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Treatment of irreparable rotator cuff tear with dual graft reconstruction: a case report and technique description

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Massive irreparable rotator cuff tears (RCTs) portend substantial morbidity and continue to be an unsolved problem. The rotator cuff maintains a centrated humeral head on the glenoid, which provides a stable fulcrum to optimize deltoid activity. Loss of rotator cuff function can lead to superior migration of the humerus, which results in nonanatomic kinematics and subsequent dysfunction.

In younger and active adult patients, treatment options for massive irreparable RCT are limited and include those intended to induce a biologic response and those intended to improve mechanics. Cellular augmentation such as platelet-rich matrices and stem cells may provide a biologic platform for rotator cuff healing. Débridement, partial rotator cuff repair (RCR), tendon transfer, subacromial balloon spacer, interpositional rotator cuff graft (IG), and superior capsule reconstruction (SCR) may provide mechanical improvement, each with described efficacy. These options may mitigate superior migration of the humerus and provide a stable fulcrum for arm elevation.[3,21]

Indications for reverse shoulder arthroplasty (RSA) have expanded to include rotator cuff deficiencies and intact shoulders.[10] In the older adult with reduced activity, RSA has become a common treatment for irreparable RCT.[6] In the younger active adult, RSA has demonstrated satisfactory outcomes, but the rates of complications are high and the durability in younger adults is unknown.[19]

A novel treatment option for an irreparable RCT in the active young patient is combined reconstruction of the rotator cuff and superior capsule. This option may delay the need for an arthroplasty[9] and has demonstrated biomechanical efficacy.[17] Clinical considerations include the viability of the rotator cuff tissue, and the acromiohumeral distance, which represents the degree of superior migration of the humerus. The Goutallier classification characterizes the rotator cuff composition, which provides prognostic value for contractile function. The Hamada classification describes the position of humerus in relation to the acromion and the potential changes that occur with acromiohumeral articulation.

Herein, we report clinical outcomes for combined reconstruction of the superior capsule and rotator cuff in younger adult patients with a Goutallier stage I/II muscle belly and Hamada grade I/II shoulder. The combined reconstruction of the superior capsule and rotator cuff utilizes dual grafts that share a common attachment laterally on the tuberosity but separate attachments medially (Fig. 1). This construct allows the grafts to function independently of each other. Attaching to the superior aspect of the glenoid, the superior capsule graft is a mechanical impediment to superior migration of the humerus. The rotator cuff graft attaches to the medially retracted tendon to reestablish the transverse force couple and maintain a stable fulcrum.

Surgical technique

The surgery is performed in a lateral decubitus position. The following portals are established: anterior, posterior, direct lateral,

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This work was performed at Larkin Hospital Department of Orthopedic Surgery.

