Technical Note

Arthroscopic Biologic Acromiotuberoplasty for Irreparable Rotator Cuff Tears

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Abstract: Recent attention has turned toward the prevention of acromiohumeral abutment in the treatment of irreparable rotator cuff tears (IRCTs). This can be achieved through tendon transfer with a bridging allograft, superior capsular reconstruction, dermal allograft application to the greater tuberosity (biologic tuberoplasty), bursal acromial reconstruction, or subacromial balloon spacer placement. Recent literature has demonstrated increased graft thickness is associated with improved clinical outcomes after superior capsular reconstruction, suggesting a potential role of a direct bone-to-bone contact between the greater tuberosity and acromion in symptom generation in patients with IRCTs. In keeping with this ethos and building on the principle of both biologic tuberoplasty and bursal acromial reconstruction, the authors propose biologic acromiotuberoplasty as a treatment for IRCTs wherein a 3-mm dermal allograft is fixated to both the greater tuberosity of the humerus and the undersurface of the acromion for a total of 6 mm of allograft interposition.

Various surgical treatments have emerged to help patients with irreparable rotator cuff tears (IRTCs) who do not respond to nonoperative management. Joint-preserving reconstructive procedures often are employed in patients with a low Hamada classification,[1] whereas reverse shoulder arthroplasty frequently is employed in patients with a high Hamada classification or concomitant glenohumeral arthritis.[2-5] Previous techniques developed to treat IRTCs have the common objective of decreasing painful acromiohumeral abutment.[3-5] They include superior capsular reconstruction with autograft fascia lata[6] or dermal allograft,[7,8] augmentation using the long head of the biceps tendon,[9] hamstring allograft cable augmentation,[10] latissimus dorsi tendon transfer,[11] lower trapezius tendon transfer,[12] greater tuberosity resurfacing with dermal allograft (biologic tuberoplasty, BT),[13,14] bursal acromial reconstruction (BAR),[15-17] and subacromial balloon spacer placement.[18]

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The authors propose a new technique, the arthroscopic biologic acromiotuberoplasty (BAT) procedure. Two 3-mm-thick acellular dermal allografts are affixed to both the upper surface of the greater tuberosity and the undersurface of the acromion, resulting in a total of 6-mm-thick allograft interposition. Indications for this technique include patients with IRTC with low Hamada classifications (grade 1 or 2), preserved forward elevation without pseudoparalysis, preserved active external rotation without lag, preserved coracoacromial arch, no os acromiale, and an intact or repairable subscapularis.

Surgical Technique

The technique for arthroscopic BAT is shown in Video 1.

Diagnostic Arthroscopy and Debridement

Routine diagnostic arthroscopy of the shoulder is performed with the patient in the beach-chair position from a standard posterior viewing portal and anterior working portal. Intra-articular pathology is addressed within the glenohumeral joint space. The subacromial space is entered, and a lateral working portal is created. The undersurface of the acromion is thoroughly debrided. The acromioclavicular joint is visualized to facilitate suture passage of the acromial-sided graft later. Care is taken to preserve the attachment of the coracoacromial ligament to the anterior-most part of the acromion. The rotator cuff footprint on the greater tuberosity is debrided of any remaining soft tissue and slightly decorticated.

Graft Preparation

A single 3-mm-thick sheet of acellular dermal allograft (ArthroFlex; Arthrex, Naples, FL) is used to create 2 pieces of allograft (Fig 1A). The acromial-sided graft is prepared to a size of 25 mm × 20 mm (Fig 1B). An arrow is drawn on the graft pointing anteriorly (Fig 1 C and E). A Scorpion suture passer (Arthrex) can be used to assist with suture passage through the dense dermal allograft tissue (Fig 1D). Six (3 medial, 3 lateral) No. 2 FiberWire sutures (Arthrex) are placed equidistant at the medial and lateral borders of the graft using a single-strand luggage-tag configuration. After knots are tied, one tail of the suture is cut and removed from each knot (Fig 1E). The tuberosity-sided graft is then prepared to a size of 20 mm × 20 mm with an arrow pointing medially. A mark is made at the middle of the medial border of the graft (i.e., 1 cm, Fig 1 C and F). The lateral border of the graft is prepared with two No. 2 FiberWire sutures placed as untied inverted horizontal mattress sutures at each corner (Fig 1F).

