Technical Note

Dermal Allograft Augmentation of Rotator Cuff Repair via the Arthroscopic Shoulder Kite Technique

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Abstract: Rotator cuff tears are a common cause of shoulder pain and dysfunction. Recent and historical reports suggest that a sizable percentage of patients may experience a retear of the rotator cuff despite surgical intervention. Multiple biological and mechanical factors can influence outcomes after rotator cuff surgery, including patient age, rotator cuff tear size, chronicity, and rotator cuff tissue quality. Given this, there remains significant interest in modalities that can minimize surgical failure and improve patient outcomes after this procedure. Allograft augmentation is one option for rotator cuff augmentation in patients with large complex tears or impaired tissue quality. This technical note describes our surgical technique for arthroscopic dermal allograft augmentation of a massive rotator cuff repair with the shoulder kite technique.

Rotator cuff tears (RCTs) are frequently seen in middle-aged and elderly patients. Studies have shown that more than 60% of patients aged 80 years or older have RCTs. Additionally, patients aged 66 years or older have a 50% likelihood of experiencing bilateral RCTs.[1] Nonoperative treatment modalities can be extremely effective for these patients, but limitations in function or ongoing pain may motivate patients to consider surgical management. Rotator cuff repair techniques have evolved from open to arthroscopic repair because the latter approach is associated with reductions in morbidity and recovery time.[2] However, despite these advances in surgical technique, repair failure rates are as high as 90% in some cohort studies of patients with massive RCTs.[3] These suboptimal failure rates precipitated an interest in surgical augmentation with grafts to reinforce rotator cuff repairs given that they provide both increased strength and additional biology. Current graft options include xenograft, synthetic, or allograft patches, which can be applied through a variety of surgical techniques.[4]

There are multiple different techniques that can be used to incorporate grafts into the rotator cuff repair, including the "kite" technique. The kite technique was introduced in hip arthroscopy to provide control and efficiency during the delivery of soft-tissue grafts in an arthroscopic setting, specifically in hip labral reconstruction. The technique involves using 2 control sutures as a pulley system similar to flying a kite with 2 fly lines, and it can be used for shoulder, hip, and other joint pathologies.[5,6] This article aims to describe a reproducible surgical technique for arthroscopic dermal allograft augmentation of a massive rotator cuff repair using the shoulder kite technique (Video 1).

Surgical Technique

Graft Selection

Graft choice is at the discretion of the surgeon; however, in his surgical technique, the senior author (S.F.D.) uses an ArthroFLEX acellular dermal allograft (Arthrex, Naples, FL) in an onlay position delivered via the shoulder kite technique. This technique is performed in patients with massive RCTs, which include full-thickness tears involving 2 or more tendons or tears measuring over 5 cm in the coronal plane.[7] The procedure is performed in the beach-chair position with graft delivery via a standard 8.5-mm anterolateral portal.