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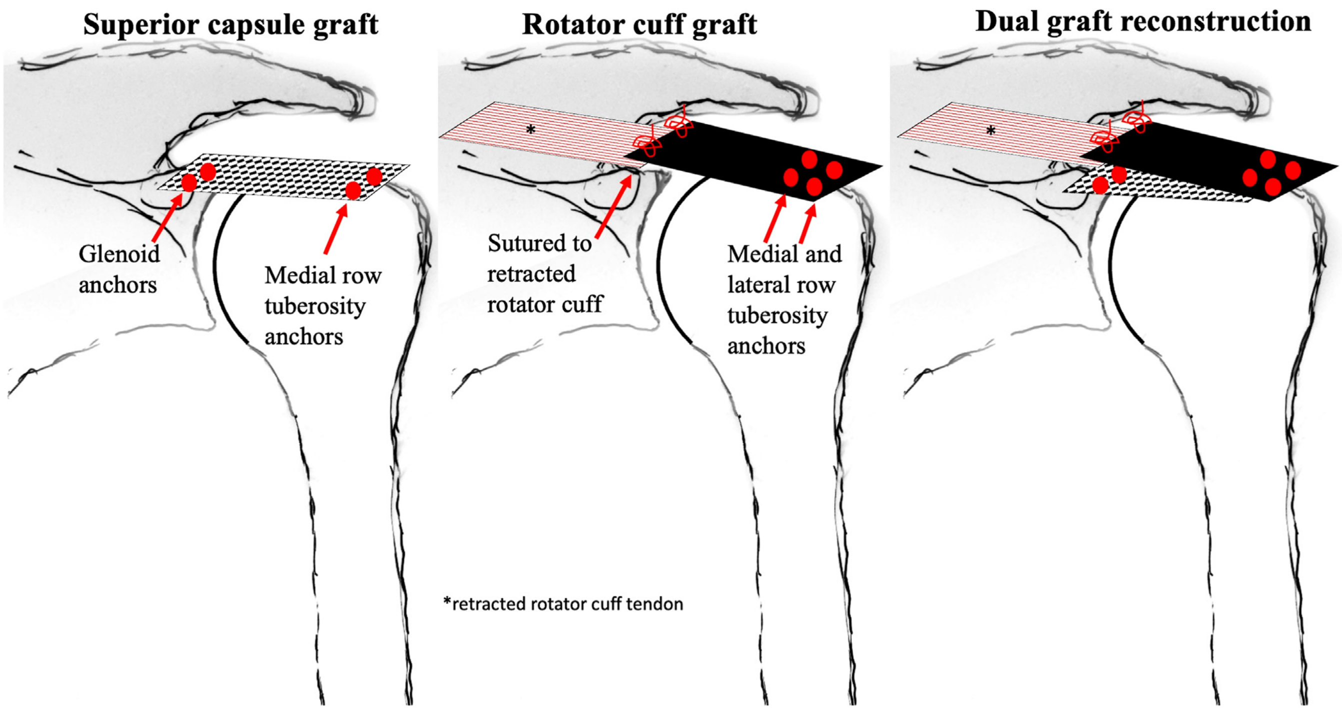

Figure 1 Graphic depicting superior capsule graft and rotator cuff interpositional graft for dual graft reconstruction of an irreparable rotator cuff.

and posterolateral. Concomitant tears of the subscapularis, infraspinatus, and teres minor are repaired in standard fashion. A biceps tenodesis is performed as needed.

The sagittal and coronal plane dimensions of the superior capsule are measured with the arm at 20-30 degrees of abduction. The graft is measured in the coronal and sagittal planes from the glenoid rim to the articular margin of the tuberosity using an arthroscopic measurement device through the anterior and lateral portals. The 3 millimeter (mm) acellular dermal graft (Arthrex, Naples, FL, USA) is sized to accommodate an additional 0.5 cm in both the coronal and sagittal planes. For reference, the graft is marked on its superior and medial aspects for orientation during implantation. Two 2.6 mm all-suture anchors with sliding #2 tape suture are placed at the 11 and 1-o'clock positions on the lightly decorticated glenoid rim through the anterior and posterolateral portals. Two 4.75 mm screw-in absorbable anchors with sliding #2 suture and nonsliding #2 tape sutures are placed on the medial tuberosity articular margin, 1.5-2 centimeters (cm) apart, through a small stab incision off the lateral border of the acromion.