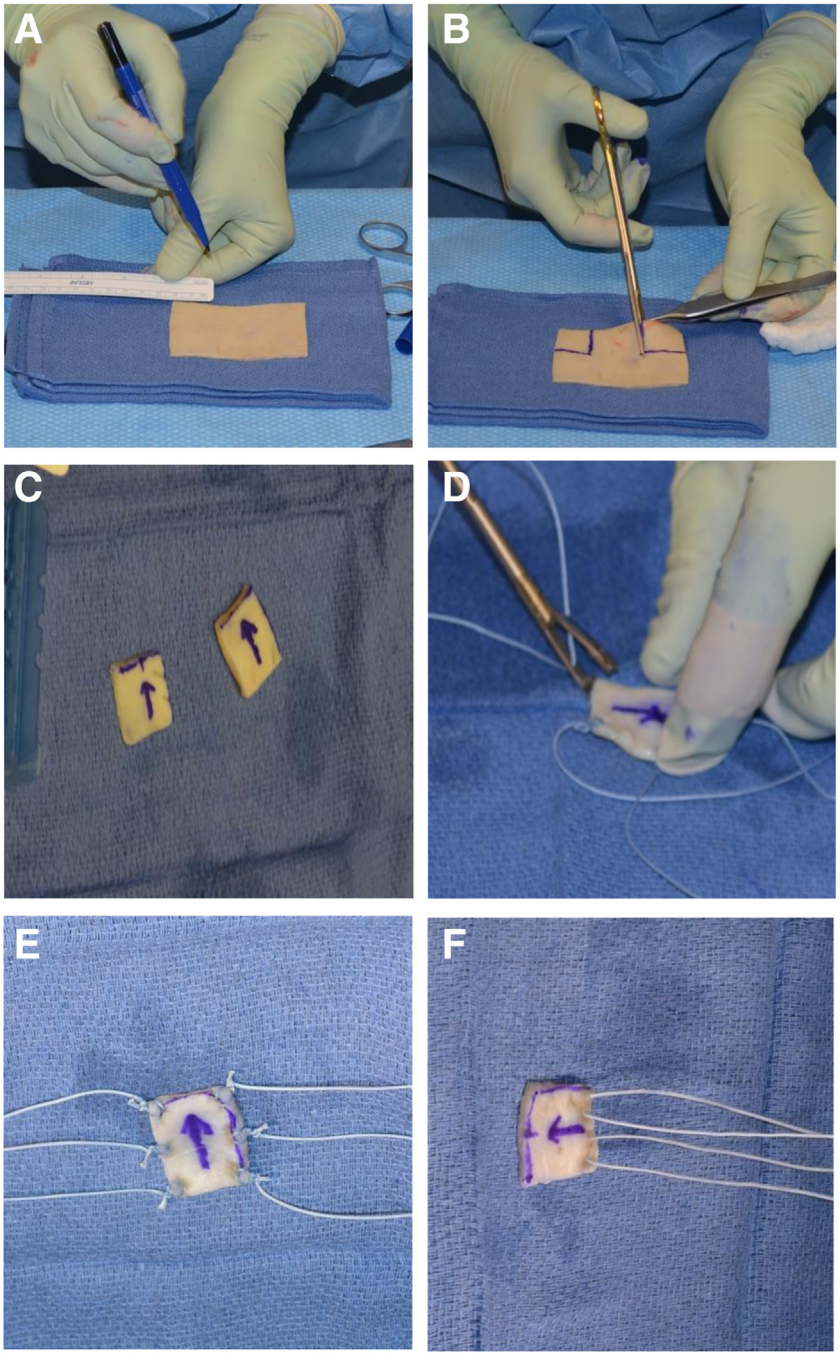

Fig 1. (A-F) Photographs demonstrating graft preparation. (A) Measuring grafts to be cut from a 3-mm thick acellular dermal allograft sheet. (B) Trimming grafts. (C) Grafts labeled with arrows to assist with intra-articular graft positioning. The acromial-sided graft's arrow points anteriorly, whereas the tuberosity-sided graft's arrow points medially. (D) Use of a Scorpion suture passer to assist with graft preparation using a No. 2 FiberWire suture. (E) A 25- × 20-mm acromial-sided graft with 3 single-strand luggage-tag sutures equally spaced at the medial and lateral graft borders. One tail of the sutures is cut. Arrow points anteriorly. (F) A 20- × 20-mm tuberosity-sided graft with 2 untied inverted mattress sutures at the lateral graft border is shown. Medial border center is marked at 1 cm. Arrow points medially.