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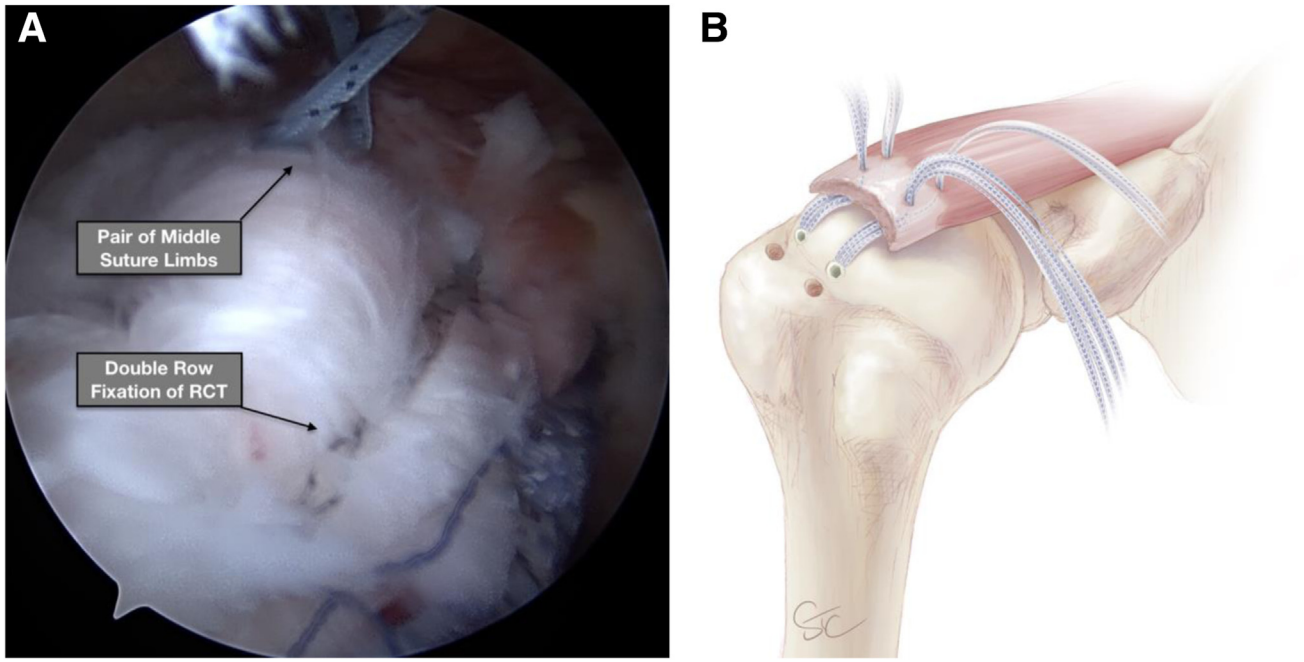


Fig 1. (A) Arthroscopic view of right shoulder from lateral portal via 30° arthroscope with patient in beach-chair position. Regarding orientation, left is posterior, top is medial, right is anterior, and bottom is lateral. A pair of untied middle suture limbs from the posterior suture anchor are visualized posterior to double-row fixation of the native rotator cuff. (RCT, rotator cuff tear.) (B) Sketched view of 12 suture limbs prior to rotator cuff repair. Both suture anchors have a pair of middle suture limbs passed through the musculotendinous junction for graft delivery and fixation.

Rotator Cuff Repair

For the described technique, a standard double-row rotator cuff repair is performed. During rotator cuff repair, two 4.75-mm triple-loaded Corkscrew suture anchors (Arthrex) are used to allow for 12 total limbs of suture to pass through the rotator cuff. The pairs of the middle limbs of both suture anchors are passed at the musculotendinous junction, slightly more medial than the other sutures, and are left untied while the remaining 8 limbs are used for double-row fixation of the native rotator cuff tendon (Fig 1). The distance between untied limbs from separate anchors is measured to select the size of the dermal allograft. A pre-sized ArthroFLEX dermal allograft is selected based on the measurements and prepared on the back table. The graft is then brought to the surgical field, and 2 TigerLink cinch sutures (Arthrex) are applied to the lateral edge of the graft. The medial edge of the graft is marked with a marking pen to better orient the graft arthroscopically (Fig 2).

One strand of each of the untied medial limbs from the anterior and posterior suture anchors is retrieved through the anterolateral portal to deliver the graft into the surgical field while the corresponding limbs remain in the percutaneous incisions through which the anchors were placed. The limbs are then passed through the medial portion of the graft at a distance similar to the distance between the anchors and are tied down on the graft patch with mulberry knots (Fig 3). This allows for shuttling of the graft into the joint by pulling the corresponding untied limbs from the suture