The graft is clamped to a towel, which is secured on the external surface of the proximal arm. One tail from each glenoid anchor is retrieved through a 10 mm lateral cannula and passed through its corresponding anteromedial and posteromedial aspects of the graft using a suture passer. A large mulberry knot is tied on the superior aspect of the graft on each tail. The mulberry knot serves the following two purposes: 1) It secures one suture tail to the graft, which allows the other tail to pull the graft into the shoulder; 2) It is later retrieved and tied to its other tail to secure the graft to the glenoid. The tails from each glenoid anchor that were not secured to the graft are stored in their corresponding anterior or posterior cannula. The nonsliding tapes from the medial tuberosity anchors are retrieved through the lateral cannula and passed through their corresponding anterolateral and posterolateral aspects of the graft. The graft is inserted through the lateral cannula with the assistant pulling the free end tails of the sliding sutures stored in the anterior and posterior cannulas. Simultaneously, the surgeon pushes the graft down through the tensioned tape sutures using a grasper. To secure the graft to the glenoid, the surgeon retrieves the mulberry knot from the anteromedial graft and its corresponding free suture tail from the anterior cannula. An arthroscopic knot is tied, and the ends are cut, leaving a short tail. This step is repeated for the posterior mulberry knot. The graft is secured anteriorly to the subscapularis tendon with sliding suture from the anterior medial row anchor. Posteriorly, the graft is secured to the tuberosity with a sliding suture from the posterior medial row anchor. The nonsliding tape sutures from the medial row anchors are saved and later passed through the rotator cuff graft.

A second 3 mm acellular dermal graft (Arthrex, Naples, FL, USA) is prepared in similar fashion to the SCR graft. The RCR graft is measured in the coronal and sagittal planes from the retracted rotator cuff to the lateral aspect of the tuberosity. The graft is oversized by 0.5 cm in both the coronal and sagittal planes.

The retracted rotator cuff is prepared anteriorly with a free #2 sliding suture passed in a vertical mattress configuration. The lateral tail is brought out the lateral cannula and secured to the anteromedial aspect of the RCR graft with a mulberry knot. Its corresponding medial tail is stored in the anterior cannula. This step is repeated for the posterior rotator cuff with its corresponding suture tail stored in the posterior cannula. The nonsliding tape suture, previously placed through the lateral aspect of the SCR graft, is retrieved through the lateral cannula and placed one cm medially to the lateral aspect of the RCR graft. The graft is simultaneously pulled and pushed through the lateral cannula using the technique described for the SCR graft. The RCR graft is secured medially to the retracted rotator cuff by retrieving the Mulberry knots and tying each limb to its corresponding tail. The nonsliding tape suture from the medial row tuberosity anchors, which now pass through both grafts, are divided and shuttled into two lateral row 4.75 mm screw-in absorbable anchors. Additional sutures from the lateral row anchors may be used to secure any untethered portion of the RCR graft to the infraspinatus and subscapularis tendons.

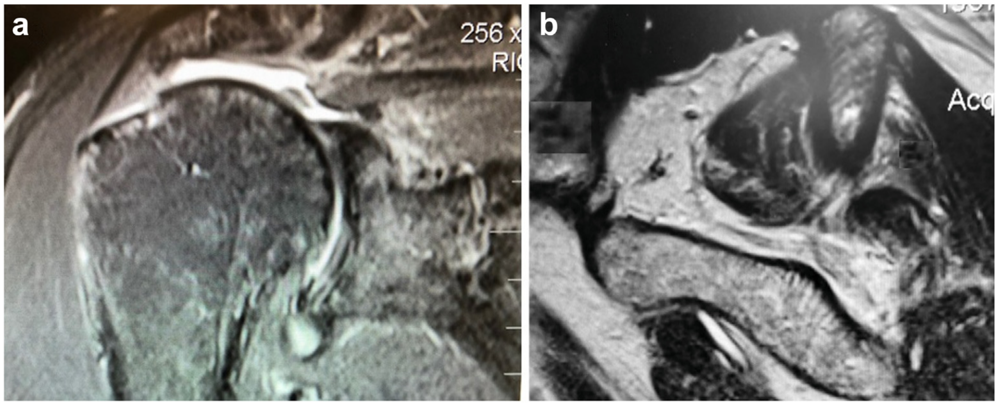

Figure 2 (**a**) Preoperative coronal T2 and (**b**) sagittal T1 magnetic resonance imaging (MRI) showing four-centimeter retracted rotator cuff tear and Goutallier stage II supraspinatus.