Tuberosity Graft Fixation

Attention is then turned back to the subacromial space, where 3 medial-row 2.9-mm knotless FiberTak anchors (Arthrex) are inserted through 3 percutaneous stab incisions made along the lateral border of the acromion. They are placed just lateral to the articular margin of the humeral head. The first anchor is placed just posterior to the bicipital groove. The second anchor is placed 1 cm posterior and the third 2 cm posterior (Fig 2A). A 12-mm PassPort cannula (Arthrex) is then placed in the lateral portal. A divider is inserted into the cannula to assist with suture management (Fig 2B).

The anterior-most blue repair suture and its associated shuttle suture are retrieved from the medial row through the cannula. Once outside the body, a Scorpion (Fig 2C) is used to pass the repair suture through the medial aspect of the tuberosity-sided graft from bottom to top at its anteromedial corner. The repair suture is then converted through its FiberTak anchor using its respective shuttle suture. This process is repeated for the second and third medial-row repair sutures with graft passage occurring halfway at the 1-cm mark and at the posteromedial corner of the tuberosity-sided graft, respectively (Fig 2D). The divider is removed from the cannula. The graft is delivered into the subacromial space with sequential tensioning of the repair sutures (Fig 2E) and seated under direct arthroscopic visualization (Fig 2F). The lateral row sutures are gently tugged to ensure snug medial row fixation (Fig 3A). The lateral row is fixated using the inverted mattress sutures at each corner and two 4.75-mm SwiveLock anchors (Arthrex, Fig 3B).

