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Arthroscopic revision rotator cuff repair of large and massive retears using an interpositional bridging dermal allograft

Tanujan Thangarajah, MC ChB (Hons), MSc, PhD, FRCS (Tr&Orth), MAcadMEd*, Saho Tsuchiya, MD, Jayd Lukenchuk, MD, Ian K. Lo, MD, FRCSC

Department of Trauma and Orthopaedic Surgery, University of Calgary, Calgary, Alberta, Canada

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Background: The purpose of this study was to report the clinical outcomes and retear rate following arthroscopic interpositional bridging dermal allograft for revision rotator cuff repair of large and massive retears.

Methods: Twenty-three patients were retrospectively reviewed at a minimum follow-up of 24 (mean, 47; range, 24-77) months after revision rotator cuff repair using an interpositional bridging dermal allograft. There were 17 males and 6 females with a mean age of 56 (range, 40-74) years. Clinical outcomes were assessed using range of motion, the American Shoulder and Elbow Surgeons score and Western Ontario Rotator Cuff Index. Graft integrity was assessed at 12-months using magnetic resonance imaging.

Results: The interval between the primary rotator cuff repair and interpositional bridging graft was a mean of 82 (range, 7-192) months. Forward flexion improved from a mean of 145° (range, 60-180°) preoperatively to 152° (range, 135-170°) postoperatively ($P = .3561$). There was a decrease in external rotation from a mean of 50° (range, 20-80°) preoperatively to 37° (range, 0-45°) postoperatively ($P = .0021$). The American Shoulder and Elbow Surgeons score improved ($P = .0196$) from a mean of 50 (range, 10-88) to 69 (range, 22-97), and the Western Ontario Rotator Cuff index improved ($P = .0008$) from a mean of 34 (range, 3-90) to 57 (range, 14-93). The graft was intact in 39% of patients. No patients underwent further surgery.

Conclusion: Interpositional bridging grafting for revision rotator cuff repair of large and massive retears leads to a significant improvement in functional outcome but is associated with a high retear rate.

The incidence of primary rotator cuff repair has been consistently rising over the last 2 decades.[8] The best outcomes are observed in tendons that go onto heal.[5] Despite advances in surgical technique, retear rates range from 13.1% to 94% and can be influenced by the number of tendons involved and the size of the tear.[13,19,24] Although some retears may be asymptomatic, there is a risk of tear progression and deterioration in muscle quality resulting in the onset of debilitating symptoms and cuff tear arthropathy.[22,28]

Surgical strategies to deal with large and massive retears after structural failure of a primary rotator cuff repair may either be joint sacrificing (reverse total shoulder arthroplasty [RTSA]) or joint preserving. The latter includes procedures such as a subacromial decompression with or without tear débridement, partial rotator cuff repair, the use of grafts, muscle or tendon transfers, and a subacromial balloon spacer.[3,7,10,26,30] Revision surgery is indicated for symptomatic retears with shoulder dysfunction. The results are favorable and characterized by an improvement in range of motion and functional outcome. However, these though are accompanied by complication and reoperation rates of 12% and 5%, respectively.[4] Independent risk factors for a poor clinical outcome after a rotator cuff retear include smoking, female sex, and retears of the same or larger size than the initial tear.[23]

When dealing with a large and massive rotator cuff retear after a previous repair, direct tendon-bone repair is not often possible because of a combination of tissue loss, poor tendon quality, and limited tendon mobility. The use of an interpositional graft here may be advantageous because by bridging the gap between the torn rotator cuff tendon and the humerus, it may create an environment conducive to healing by permitting a tension-free repair,

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*Corresponding author: Tanujan Thangarajah, MC ChB (Hons), MSc, PhD, FRCS (Tr&Orth), MAcadMEd, Department of Trauma and Orthopaedic Surgery, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada.
E-mail address: Tanujan1@hotmail.com (T. Thangarajah).