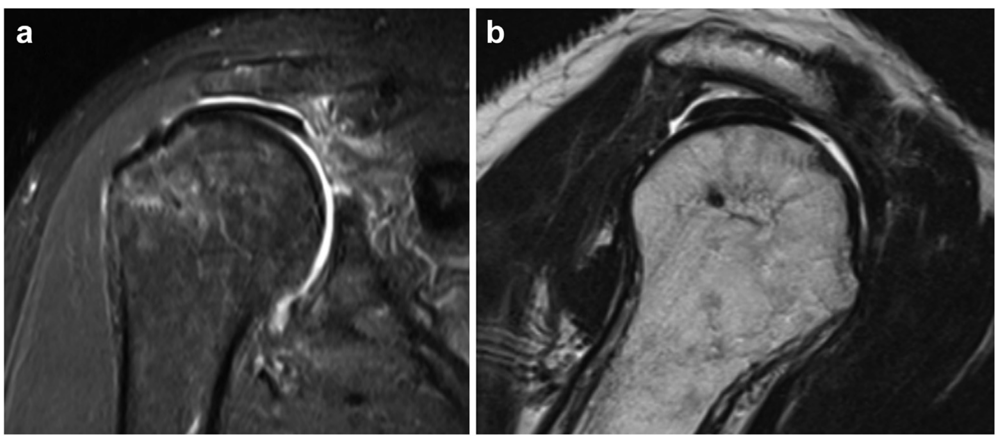

Figure 3 (**a**) Postoperative coronal T2 and (**b**) sagittal T1 MRI at one year showing intact graft. *MRI*, magnetic resonance imaging.

All patients are immobilized in a sling for nine weeks at which point active range of motion is initiated. Resistance training is initiated at 12 weeks.

Case report

The following report describes three cases that were treated with combined reconstruction of the superior capsule and rotator cuff with two-year follow-up. Informed consent was given by each patient, and the data was collected from the Surgical Outcome System global registry, which compiles patient responses to postoperative surveys.[15]

Case 1

A 53-year-old male was diagnosed with massive RCT of the supraspinatus and infraspinatus, with a high-grade partial tear of the subscapularis (Fig. 2). Active/passive ranges of motion were the following: forward flexion 90°/160°, external rotation 20°/60°, and internal rotation L5/L2. The patient had an arthroscopic débridement two months prior. This was an acute on chronic injury due to a recent fall and prior work history. Further investigation revealed a Goutallier stage II/III supraspinatus in a Hamada grade II shoulder. The patient was treated with a combined reconstruction of the superior capsule and rotator cuff, repair of the infraspinatus and subscapularis, and a biceps tenodesis (Fig. 3). The progression of clinical outcomes is shown in Table I. At two years follow-up, the patient reported that return of strength and function had exceeded expectations (Fig. 4). Active/passive ranges of motion were the following: forward flexion 160°/160°, external rotation 60°/60°, and internal rotation L1/L1. Further, the American Shoulder and Elbow Surgeons (ASES) index score improved from 39.5 preoperatively to 88.4, and visual analog scale (VAS) for pain improved from 4.1 preoperatively to 0.9.

Case 2

A 55-year-old male presented with a six-month history of right shoulder pain after lifting a heavy object, followed by an acute long head of the bicep tendon rupture six weeks prior while starting the lawn mower. The patient had no prior surgical history of the injured shoulder. Magnetic resonance imaging scans demonstrated a Goutallier stage II supraspinatus and a Hamada grade I on radiographs. The patient was treated with a combined reconstruction of the superior capsule and rotator cuff, repair of the infraspinatus and teres minor, and an open subpectoral biceps tenodesis. The patient described strength and function that exceeded expectations at two years postoperatively. At two years, the ASES index score improved from 26.6 preoperatively to 85.7, and VAS for pain improved from 8.0 preoperatively to 0.2.