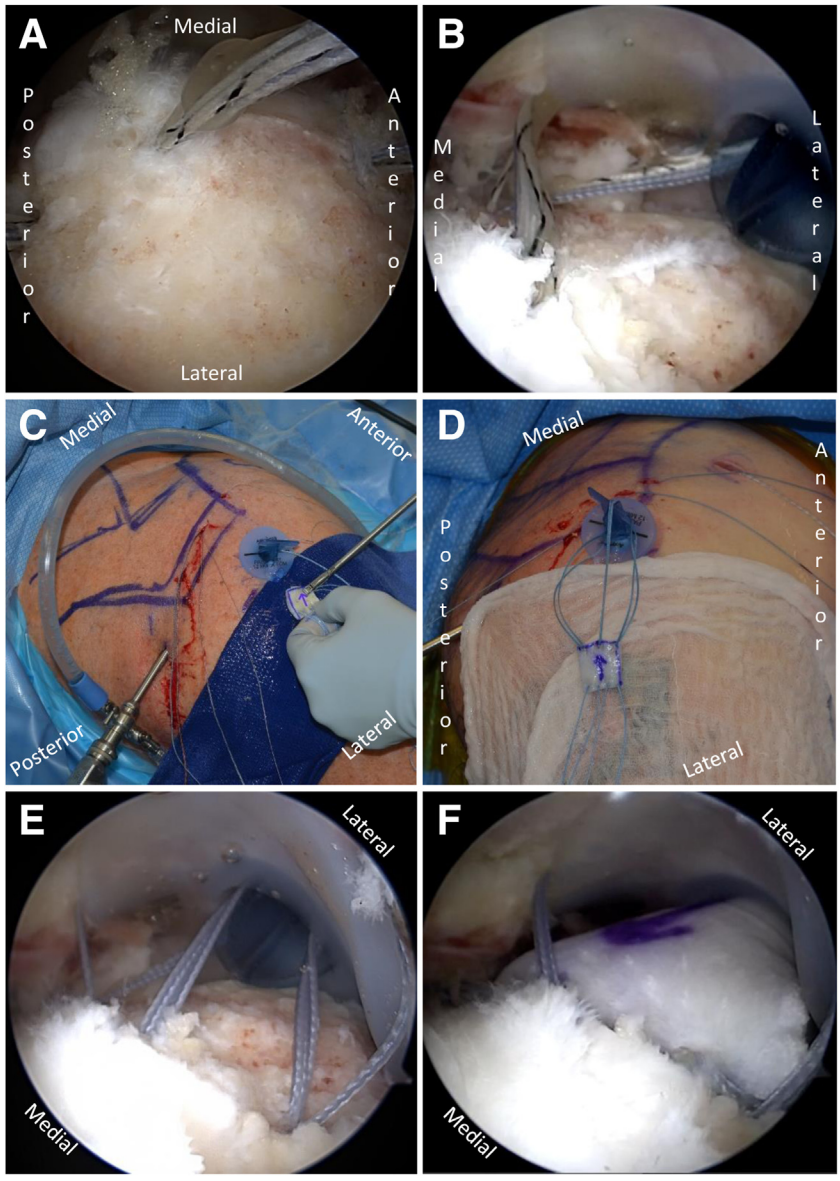

Fig 2. (A) Right shoulder lateral viewing portal demonstrating placement of 3 knotless FiberTak anchors at the medial row of the greater tuberosity just lateral to the chondral margin. The first anchor is placed just posterior to bicipital groove, the second anchor 1 cm posterior to the first, and the third anchor 1 cm posterior to the second. (B) Posterior viewing portal demonstrating placement of a PassPort cannula with a divider to assist with repair and shuttle suture retrieval. (C) Right shoulder photograph demonstrating Scorpion suture passer usage to pass repair sutures from bottom to top through medial graft border at each corner and the 1-cm halfway mark. (D) Right shoulder photograph demonstrating tuberosity graft after repair suture passage resting atop sponge to prevent skin contamination before graft delivery into joint. (E) Right shoulder posterior viewing portal demonstrating all repair sutures shuttled through their associated FiberTak anchors. (F) Right shoulder posterior viewing portal demonstrating seating of tuberosity graft within the subacromial space after sequential tensioning of the repair sutures.

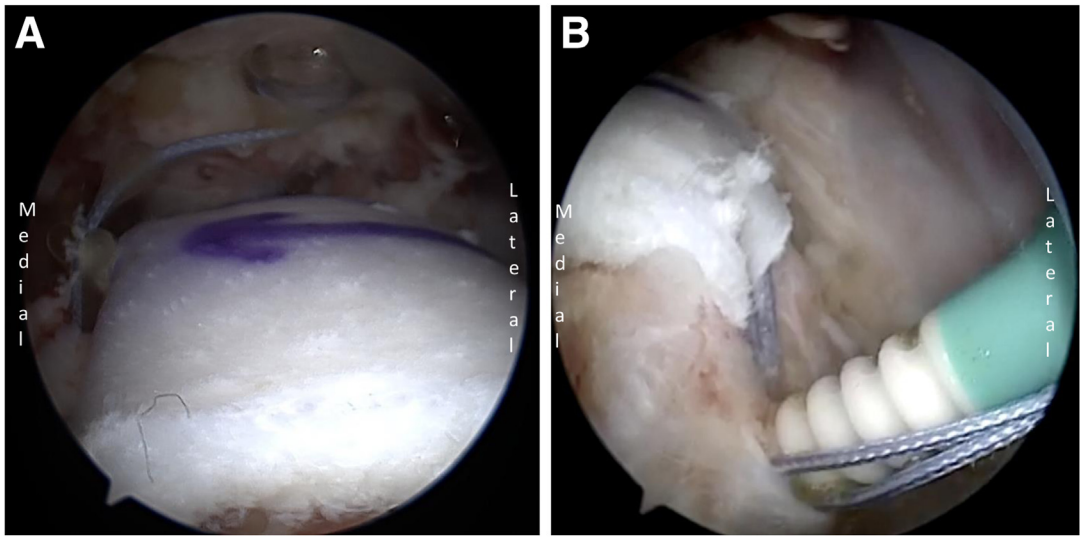

Fig 3. Right shoulder posterior viewing portal demonstrating final fixation of the tuberosity graft's medial row (A) and 4.75-mm PEEK (polyether ether ketone) SwiveLock anchor insertion for fixation of the tuberosity graft's lateral row (B).