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complete footprint coverage, and sealing the joint from the subacromial space. Types of graft include autografts (biceps tendon and fascia lata), allografts (human dermal matrix), xenograft (porcine dermal matrix), and synthetic materials derived from a number of polymers such as polytetrafluoroethylene.[35] Studies examining the use of interpositional bridging grafting in primary rotator cuff repair have demonstrated an improvement in range of motion and functional outcome.[20,30,33] Patient selection is crucial with those who are younger and more active identified as being the most suitable candidates provided they have good residual tendon quality and no arthritis.[35] However, the results of interpositional bridging grafts have not been specifically studied in the revision setting.

The purpose of this study was to report the clinical outcomes and retear rate following arthroscopic interpositional bridging dermal allograft for revision rotator cuff repair of large and massive retears.

Materials and methods

We performed a retrospective review of consecutive patients who underwent arthroscopic revision rotator cuff repair using an interpositional bridging dermal allograft. Institutional review board approval was obtained before the commencement of the study. Eligible subjects included those with persistent pain and limited function after previous rotator cuff repair with documented failure of healing or a retear (as determined on the basis of ultrasonography [US] or magnetic resonance imaging [MRI]). All recurrent tears involved the posterosuperior rotator cuff (supraspinatus and infraspinatus) and were categorized as large (3-5 cm) or massive (>5cm and/or involving at least 2 tendons) as described by DeOrio and Cofield and Gerber et al.[9,14] All subscapularis tears were also included.

Inclusion criteria were a consecutive group of patients who had failed nonoperative treatment (physiotherapy and analgesia) and had persistent pain and limited function that required a revision rotator cuff repair of a large or massive retear using an interpositional bridging graft (ArthroFlex; LifeNet Health, Richmond, VA, USA). Minimum follow-up was 2 years. Exclusion criteria comprised the presence of arthritis on plain radiographs, Workers' compensation patients, and those who did not give their consent for participation in research. Medical records and operative reports were analyzed by an orthopedic surgeon who had not been involved in the surgical procedures.

Participants

From September 2014 to July 2019, 23 patients were eligible for the study. There were 17 males and 6 females with a mean age of 56 (range, 40-74) years at the time of surgery. The number of diabetics and smokers in the cohort was recorded because these factors can lead to structural failure after a rotator cuff repair.[1,31] Surgery was performed on the dominant shoulder in 16 cases. The mean duration of symptoms before revision repair was 33 (range, 3-156) months. The interval between primary rotator cuff repair and revision surgery was 82 (range, 3-192) months. Two patients had 2 previous rotator cuff repairs, but the remaining patients had all undergone 1 previous surgery.

Clinical and radiological assessment

Preoperative evaluation was undertaken by assessing pain, range of motion (forward flexion and external rotation), patient-reported outcome measures (PROMs), and integrity of the initial repair using US or MRI. Postoperative evaluation was undertaken by assessing PROMs, range of motion (forward flexion and external rotation), and graft integrity on MRI at 12 months. PROMs comprised the American Shoulder and Elbow Surgeons (ASES) score and the Western Ontario Rotator Cuff (WORC) Index.[25,27] The WORC index relies on patient self-reporting and consists of 21 questions grouped into 5 categories: physical symptoms, sports/recreation, work, lifestyle, and emotions. Each question uses a visual analog scale to provide a final rating from 0% (lowest functional status) to 100% (the highest functional status).

All PROMs were collected and managed using Research Electronic Data Capture electronic data capture tools hosted at the University of Calgary.[16,17] This is a secure, web-based software platform designed to support data collection for research studies.

Table I
Details of previous rotator cuff repair surgery that were evaluated.

