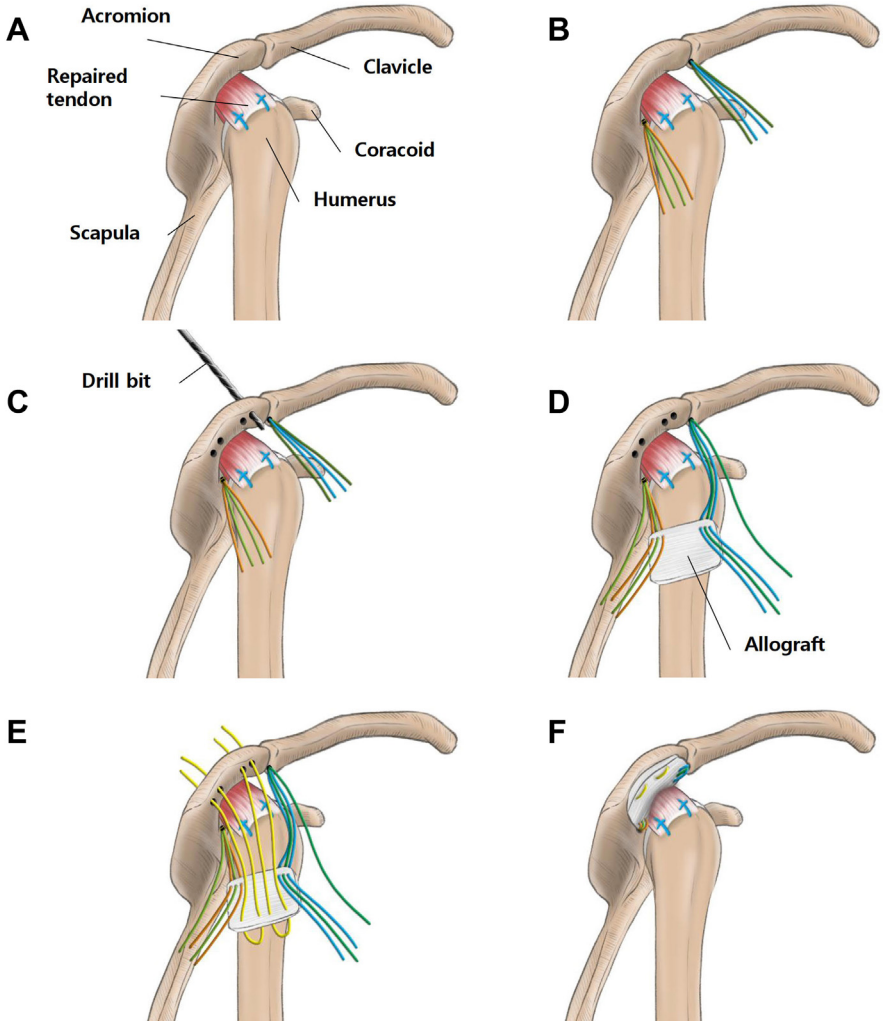

Fig 6. A. Illustration of the right shoulder with lateral decubitus in the partial repair state. (B) All suture-type anchors were fixed to the distal end of the clavicle. A PEEK-type anchor is fixed to the base of the scapular spine. (C) We use an electric drill to make the lateral hole on the acromion. (D) The allograft is sutured with threads from the medial side of each anterior and posterior anchor. (E) A thread from the lateral hole passes through the allograft and returns to the lateral hole beside the starting hole. (F) All the process of allograft fixation is completed.

acromion (Fig. 1). Anterolateral skin incisions are made 5 mm proximally and posteriorly to the anterolateral edge of the acromion and a posterolateral skin incision is made 5 mm proximally and anteriorly to the posterolateral edge of the acromion in the same manner, above the acromion bone. We drill a pair of holes through the skin incisions on the anterolateral and posterolateral sides of the acromion. The interval between each hole is about 5 mm. We withdraw the fiber wires passed through one hole of the anterolateral and posterolateral parts using a spinal needle to the anterolateral portal in the subacromial space. We make this fiber wire pass through 5 mm from the inner corners of the lateral side of the allograft. Each fiber wire is first passed through the allograft from top to bottom and then passed through the allograft again from

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
- Tapping is needed when you fix the anchor on the scapular spine. - Tagging the allograft not to furl - Gentle traction and pushing using two knot pushers	- With insufficient debridement, orientation of the structure can be confusing. - Care should be taken not to damage the infraspinatus branch of artery and nerve.