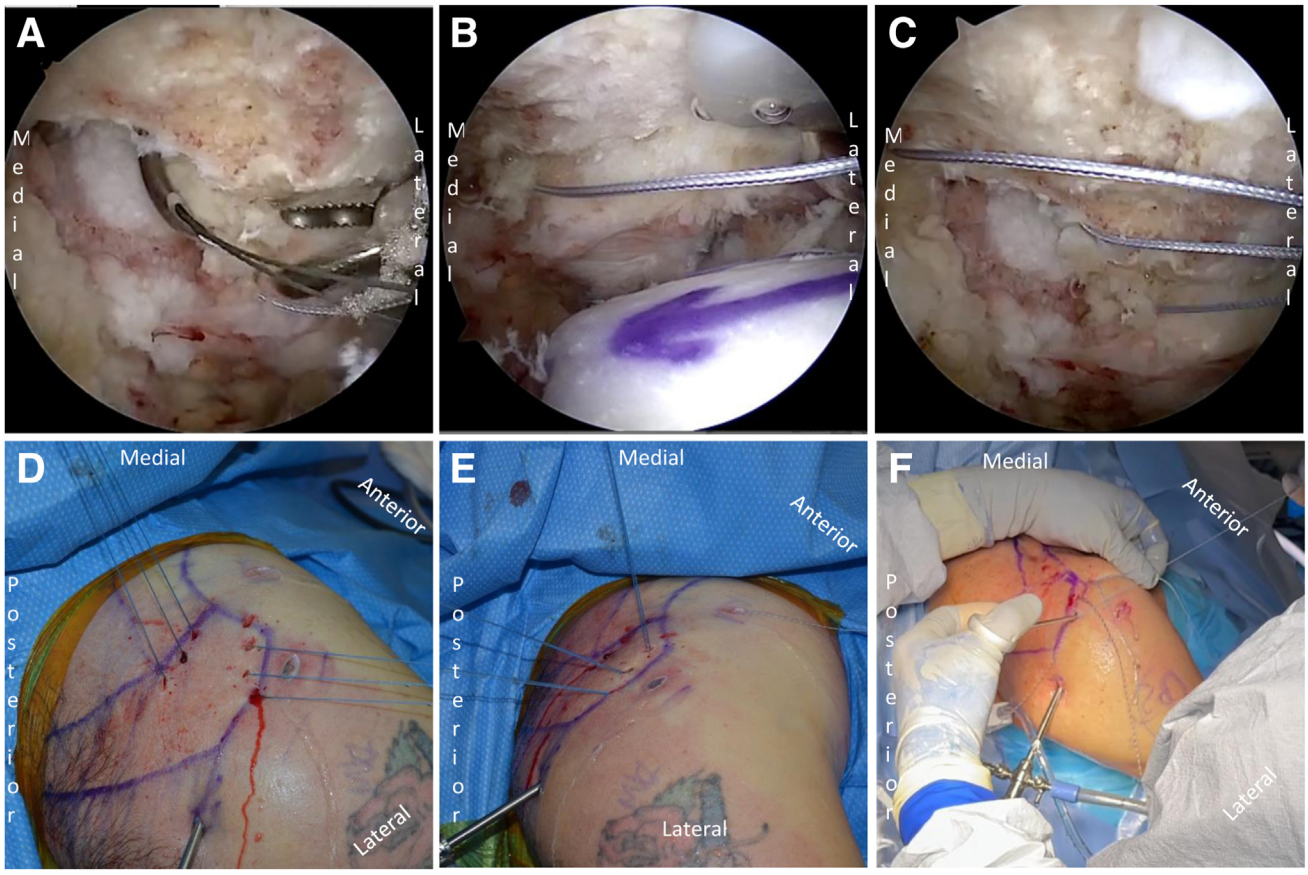

Fig 4. Right shoulder posterior viewing portal demonstrating retrieval of the suture lasso nitinol wire from the medial acromion out the lateral portal using a grasper (A), shuttling the anterior most suture tail from the medial row of the acromial graft (B), and all 3 suture tails from the acromial graft's medial row shuttled underneath the acromion (C). (D) Right shoulder photograph with 3 suture tails shuttled both medially and laterally through stab wounds at the medial and lateral borders of the acromion. (E) Right shoulder photograph demonstrating all suture tails paired with their corresponding anterior to posterior suture after subcutaneous tunneling is used with a loop grasper to retrieve the 3 medial suture tails. (F) Right shoulder photograph demonstrating the use of a knot pusher to tie medial and lateral suture tails together at the lateral border of the acromion for final acromial graft fixation.