Tear size
Tear retraction (cm)
Tendon quality (thick vs. thin)
Tendon mobility
Tendons involved
Concurrent shoulder pathology
Biceps tenotomy/tenodesis
Acromioplasty
Distal clavicle excision
Single or double row repair

Surgical technique

All operations were performed by the senior author (I.K.L.). Preoperative assessment specifically focused on determining the precise details of all prior surgeries (Table I). Under general anesthesia, the patient was positioned in the lateral decubitus position. The arm was held in place with the SPIDER Arm positioner (TENET Medical Products, Smith & Nephew, Andover, MA, USA) to allow traction with simultaneous rotation. A diagnostic arthroscopy was performed with an arthroscopic pump maintaining pressure at 30 mm Hg.

In cases where the long head of biceps tendon was grossly tendinopathic or unstable, a tenotomy or a tenodesis was done. For the latter, a 7.0 mm Biotenodesis screw (Arthrex, Inc., North Naples, FL, USA) was inserted at the inferior aspect of the biceps groove for interference fixation of the biceps tendon within the bone. Upper and full-thickness subscapularis tears were repaired in all cases. In those with retraction, a 3-sided release (anterior, posterior, and superior) was performed before reattaching it to the lesser tuberosity. Attention was then turned to the posterosuperior rotator cuff (supraspinatus and infraspinatus tendons). Acromioplasty was not routinely performed and nor was resection of the coracoacromial ligament, so as to prevent anterosuperior escape of the humeral head.[21] Retraction, mobility, and thickness of the remaining tendon tissue were assessed (Fig. 1). Sutures from previous surgery were débrided to leave a smooth tendon capable of retaining sutures. Existing suture anchors were removed if possible. All tears were extensively mobilized, and after preparing the footprint to achieve a bleeding bone bed, a partial repair was carried out when possible. Interpositional bridging grafting was performed when a residual gap remained between a good quality tendon edge and the footprint (Fig. 2).

Two 4.75-mm medial row double-loaded suture anchors (Healicoil Regenesorb; Smith & Nephew, Andover, MA, USA) were placed anteriorly and posteriorly at the articular margin (Fig. 3). Simple sutures from these were passed into the anterolateral and posterolateral portions of the rotator cuff. Multiple simple sutures

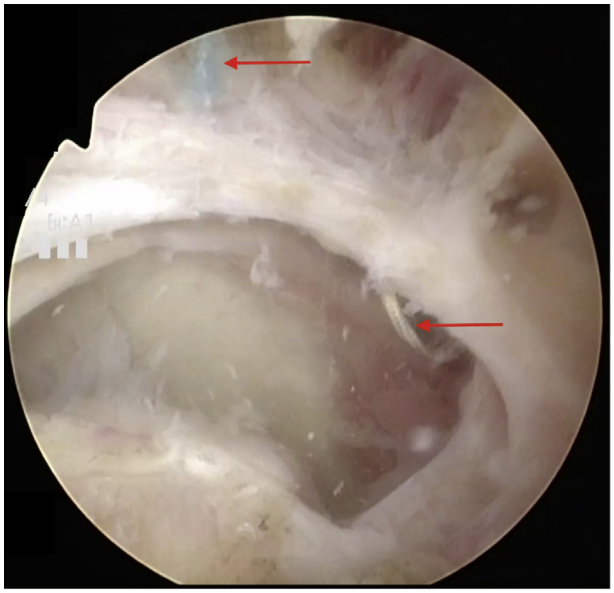

Figure 1 Left shoulder viewing through the lateral portal. Massive, retracted rotator cuff tear with sutures from a previous repair (←).