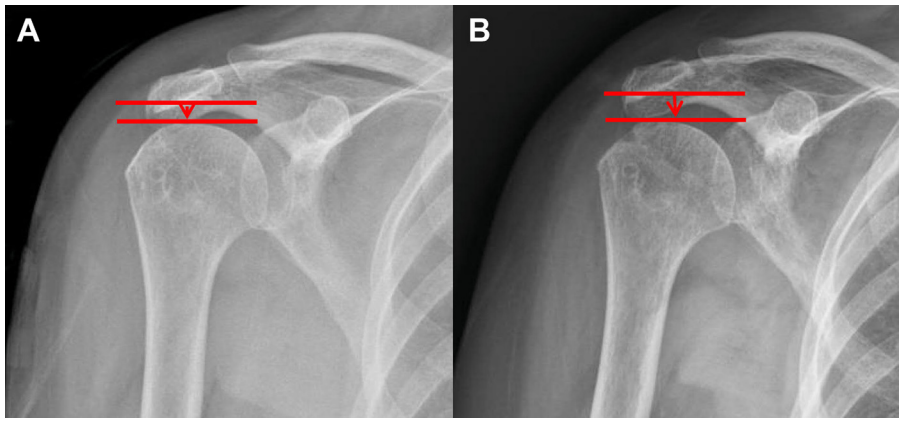

Fig 7. Plain X-ray of the anteroposterior view of the shoulder. (A) In the preoperative X-ray, the acromiohumeral distance was 7.1 mm. (B) In the postoperative X-ray, the acromiohumeral distance was enlarged to 9.4 mm.

bottom to top at an interval of about 5 mm. Then, we pull out the thread that passed through the allograft into the remaining drill hole at the lateral side of the acromion using a shuttle relay.

After we perform the above preparations, two-knot pushers for each thread from the anteromedial and posteromedial anchors are used to push the allograft down along the thread to its final position under the acromion. We use two-knot pushers to push the allograft inside, while simultaneously pulling the fiber wires taken from the anterolateral and posterolateral sides of the acromion and deliver it to make contact under the acromion (Fig 5). All surgical procedures are expressed in order using illustrations for easy understanding (Fig 6) (Table 1).

An immediate postoperative plain radiograph of the anteroposterior view of the shoulder reveal that the acromiohumeral distance is significantly increased to 9.4 mm from 7.1 mm (Fig 7). Two months after surgery, follow-up magnetic resonance imaging (MRI) show that the allograft is well fixed to the undersurface of the acromion (Fig 8).

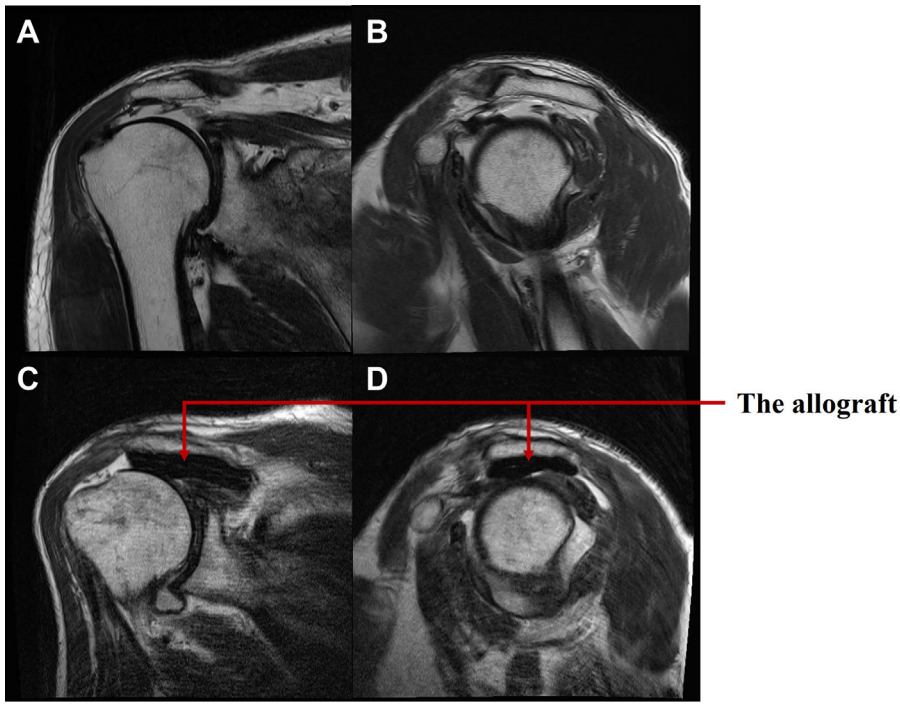

Fig 8. MRI findings. (A, B) The preoperative MRI (T2, oblique coronal) showed a massive cuff tear. (C, D) In the postoperative MRI (T2, oblique sagittal), the allograft was well fixed to the undersurface of the acromion 2 months after surgery.