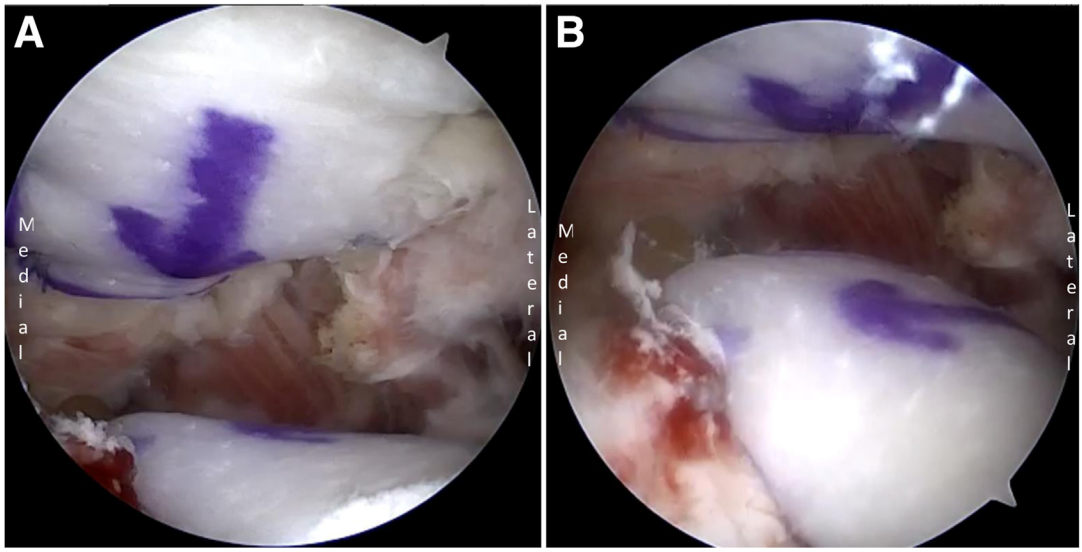

Fig 5. Right shoulder posterior viewing portal demonstrating final seating of the acromial graft (A) and acromial and tuberosity grafts facing one another after final fixation (B). Shoulder abduction delivers the tuberosity graft into the acromial graft.

Acromial Graft Fixation

A spinal needle is used at the medial acromion to localize passage locations for the 3 medial side sutures of the acromial-sided graft. Stab incisions are made, and a 90° suture lasso (Arthrex) is inserted through the anterior-most stab incision and into the subacromial space (Fig 4A). The nitinol wire of the suture lasso is retrieved through the lateral portal, and the corresponding anterior suture from the medial side of the graft is shuttled into the subacromial space, around the medial aspect of the acromion, and out the skin (Fig 4B). This is repeated for the middle and posterior sutures (Fig 4C). Sequential tensioning of the sutures delivers the graft through the cannula and into the undersurface of the acromion. The lateral side sutures from the graft are then retrieved through the 3 percutaneous stab incisions that were made along the lateral margin of the acromion. At this point, 3 suture tails are out of the skin medial to the acromion, and 3 are lateral (Fig 4D). A loop grasper is tunneled subcutaneously atop the acromion from lateral to medial to retrieve the 3 medial side sutures and match them with their lateral side counterparts (Fig 4E). While keeping the graft in the desired position underneath the acromion, the sutures are then tied over the acromion using a knot pusher (Fig 4F). The tuberosity-sided graft can now be seen gliding under the acromial-sided graft with shoulder abduction. (Fig 5 A and B). Sutures tails are cut, and skin is closed per surgeon preference. See Table 1 for technique pearls and pitfalls.