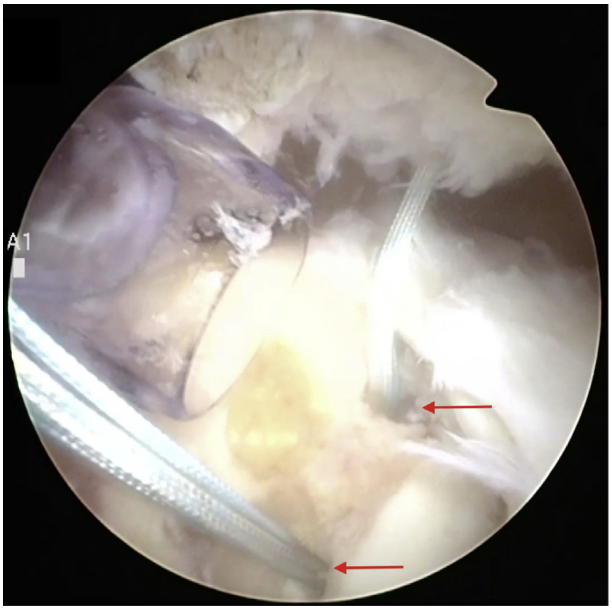

Figure 3 Left shoulder viewing through the posterior portal illustrating 2 medial row suture anchors (←).

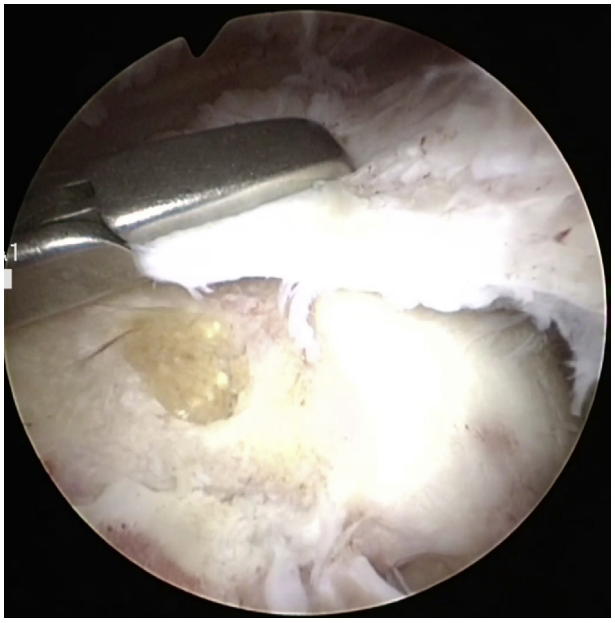

Figure 2 Left shoulder viewing through the posterior portal demonstrating insufficient tendon mobility to achieve a tension-free repair without the use of a graft.

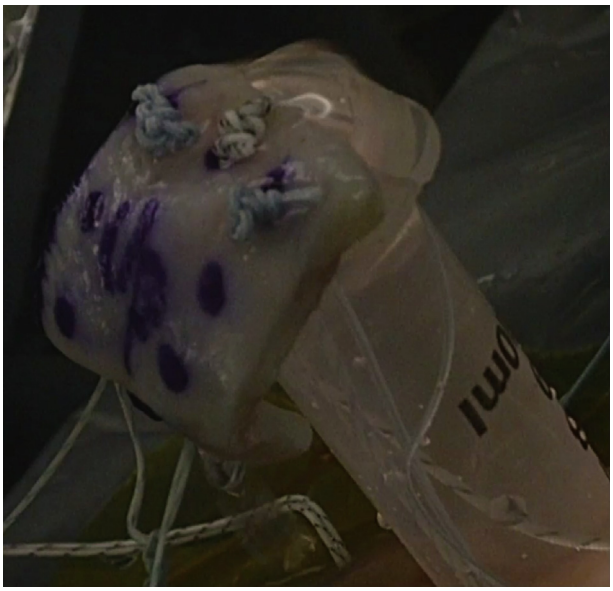

Figure 4 Graft being prepared for delivery into the shoulder having had sutures passed through it.