Table 2. Important Concepts and the Limitations

Important Concepts	Limitation
Widening the acromiohumeral interval	Risk of fracture in case of thin acromion
Pulling down the humeral head	
Subacromial spacer	
Humeral stability	

Postoperative Rehabilitation

We usually apply an interscalene block to alleviate postoperative pain. Postoperative rehabilitation starts the day after surgery with an abduction brace. Continuous passive motion (CPM) is allowed only for forward flexion in the painless range. Four weeks after surgery, the patient is allowed to begin pendulum and pulley exercises. Active range of motion starts after 8 weeks. Muscle-strengthening exercises are allowed from 12 weeks after surgery.

Discussion

The basic concept of this technique is widening the acromiohumeral interval (AHI) by pulling down the humeral head. This concept follows the concept of a balloon.[12,13] We believe the fixed allograft functions as a spacer in the subacromial space to prevent proximal migration of the humeral head and finally, attains humeral stability.[9,14-16] (Table 2).

We introduced the technique of attaching a sufficiently thick allograft to the undersurface of the acromion to achieve joint stability by pressing the humeral head down. There are some advantages of using this technique over the other methods that have been introduced so far. This technique does not have harvest site morbidity, which is a common problem of SCR using an autograft. Since the allograft was attached to the undersurface of the acromion instead of over the greater tuberosity, there was the advantage of avoiding crowding of the anchors to be fixed to the greater tuberosity. As a result, it could be more easily and quickly implemented, free from the problem of twisting the thread. In addition, the size of the area underneath the acromion to which the allograft is attached is 894.77 mm^2 (AP: 41.007 mm × ML: 21.82 mm)[17] and the footprint of the greater tuberosity is 333.54 mm^2 (AP: 32.7 mm × ML: 10.2 mm).[18] We can expect a higher rate of allograft tendon healing on the bone underneath the acromion than on the footprint of the greater tuberosity since the bone bed area for biological healing is much broader than that of the greater tuberosity. During surgery on retear cases, it is frequently observed that the retorn tendon is attached to the undersurface of the acromion where acromioplasty was performed.[19] Judging from this, it is thought that for tendon-bone healing, the static undersurface of the acromion is more advantageous than the round, moving greater tuberosity (Table 3).

Also, in the case of SCR, if the undersurface of the acromion is uneven, the graft may be worn during humeral rotation after surgery.[20] We can avoid those worries by implementing a rescue technique, the acromiograft. Because we can repair a torn cuff tendon while performing an acromiograft, the fixed allograft can serve as a static stabilizer by placing the spacer in the subacromial space while maintaining dynamic stabilization of the rotator cuff.

There are a few points to be aware of when performing this technique. To attach the allograft to the undersurface of the acromion, we made a pair of holes on the acromion with an electric drill. It is necessary to ensure the orientation of the acromial contour by sufficient visualization. The thickness of the acromion varies from person to person, so a patient who has a thin acromion needs attention. The preoperative evaluation of the acromion should be done using a plain radiograph or computed tomography.

One report regarding subacromial allograft fixation was found in the literature.[14] However, our technique is entirely different from that. The previously published technique was the addition of an allograft in the subacromial space with the remaining allograft after SCR. In contrast, our rescue technique is a procedure for both repairing the rotator cuff itself and attaching an allograft with enough thickness under the acromion. The graft in our technique is thick enough to act as a spacer, whereas the graft used in the previous technique was too thin to press down the humeral head, and we do not know how it will perform in restoring humeral stability. In a cadaveric study subsequently published by these authors, their technique widened the acromiohumeral interval, but the subacromial pressure also increased.[21] This was probably due to low interest in the dynamic stabilizer as a technique, focusing only on static stabilizers. Unlike our approach, these techniques focused only on static stabilizers. That is, only the superior capsule was reconstructed without repairing the torn tendon. Therefore, we can easily postulate that the subacromial pressure rose because there was no dynamic stabilizer.

To summarize, our technique, the acromiograft, is considered an effective procedure for patients with irreparable large-to-massive cuff tears. It is a spacer to

Table 3. Advantages and Disadvantages

Advantages	Disadvantages
No donor site morbidity	Not feasible for patients who have thin acromion
No anchor crowding on humeral head	Costs of allograft
Relatively easier technique than conventional SCR	Risk of infection due to allograft
Act as a spacer	

restore humeral stability that can replace the role of SCR and is another option for patients with massive cuff tears along with poor bicep tendons in whom BR is not indicated. Further clinical trials should be conducted to investigate the long-term benefits of this technique and identify the best indications for this technique.