Case 3

Five months following an arthroscopic débridement of rotator cuff calcific tendonitis and RCR by an outside surgeon, a 53-year-old

Table I
Preoperative and postoperative values at each term of follow-up for combined reconstruction of the superior capsule and rotator cuff.

Outcome metric	Case 1	Case 2	Case 3
ASES function*			
Preoperative	6	10	8
3 mo	16	10	1
6 mo	23	28	24
1 y	24	24	21
2 y	26	22	25
Change from preoperative	18	12	17
ASES index*			
Preoperative	39.5	26.6	53.5
3 mo	61.7	66.5	40.7
6 mo	83.3	96.6	90
1 y	82.9	85	80
2 y	88.4	85.7	91.7
Change from preoperative	43.4	59.1	18.2
VAS pain*			
Preoperative	4.1	8.0	2.0
3 mo	3.0	0.3	2.2
6 mo	1.0	0	0
1 y	1.4	1.0	1.0
2 y	0.9	0.2	0
Change from preoperative	3	8	2
VR 12 physical*			
Preoperative	48.3	38.5	27.9
3 mo	-	-	-
6 mo	55.9	50.1	52.5
1 y	49.7	53.07	47.7
2 y	50.7	55.7	55.7
Change from preoperative	1.4	17.2	27.8
Patient expectations for outcomes			
Pain			
1 y	met	exceeded	exceeded
Function			
1 y	exceeded	exceeded	exceeded
Strength			
1 y	exceeded	met	exceeded
Sporting			
1 y	not met	met	n/a
Pain			
2 y	exceeded	exceeded	exceeded
Strength			
2 y	exceeded	exceeded	exceeded
Function			
2 y	exceeded	exceeded	exceeded
Sporting			
2 y	met	met	n/a

*ASES, American Shoulder and Elbow Surgeon, VAS, visual analog scale, VR-12, Veteran's RAND 12-item health survey.

female presented with a three-centimeter retracted supraspinatus tear (Fig. 5). The shoulder was classified as Hamada grade IIa and the supraspinatus as Goutallier stage 0/I. Preoperatively, the patient's range of motion (active/passive) was the following: forward flexion of 90°/100°, external rotation of 50°/60°, and internal rotation of L3/L1. The patient was treated with a combined reconstruction of the superior capsule and rotator cuff and a biceps tenodesis was performed (Fig. 6). At one year (Fig. 7) and two years postoperatively, the patient reported that strength and function had exceeded expectations. At two years, the patient demonstrated improvement in shoulder range of motion (Fig. 8). The ASES index score improved from 53.5 preoperatively to 91.7, and VAS for pain improved from 2.0 preoperatively to 0.

Discussion

In the younger active adult, treatment options for massive irreparable RCT are limited. Often, the rotator cuff is retracted medially, which precludes reapproximation of the tissue. Further, failed prior repairs reduce the availability of viable tissue.

Current options for treatment of massive irreparable RCT are those attempting to improve the existing tissue and those supplementing the existing tissue. Débridement provides pain relief and improves the mechanics of motion following removal of tissue that may impinge during motion. Results are generally consistent for pain relief, but functional improvement varies.[4] Partial repair was advocated by Burkhart et al[3] to restore the transverse force couple of the shoulder. Despite the potential for a defect remaining superiorly, the authors report that the functioning force couple may restore motion and relieve pain. Some studies report satisfactory improvement in function, but rates of construct failure are concerning.[4] Tendon transfers are intended to restore the balanced force couple of the rotator cuff to maintain a centrated humerus on the glenoid. The latissimus dorsi is the tendon most often transferred; the pectoralis major, lower trapezius, and teres major are used less frequently. Considerations for the most appropriate tendon choice include the line of action of the tendon and the inherent force potential. Latissimus dorsi transfers have demonstrated short-term satisfactory outcomes with improved function,[16] but long-term outcomes are less compelling in cases of failed RCR.[5] A subacromial balloon spacer is a novel device intended to restore the anatomical relationship of the humeral head on the glenoid. This glenohumeral position optimizes the length tension relationship of the deltoid. Biomechanical results demonstrated increased glenohumeral and decreased subacromial pressures, which implies that the device contributes to a maintained position of the humerus on the glenoid.[11] Kunze et al[13] aggregated short to midterm outcomes for the subacromial balloon as treatment for massive irreparable RCT. The authors reported high rates of improvement in ASES and Constant-Murley Scores that reached the threshold for a minimal clinically important difference. Notably, this is an important distinction when comparatively evaluating outcome reports.