using #2 FiberWire (Arthrex, North Naples, FL, USA) were placed into the medial, anterior, and posterior leaves of the tendon to serve as multiple attachment points for the graft. The size of the defect was determined using a dedicated measuring device (SCR Guide, Arthrex, Inc.). Human dermal allograft (Arthroflex 301; Arthrex, Inc.) was then appropriately cut and contoured with a 5 mm overlap medially, anteriorly, and posteriorly and a 1 cm overlap laterally on the humeral footprint to facilitate a double-row repair. The previously placed sutures were subsequently passed through the graft extra-corporeally and arranged around a 10 mL syringe using a previously described technique (Fig. 4).[32] The graft was then shuttled through the syringe to cover the residual rotator cuff defect. The lateral sutures were tied first, followed by the medial ones. The side-to-side sutures were then passed through the anterior and posterior portions of the graft and tied (Fig. 5). The repair was completed by securing the lateral aspect of the graft with 2 further lateral row anchors (4.75 m Biocomposite Swive-Lock; Arthrex, Inc., Naples, FL, USA), thus creating a double-row construct with good tendon-bone compression.

During the first 6 weeks, hand, wrist, and elbow range of motion was allowed. Passive external rotation was allowed as tolerated unless there was a concomitant subscapularis repair, whereby external rotation was limited to 0°. Sling immobilization was discontinued after 6 weeks. Beginning in the seventh postoperative week and progressing through the 12th postoperative week, patients performed passive overhead stretches and progressive active

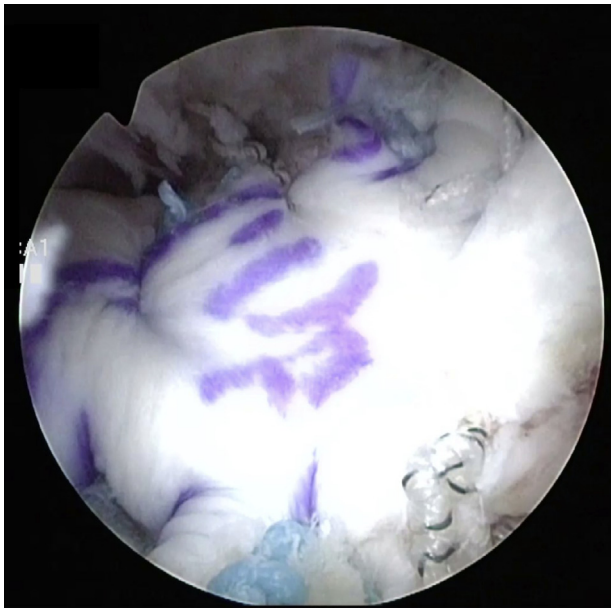

Figure 5 Left shoulder viewing through the posterior portal. Graft secured to the remaining rotator cuff tissue and covering the defect.

assisted to active range of motion. Strengthening was delayed until 16 weeks postoperatively. Full return to activity was not allowed until 1 year postoperatively. Return to work was individualized based on the specific demands of each patient.

Statistical analysis

Data were summarized with routine descriptive statistics. Paired *t* tests were used to evaluate differences between preoperative and postoperative range of motion, ASES scores, and WORC index. A *P* value <.05 was considered to be statistically significant. The SPSS software package, version 22 (IBM, Armonk, NY, USA), was used to analyze data.

Results

The mean duration of follow-up was 47 (range, 24-77) months after revision rotator cuff repair using an interpositional bridging dermal allograft. The cohort consisted of 2 smokers and 7 diabetics. Dimensions of the grafts were 4.7 (range, 1.5-4.3) cm anteriorly, 4.8 (range, 1.5-4) cm posteriorly, 2.5 (range, 1.5-3.4) cm medially, and 2.3 (range, 1.5-3.2) cm laterally. At revision surgery, all retears were large and massive, and the mean tendon retraction was 3 (range, 1.3-5) cm. Associated procedures performed at the time of surgery included 5 subscapularis repairs, 8 partial infraspinatus repairs, 3 capsular releases, 2 biceps tenodeses, and 4 biceps tenotomies. No perioperative complications were noted, and no further surgery was carried out. There were no cases of any excessive inflammatory reactions, infections, or tissue rejection identified.