References

1. Elhassan BT, Sanchez-Sotelo J, Wagner ER. Outcome of arthroscopically assisted lower trapezius transfer to reconstruct massive irreparable posterior-superior rotator cuff tears. *J Shoulder Elbow Surg* 2020;29:2135-2142.
2. Mihata T, McGarry MH, Kahn T, Goldberg I, Neo M, Lee TQ. Biomechanical role of capsular continuity in superior capsule reconstruction for irreparable tears of the supraspinatus tendon. *Am J Sports Med* 2016;44:1423-1430.
3. Pandey R, Tafazal S, Shyamsundar S, Modi A, Singh HP. Outcome of partial repair of massive rotator cuff tears with and without human tissue allograft bridging repair. *Shoulder Elbow* 2017;9:23-30.
4. Rhee YG, Cho NS, Lim CT, Yi JW, Vishvanathan T. Bridging the gap in immobile massive rotator cuff tears: augmentation using the tenotomized biceps. *Am J Sports Med* 2008;36:1511-1518.
5. Rho JY, Kwon YS, Choi S. Current concepts and recent trends in arthroscopic treatment of large to massive rotator cuff tears: A review. *Clin Shoulder Elb* 2019;22:50-57.
6. Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthroscopy* 2013;29:459-470.
7. Yoon JY, Kim PS, Jo CH. Clinical and radiological results after athroscopic superior capsular reconstruction in patients with massive irreparable rotator cuff tears. *Clin Shoulder Elb* 2018;21:59-66.
8. Sanchez G, Rossy WH, Lavery KP, McHale KJ, Ferrari MB, Sanchez A, et al. Arthroscopic superior capsule reconstruction technique in the setting of a massive, irreparable rotator cuff tear. *Arthrosc Tech* 2017;6:e1399-e1404.
9. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary results of arthroscopic superior capsule reconstruction with dermal allograft. *Arthroscopy* 2018;34:93-99.
10. Kim YS, Lee HJ, Park I, Sung GY, Kim DJ, Kim JH. Arthroscopic in situ superior capsular reconstruction using the long head of the biceps tendon. *Arthrosc Tech* 2018;7:e97-e103.
11. Han SY, Lee TQ, Wright DJ, et al. Effect of biceps rerouting technique to restore glenohumeral joint stability for large irreparable rotator cuff tears: A cadaveric biomechanical study. *J Shoulder Elbow Surg* 2020;29:1425-1434.
12. Kim JH, Lee HJ, Park TY, Lee JU, Kim YS. Preliminary outcomes of arthroscopic biceps rerouting for the treatment of large to massive rotator cuff tears. *J Shoulder Elbow Surg* 2020;30:1384-1392.
13. Burkhart SS, Denard PJ, Adams CR, Brady PC, Hartzler RU. Arthroscopic superior capsular reconstruction for massive irreparable rotator cuff repair. *Arthrosc Tech* 2016;5:e1407-e1418.
14. Makovicka JL, Patel KA, Tokish JM. Superior capsular reconstruction with the addition of an acromial acellular dermal allograft spacer. *Arthrosc Tech* 2018;7:e1181-e1190.
15. Galvin JW, Kenney R, Curry EJ, et al. Superior capsular reconstruction for massive rotator cuff tears: A critical analysis review. *JBJS Rev* 2019;7:e1.
16. Savoie FH. Editorial commentary: Shoulder superior capsular reconstruction: When a systematic review of a procedure can be misleading. *Arthroscopy* 2019;35:1278-1279.
17. Saha S, Vasudeva N. Morphometric evaluation of adult acromion process in north Indian population. *J Clin Diagn Res* 2017;11:AC08-AC11.
18. Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus. New anatomical findings regarding the footprint of the rotator cuff. *J Bone Joint Surg Am* 2008;90:962-969.
19. de Franca FO, Freitas JMA, Medeiros RP, de Queiroga RRC, Nunes TP, Godinho GG. Captured rotator cuff: A poor prognostic factor in rotator cuff repair. *Rev Bras Ortop (Sao Paulo)* 2021;56:83-90.
20. Fujisawa Y, Mihata T, Murase T, Sugamoto K, Neo M. Three-dimensional analysis of acromial morphologic characteristics in patients with and without rotator cuff tears using a reconstructed computed tomography model. *Am J Sports Med* 2014;42:2621-2626.
21. Curtis DM, Lee CS, Qin C, Edgington J, Parekh A, Miller J, et al. Superior capsule reconstruction with subacromial allograft spacer: Biomechanical cadaveric study of subacromial contact pressure and superior humeral head translation. *Arthroscopy* 2020;36:680-686.