Table 1. Pearls and Pitfalls of Arthroscopic Biologic Acromiotuberoplasty

Pearls	Pitfalls
Fully prepare the subacromial space before graft advancement	In osteopenic bone, the medial-row anchors can be pulled out of bone when advancing the graft into the subacromial space. Consider using a grasper to deliver the graft close to the medial-row anchors instead of solely relying on pulling the sutures for graft advancing
A thorough exposure of the undersurface of the acromion and acromioclavicular joint facilitates suture passage for the acromial-sided graft	Avoid contact between the dermal allografts and skin to prevent contamination
Preserve the coracoacromial ligament at the anterior margin of the acromion to prevent anterosuperior humeral head escape	Bunching or slacking of the tuberosity-sided graft as the result of unequal anchor spacing or unequal tensioning
A smaller tuberosity-sided graft is easy to handle in the subacromial space. A 20- × 20-mm size works in most cases	
Use a PassPort cannula with a divider for suture management during tuberosity-sided graft medial-row fixation	
Sequentially tension the tuberosity-sided graft into place to avoid intra-articular bunching	
Adjust the acromial-sided graft to be at the center of the acromial undersurface before final suture tying over the acromion	

Table 2. Advantages and Disadvantages of Arthroscopic Biologic Acromiotuberoplasty

Advantages	Disadvantages
Biologic material, long-term implant	Increased procedure time compared with when grafting only one side
Provides resurfacing of both the acromial and tuberosity sides	Suture management can be potentially complicated
Early rehabilitation compared with superior capsular reconstruction or tendon transfers	Cost of allograft
Able to convert to reverse shoulder arthroplasty in case of failure	Relatively narrow indications
Provides a thicker biologic cushion between the acromion and tuberosity compared with biologic tuberoplasty or bursal acromial reconstruction	

Rehabilitation Protocol

The shoulder is immobilized in a sling with an abduction pillow for 4 weeks, with passive/active-assisted range of motion exercises beginning 2 weeks postoperatively. Active motion exercises start at 6 weeks, and strengthening begins at 10 weeks.

Discussion

The "tuberoplasty" technique was initially described by Fenlin in 2002 and involved resection and rounding of the greater tuberosity to decrease acromiohumeral abutment.[19] The "biologic tuberoplasty effect" was coined by Mirzayan et al.[20] in 2019 to describe postoperative superior capsular reconstruction patient observations that patients with an intact graft or a graft tear with residual tuberosity coverage had less pain and greater functional scores than those whose torn graft left the tuberosity uncovered. Mirzayan et al.[20] formally introduced the modern arthroscopic BT technique in 2021 by fixating a 3-mm-thick acellular dermal allograft to the greater tuberosity with 3 medial and 3 lateral row anchors.[14] Suri et al.[21] later simplified the technique. Although long-term BT results are yet to be published, Mirzayan et al.[22] reported preliminary outcomes in his 10-patient, 21-month mean follow-up cohort with significant improvements in patient-reported outcome measures. Postoperative magnetic resonance imaging was obtained in 7 patients at a mean of 5 months of surgery, and all 7 magnetic resonance imaging scans suggested graft incorporation into the tuberosity.[22]

Ravenscroft et al.[17] focused on acromial rather than tuberosity resurfacing when they introduced the BAR technique in 2021. Their technique fixates an acellular dermal allograft to the undersurface of the acromion to reconstruct the normal bursal layer between the humeral head and acromion. A subsequent biomechanical study supported the concept of this procedure, demonstrating significantly improved glenohumeral superior translation, maximum abduction angle, and peak subacromial contact pressure compared with the irreparable rotator cuff tear setting.[15] The clinical outcomes of the BAR procedure are yet to be published.

The current technique, BAT, combines principles from both the BT and BAR techniques. It creates a greater total interposition thickness between the acromion and the tuberosity (3 mm on each surface, totaling 6 mm) through resurfacing of both the undersurface of the acromion and the upper surface of the greater tuberosity. The authors theorize a larger decrease in painful abutment can be achieved with BAT as compared with single-sided resurfacing techniques through the creation of a smoother articulation between the acromion and greater tuberosity. The current technique has made several modifications from the original techniques of both Mirzayan et al. and Ravenscroft et al. to further efficiency. Time is saved by use of fixed graft sizes, eliminating the need for arthroscopic measurements. For the tuberosity-sided graft fixation, a simplified configuration is used (i.e., 3 simple sutures medially and 2 horizontal mattress sutures laterally, both through knotless anchors) instead of the expanded suture bridge configuration of Mirzayan et al. For the acromial-sided graft fixation, 6 single-stranded luggage tag sutures with no diagonal suture crossing are created which greatly facilitate graft preparation and contact against the acromion. Advantages and disadvantages of this technique are listed in Table 2.

Disclosures

All authors (J.R., D.W., H.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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