Clinical and radiological assessment

All patients were available for the evaluation of range of motion, although complete pre- and post-operative PROMs were available for 15 patients. Forward flexion improved from a mean of 145° (range, 60°-180°) preoperatively to 152° (range, 135°-170°) postoperatively but was not significantly different ($P = .3561$). There was a decrease in external rotation from a mean of 50° (range, 20°-80°) preoperatively to 37° (range, 0°-45°) postoperatively ($P = .0021$). The ASES score improved from a mean of 50 (range, 10-88) to 69 (range, 22-97; $P = .0196$), and the WORC index improved from a mean of 34 (range, 3-90) to 57 (range, 14-93; $P = .0008$). Eighteen patients underwent MRI at a minimum of 12 months after surgery. Of those 18 patients, 7 (39%) had intact grafts, and of the 11 retears, no patients underwent further surgery.

Outcomes in intact and ruptured grafts

Complete pre- and postoperative outcome scores were available for 10 of 18 patients who underwent an MRI to evaluate graft integrity. The entire cohort though (18 patients with MRIs) did have range of motion assessment. Because of the small numbers, comparative statistics between groups with an intact and ruptured graft were not carried out.

In the group with intact grafts, forward flexion improved from a mean of 146° (range, 115°-150°) preoperatively to 156° (range, 140°-170°) postoperatively ($P = .2778$). There was a decrease in external rotation from a mean of 46° (range, 20°-90°) preoperatively to 43° (range, 30°-50°) postoperatively ($P = .6842$). In the subset of 10 patients with complete functional outcomes scores, the ASES score improved from a mean of 45 (range, 10-92) to 60 (range, 43-95; $P = .2327$), and the WORC index improved from a mean of 32 (range, 12-47) to 69 (range, 32-93; $P = .0755$).

In the retear group, forward flexion improved from a mean of 153° (range, 135°-180°) preoperatively to 159° (range, 145°-180°) postoperatively ($P = .5183$). There was a decrease in external rotation from a mean of 56° (range, 20°-90°) preoperatively to 34° (range, 0°-45°) postoperatively ($P = .2015$). In the subset of 10 patients with complete functional outcomes scores, the ASES score improved ($P = .1412$) from a mean of 46 (range, 16-88) to 63 (range, 22-91), and the WORC index improved ($P = .0706$) from a mean of 32 (range, 3-55) to 46 (range, 14-75).

Discussion

The available surgical options for managing structural failure after a rotator cuff repair are limited. A recent systematic review examining revision repair reported that of the 804 patients studied, only 12% had augmentation with a graft.[4] Although the clinical results were characterized by an improvement in range of motion (forward flexion and internal/external rotation) and functional outcome, the complication (12%) and reoperation (5%) rates were relatively high. The highest complication rate of 17% was associated with the use of grafts and most frequently involved failure (88%). Poorer outcomes were demonstrated in large or massive tears and in cases where there had been more than one previous surgery. As RTSA is arguably the “end stage” procedure in a patient with a failed rotator cuff repair, this should be borne into consideration early in the surgical decision-making process.

To our knowledge, this is the first study to report the clinical outcomes and retear rates after arthroscopic interpositional bridging grafting for revision rotator cuff repair using acellular dermal matrix in a cohort of large and massive tears. At a mean follow-up of 47 months, there was a significant improvement in PROMs, but this was accompanied by a reduction in external rotation and a rerupture rate of 61%. Subgroup analysis of the retear group illustrated a trend toward improved forward flexion and PROMs but a reduction in external rotation.