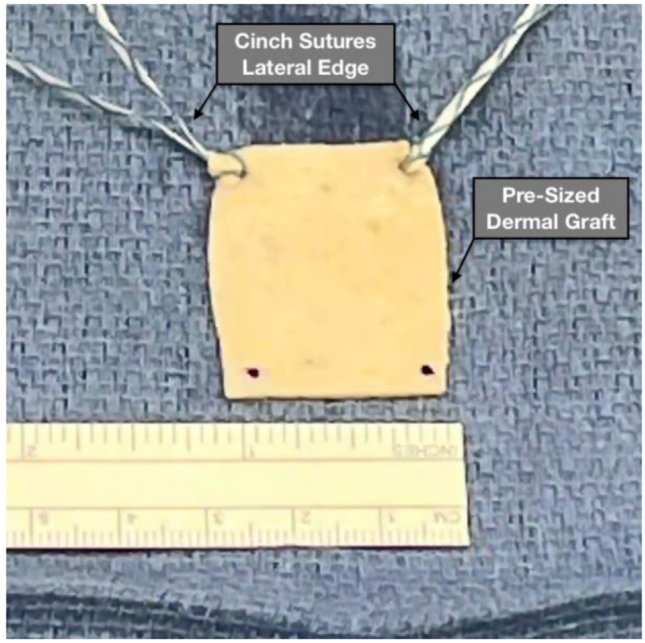


Fig 2. Initial pre-sized dermal allograft patch with 2 cinch sutures applied to its lateral edge on back table. The medial edge of the graft is marked with a marking pen.

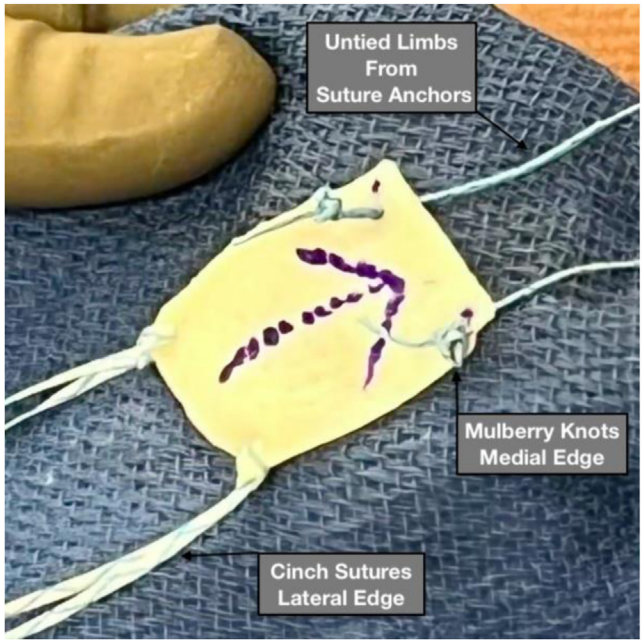
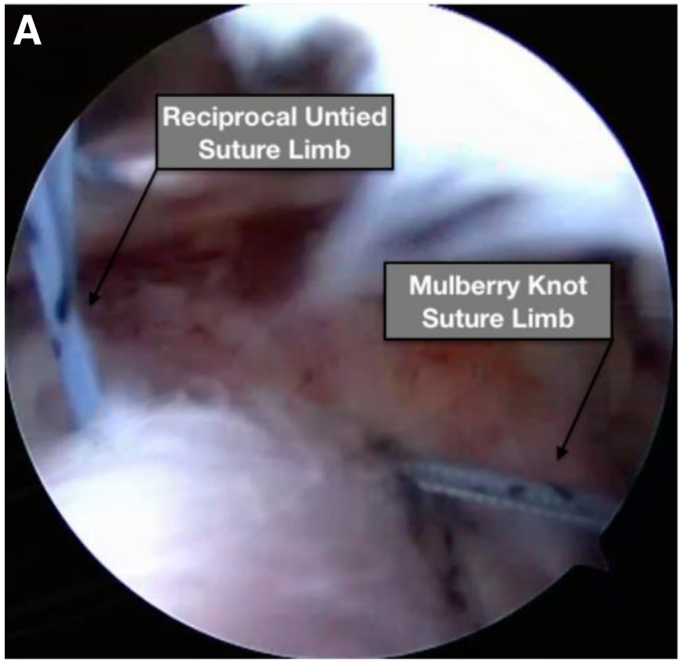


Fig 3. Surgical field showing final dermal allograft patch with 2 medial mulberry knots from untied medial suture limbs of suture anchors, 2 lateral cinch sutures, and additional arrow marking with marking pen to indicate medial edge of graft.