When reapproximation of the rotator cuff is not feasible, an interpositional graft provides a scaffold for biologic integration and a mechanical bridge between the retracted tissue and the bony origin. Lin et al[14] performed a comparative review of IG and SCR for all indications. IG demonstrated greater degrees of improvement in clinical outcomes compared to SCR. The authors postulate that the superior outcomes for IG compared to SCR are due to the combined mechanical and kinematic improvement. These findings are consistent with the review by Baek et al,[2] who reported a more favorable outcomes and lower complications for IG compared to SCR in massive irreparable RCT. Further, Ono et al[20] described clinical efficacy for IG in massive irreparable RCTs potentially due to the low degree of tension on the graft construct. However, there is a wide range of radiographic findings for intact bridging rotator cuff grafts.[8] Aggregate reporting on SCR have detailed satisfactory improvement in clinical outcomes[7] and variable rates of reoperation with the most common being revision to RSA.[22] Notably, recent analysis has suggested that a superior capsule graft may not need to demonstrate radiographic healing to yield the intended effect of mechanical impedance to superior translation of the humerus.[18] In totality, the treatment options that improve or supplement the existing rotator cuff are joint preserving procedures. When these options prove inadequate, an arthroplasty may be the most appropriate treatment choice. Reverse shoulder arthroplasty has become more commonly utilized with favorable clinical outcomes, but the rates of failure reduce the utility of this option.[12] Further, aggregate long-term outcomes in younger adult patients are unknown.

A novel treatment for the younger active adult with irreparable RCT is a combined graft reconstruction of the superior capsule and rotator cuff. This option may increase the likelihood of function restoration and delay the need for an arthroplasty.[9] Mihata et al[17] initially described and biomechanically tested a dual graft construct. There is a combined mechanical and kinematic value in a dual graft construct compared to the use of a single graft.

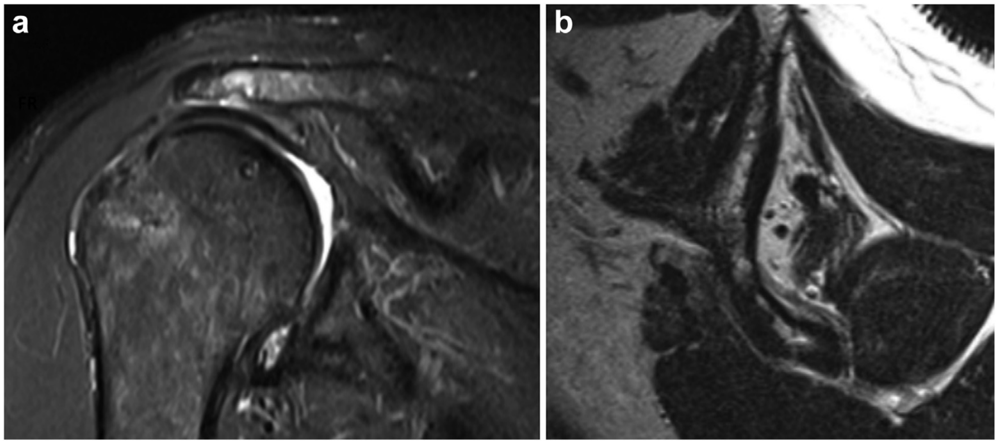

Figure 4 (**a**) Postoperative coronal and (**b**) sagittal T2 MRI at two years showing intact graft and Goutallier stage II/III supraspinatus. *MRI*, magnetic resonance imaging.