In this study exclusively focusing on the revision of large/massive retears after a previous rotator cuff repair, limited tendon mobility and tear retraction precluded direct tendon-bone reattachment necessitating in graft application. The outcomes of this study are characterized by a significant gain in functional outcome accompanied by a reduction in external rotation and a graft

rerupture rate of 61%. This can be attributed to the sole inclusion of revision procedures, as these are associated with a higher retear rate than primary repairs.[34] Potential reasons for this include reduced circulation in regions of degenerative tendon and dense fibrous tissue resulting in less neovascularization and limited tendon healing.[34] Similarly, the sole inclusion of large and massive tears in this study may be responsible for the high retear rate observed because larger tears result in higher failure rates.[6,13,18] In a systematic review of revision rotator cuff repair, Brochin et al[4] demonstrated that large and massive tears were independent predictors of a poor outcome. Djurasovic et al[11] reported on 80 revision rotator cuff repairs, of which 51 were large or massive. At 49-month follow-up, outcomes were satisfactory (excellent, good, or fair) in 55 patients (69%) and unsatisfactory (poor) in 25 (31%). Compared with those with larger tears, patients with a medium or small tear at the initial procedure had a significantly better functional outcome after revision.

Interpositional bridging grafts are appealing because they preserve native tendon tissue without being associated with some of the serious complications that can occur after RTSA.[2] Neumann et al[30] reviewed 61 patients after repair of a massive rotator cuff tear with porcine acellular dermal matrix as an interpositional graft. At a mean of 50.3-month follow-up, 92% of repairs were fully intact on ultrasonography, and there was an improvement in pain, range of motion (external rotation and forward flexion), and muscle strength. Rupture of the graft occurred in 5/61 patients. In some of these cases though, an improvement in pain and ROM was still observed, and only one patient required further surgery. In a further study evaluating the results of human dermal allograft as a bridging construct for massive rotator cuff tears, Gupta et al[15] found it improved pain, range of motion (external rotation and forward flexion), and strength at an average of 3-year follow-up. Using ultrasonography, completely intact repairs were noted in 73% of patients, and partially intact repairs were observed in 22%. On dynamic ultrasonography, all completely/partially intact repairs moved as a single unit. Subgroup analysis comparing intact and ruptured grafts was not performed; however, further surgery was required in 2 cases of rerupture, with one of these patients (a partially intact repair) still exhibiting an improvement in pain, ROM, and subjective outcomes. In this study exclusively focusing on revision rotator cuff repair, despite a graft rupture rate of 61%, no further surgery was required, and an improvement was demonstrated in flexion and PROMs. This suggests that integrity of the graft may not necessarily be the most important factor determining the results of an interpositional bridging graft and that it may simply represent a temporary spacer that decreases pain so that rehabilitation can continue uninterrupted.[12]

Although interpositional bridging grafting can improve clinical outcomes after rotator cuff repair, no previous study has examined its use in the revision repair of large/massive tears. Specific problems that must be anticipated during the procedure include tendon degeneration, as this may inhibit tendon-bone healing and the difficulty in discerning between the true tear-margin and fibrous tissue overlying the retracted tendon. We postulate that the reduction in external rotation observed in our study may be because of a combination of tightening the posterior rotator cuff tissue when securing the graft, and the double-row construct used, as this has been shown to alter normal glenohumeral kinematics and reduce motion.[29]

The limitations to this study include the retrospective design, incomplete follow-up data, and short-term follow-up. The absence of a control group prevents the improvement in functional outcome being reliably attributed to the bridging graft rather than another factor such as the natural history of the disease process. Preoperative MRI assessment of all tears would have allowed detailed characterization of fatty infiltration and muscle atrophy, as these may well have contributed to the outcome. All procedures were undertaken by a single surgeon with a high-volume tertiary referral practice dedicated to complex rotator cuff tears, and so this limits the external generalizability.

Conclusion

This is the first study to report the outcomes of arthroscopic interpositional bridging grafting of large and massive rotator cuff retears. Despite a reduction in external rotation and limited graft healing, there was still a significant improvement in patient-reported outcome at short-term follow-up. Compared with interpositional bridging grafting used in primary rotator cuff repair, its use as a salvage procedure in the revision setting is associated with worse clinical outcomes and a higher retear rate, and so it does not represent a viable solution at this stage. Future studies should compare bridging grafting for revision rotator cuff repair to other techniques (eg, partial repair and isolated débridement) and evaluate the influence of graft retears on clinical outcomes.

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