anchors. The graft is then shuttled in via the anterolateral portal and laid on top of the rotator cuff repair (Fig 4). If needed, a switching stick (Arthrex) is used to properly orient the graft. The previously tied mulberry knots allow for medial fixation of the graft by shuttling the graft to a firm endpoint. The first mulberry knot is retrieved, along with its corresponding suture limb, via the anterolateral portal to allow for tying. The switching stick is then used to provide counter tension and prevent the graft from lifting during this step (Fig 5). This is repeated for the posterior suture by retrieving the mulberry knot, cutting off the knot, and retrieving the corresponding suture limb via the anterolateral portal and tying. This completes medial-row fixation. Finally, the 2 cinch sutures from the lateral edge of the graft are placed into 2 separate 3.9-mm SwiveLock anchors (Arthrex) and are tapped and seated into the lateral humerus to allow for 4-point fixation of the graft augmentation (Fig 6).

Discussion

This technical note describes the shoulder kite technique for arthroscopic dermal allograft augmentation of a massive rotator cuff repair. Graft patches are designed with various materials and can be positioned in multiple unique ways. Synthetic and xenograft patches were developed early on but were found to have profound inflammatory reactions leading to poor outcomes. These complications led to further advancements including modifying previous patches and creating new



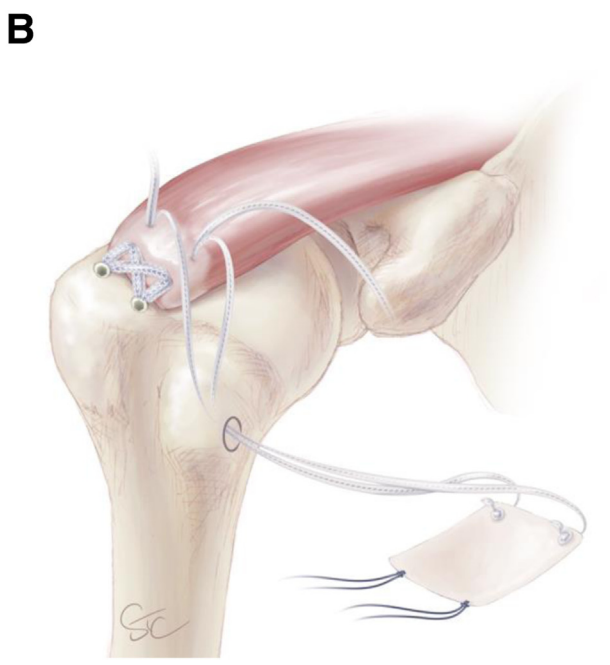


Fig 4. (A) Arthroscopic view of right shoulder from lateral portal via 30° arthroscope with patient in beach-chair position. Regarding orientation, left is posterior, top is medial, right is anterior, and bottom is lateral. The posterior pair of suture limbs with 1 suture limb is already tied to the medial edge of the graft with a mulberry knot. The reciprocal untied suture limb is being pulled to shuttle the graft onto the rotator cuff repair via the anterolateral portal. (B) Sketched view of suture limbs prior to graft shuttling. One suture limb from each pair of untied sutures is tied to the medial edge of the graft with mulberry knots.

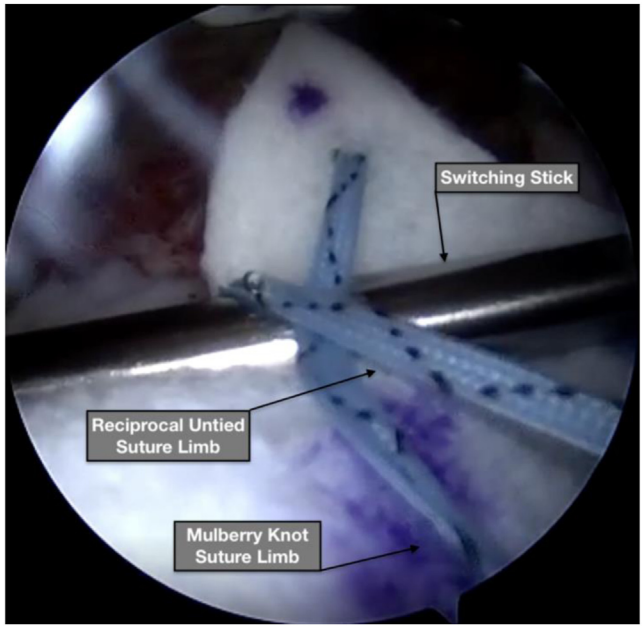


Fig 5. Arthroscopic view of right shoulder from lateral portal via 30° arthroscope with patient in beach-chair position. Regarding orientation, left is posterior, top is medial, right is anterior, and bottom is lateral. A switching stick is used to provide counter tension and prevent the graft from lifting while the reciprocal untied suture limb is pulled to allow tightening of the mulberry knot suture limb to a firm endpoint.