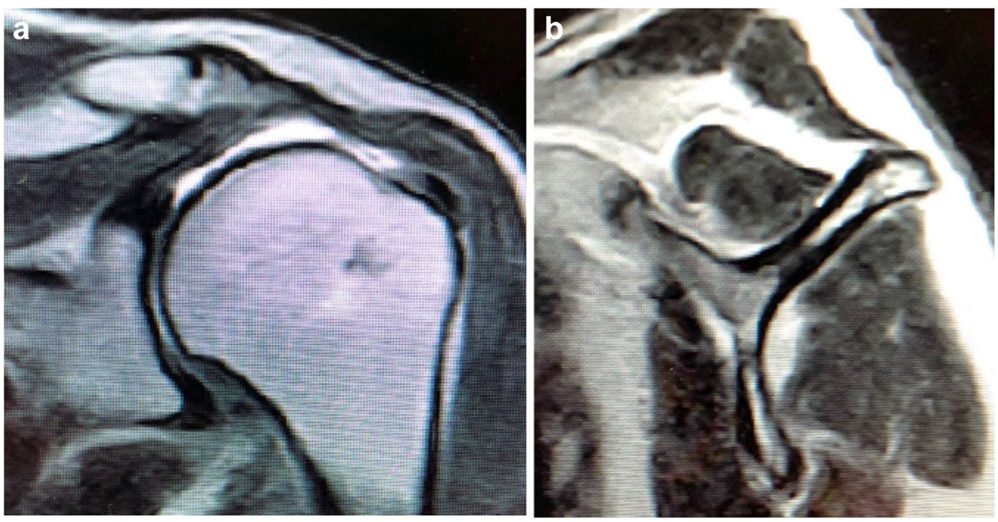

Figure 5 (**a**) Preoperative coronal and (**b**) sagittal T2 MRI showing a three-centimeter retracted rotator cuff tear and Goutallier stage 0/I supraspinatus. *MRI*, magnetic resonance imaging.

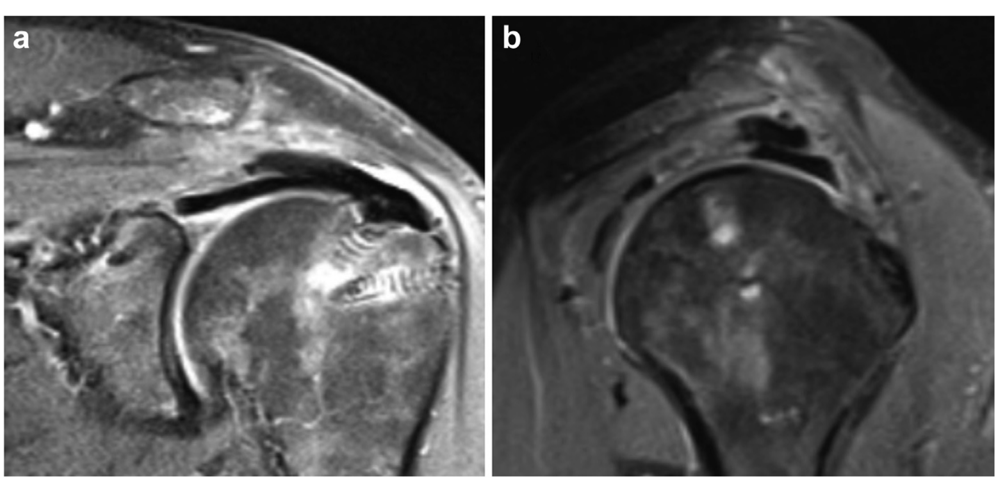

Figure 6 (**a**) Postoperative coronal and (**b**) sagittal T2 MRI at three months showing the dual grafts used for reconstruction of the superior capsule and rotator cuff. *MRI*, magnetic resonance imaging.