patches such as dermal acellular allografts that are readily available and have been reported to have superior failure rates compared with control groups.[4,8] These augmentations are very promising as shown in a recent prospective, randomized clinical trial by Barber et al.,[9] which showed an 85% success rate in patients with large rotator cuff repairs augmented with dermal acellular allograft compared with 40% in those without augmentation ($P < .01$).

Grafts can frequently be used in either an onlay or interposition manner. The onlay position fixes the graft on top of the rotator cuff, while the interposition method involves graft fixation between the rotator cuff and tuberosity.[4,10] Onlay fixation is the most widely accepted but does not affect the tendon-bone interface (enthesis), where repair failure typically occurs. This concept prompted the development of interposition fixation, which allows for migratory stem cells and tenocytes to stimulate growth and help re-form the enthesis.[10] However, to date, there are limited clinical studies on interposition graft fixation. The kite technique described in this article showcases onlay fixation for our rotator cuff repair augmentation.

The pearls that have helped us successfully reproduce the dermal allograft shoulder kite technique are outlined in Table 1. The simple use of an 8.5-mm anterolateral portal allows for easy retrieval and shuttling of

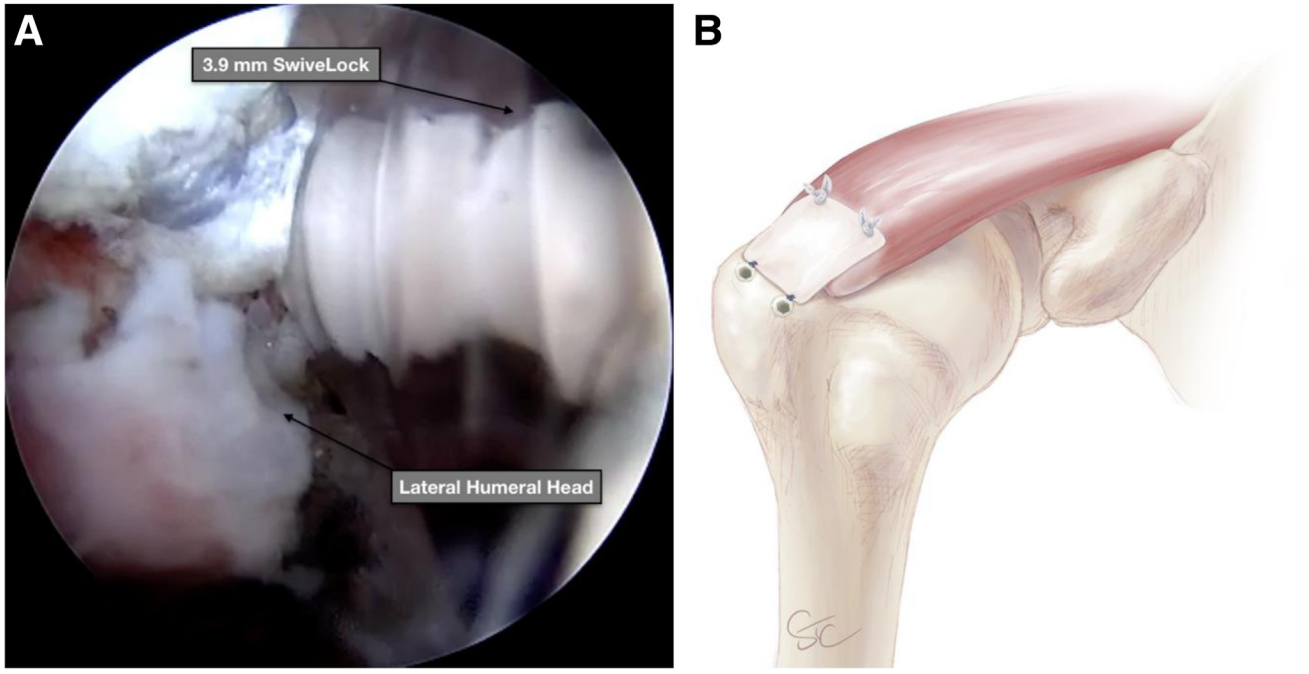


Fig 6. (A) Arthroscopic view of right shoulder from lateral portal via 30° arthroscope with patient in beach-chair position. Regarding orientation, left is posterior, top is medial, right is anterior, and bottom is lateral. A 3.9-mm SwiveLock anchor is tapped and seated into the lateral humeral head to allow for 1 of 4 fixation points of the graft. (B) Sketched view of final 4-point fixation of dermal allograft augmentation.

Table 1. Surgical Pearls and Pitfalls for Dermal Allograft Kite Technique Augmentation

Pearls	Pitfalls
The distance between untied limbs from separate anchors should be measured to select the appropriate pre-sized dermal allograft.	Care should be taken not to oversize or undersize the graft. The surgeon should leave 2-3 mm of overhang anterior/posterior to allow for adequate suture to be passed.
The medial edge of the graft patch should be marked with a marking pen to better orient the graft arthroscopically.	Careful suture management should be performed to avoid tangling or twisting during graft delivery.
Simple use of an anterolateral portal allows easy retrieval of suture limbs and prevents tangling.	Failure to use a cannula can lead to soft-tissue bridges.
A switching stick should be used to improve graft position and provide counter tension during suture tying for proper fixation.	The graft can lift up or tangle if counter tension is not applied.

suture limbs while preventing suture tangling. This strategy has been demonstrated in what is known as the "kite technique" for hip pathologies.[5,11] A switching stick can also be used to improve graft position and provide counter tension during suture tying for proper fixation. In the absence of a switching stick, many similar instruments can be used, such as a probe, to provide counter tension. Additional pearls include measuring the distance between suture anchors for appropriate pre-sized graft selection and marking the medial edge of the graft before shuttling to better orient the graft arthroscopically.

Furthermore, we highlight the advantages of the technique in Table 2. One of the major advantages of this approach is that it affords more control with soft-tissue grafts in an arthroscopic setting.[5,6] In addition, surgeons are less likely to experience graft-defect mismatches attributed to the improved accuracy with measuring distances between suture anchors.[5,11,12] Moreover, this technique allows for passage of sutures into the graft from outside the joint to avoid iatrogenic injury or misfiring of anchor- or staple-type devices.[11] Finally, this technique uses only 2 suture limbs to deliver the graft; when performed judiciously, this makes it very difficult to accidentally tangle the graft during delivery, as long as care is taken to deliver the graft "right-side up" into the cannula.

Table 2. Advantages and Disadvantages of Dermal Allograft Kite Technique Augmentation

Advantages	Disadvantages
More control with soft-tissue graft	Technically challenging
Sutures passed into graft outside of joint to avoid iatrogenic injury to rotator cuff	Increased surgical costs associated with use of dermal allograft
Improved accuracy of graft measurements, preventing graft-defect mismatch	Increased surgical time associated with preparation of graft compared with non-augmented rotator cuff repair
Relatively simple technique if suture management is performed	Long-term clinical outcomes currently lacking

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: L.O.O. reports board membership with American Academy of Orthopaedic Surgeons and *Arthroscopy*. C.W.N. reports board membership with American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, and Arthroscopy Association of North America; reports employment with *Arthroscopy*; reports a consulting or advisory relationship with Arthrex, Vericel, and Guidepoint; receives speaking and lecture fees from Arthrex and Vericel; and serves as an editorial board member for *Arthroscopy*. S.F.D. receives speaking and lecture fees from AO North America; receives funding grants from Arthrex, Stryker Orthopaedics, Arthroscopy Association of North America, and Orthopaedic Research and Education Foundation; reports board membership with Arthroscopy Association of North America and American Orthopaedic Society for Sports Medicine: and owns equity or stocks in Elsevier. The other author (A.T.B.) declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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