Reestablishing the static and dynamic stabilizers of the glenohumeral joint may provide the highest likelihood of function restoration. With its attachment at the superior aspect of the glenoid, the superior capsule graft provides static constraint, preventing superior migration of the humerus. Adams et al[1] described the superior capsule as the essential lesion in an RCR. The authors

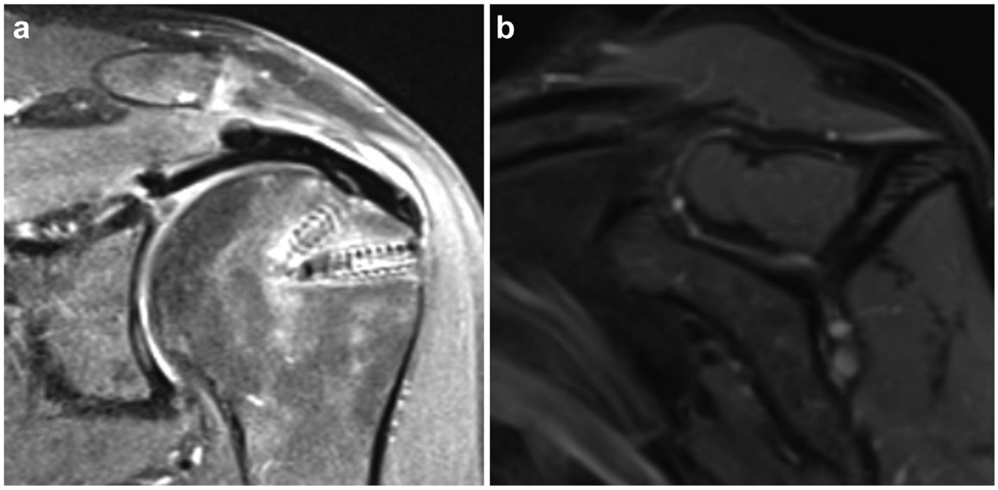

Figure 7 (**a**) Postoperative coronal T1 and (**b**) sagittal T2 MRI at 15 months showing intact superior capsule and rotator cuff grafts and Goutallier stage 0/I supraspinatus. *MRI*, magnetic resonance imaging.

Figure 8 (**a** and **b**) Telehealth follow-up at 26 months postoperatively demonstrating forward flexion of approximately 130 degrees and (**c**) internal rotation to L3.

opined that restoration of the capsule was integral to achieving native biomechanics. The rotator cuff graft attaches to the medially retracted tendon to restore the dynamic force couple of the rotator cuff. This provides a stable fulcrum, which optimizes kinematics. Further, the addition of a second graft may offload the graft-tendon interface, protecting the construct. This may reduce the risk of graft failure that has been reported for single graft reconstruction.[7,12]

Across three cases of combined reconstruction of the superior capsule and rotator cuff at two years of follow-up, the mean improvement in ASES function score was 15 (range 12-18), and the mean improvement in VAS for pain was 4.3 (range 2-8). All three patients reported improvements in function and strength and reduction in pain that exceeded their preoperative expectations.

Limitations of this technique include the increased time requirement, the complexity of the procedure, and the additional cost of a dual graft construct. Graft preparation can be complex with potential for graft and suture entanglement. Further, the lengthened operative time increases the risk of complications. Performance of additional procedures such as biceps tenodesis or acromioplasty may impact the outcomes, which confounds the evaluation of the dual graft reconstruction. Despite the additional time and resources associated with dual graft reconstruction, we think this option provides the highest likelihood of function restoration for the active younger adult. Further, this option delays the need for an arthroplasty.

Conclusion

Our results indicate that combined reconstruction of the superior capsule and rotator cuff is a viable option for younger active adults with massive irreparable rotator cuff. Preliminary results demonstrate satisfactory clinical outcomes at two years.

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