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Arthroscopic superior capsular reconstruction with acellular human dermal allograft for irreparable rotator cuff tears: outcomes, complications, and reoperations at 2-year minimum follow-up

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Background: Management of posterosuperior irreparable rotator cuff tears (IRCTs) remains challenging without clear consensus among shoulder surgeons. Arthroscopic superior capsular reconstruction (SCR) with dermal allograft has been proposed as a promising treatment option. However, current investigations are limited to short term studies and recent data has suggested variable clinical outcomes. Therefore, the purpose of this investigation was to report intermediate-term clinical outcomes in patients who underwent arthroscopic SCR with a dermal allograft for IRCTs.

Methods: Over a 4-year period (2016–2020), all patients who underwent an arthroscopic dermal allograft SCR with a minimum 2-year follow-up period were identified. SCR with dermal allograft was performed for patients with an IRCT utilizing a 3-mm acellular dermal allograft. Collected clinical outcomes included range of motion, strength, Numeric Rating Scale for pain, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score, Single-Assessment Numeric Evaluation score, complications, and reoperations.

Results: The final cohort included 41 dermal allograft SCR performed in 40 patients (1 bilateral) with a majority male cohort (n = 29; 72%), a mean age of 67 ± 7 years, body mass index of 28.4 ± 5.0, and follow-up of 5.3 ± 1.4 years. Clinically, there was a significant improvement in preoperative and postoperative Numeric Rating Scale pain scores from 5.0 to 1.8 ($P < .001$), but no differences in preoperative and postoperative forward flexion ($P = .268$), abduction ($P = .822$), external rotation ($P = .323$), or internal rotation ($P = .995$). The final postoperative American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form and Single-Assessment Numeric Evaluation scores were 66 ± 28 and 59 ± 30, respectively. There were 8 (19.5%) complications, which consisted primarily of symptomatic graft failure in 6 (14.6%) shoulders and progression of rotator cuff arthropathy in 2 (4.9%) shoulders. Reoperations occurred in 6 (14.3%) shoulders: 4 (9.8%) were conversion to reverse total shoulder arthroplasty and 2 (4.9%) were arthroscopic revision dermal allograft SCR with partial repair and reattachment of the torn graft.

Conclusion: At a cohort mean of 5 years after arthroscopic SCR with dermal allograft for IRCTs, patients experienced sustained pain relief but no significant improvement in shoulder function. Additionally, 20% sustained a postoperative complication with a 14% reoperation rate. These findings should be considered when counseling patients about the challenges of managing IRCTs and the possible outcomes of utilizing dermal allograft SCR as a surgical modality.

Posterosuperior irreparable rotator cuff tears (IRCTs) remain a challenging condition to manage, particularly in young, active patients without glenohumeral osteoarthritis. Numerous surgical treatments are utilized in this cohort including, partial rotator cuff repair, bridging allograft augmentation, subacromial balloon spacer implantation, lower trapezius tendon transfers (LTTs), and superior capsular reconstruction (SCR), without clear comparative data among modalities or longer-term follow-up.[2,3,9,10,31] Furthermore, management strategies can vary significantly from surgeon to surgeon based on several factors including clinical experience, patient age, activity level, and characteristics of the rotator cuff tear

This study was approved by the Institutional Review Board at the Hospital for Special Surgery.

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including muscle quality, chronicity, tendon retraction, and tear size.

In 2012, Mihata et al[26] described the SCR as a joint-preserving treatment option for patients with IRCT. Though the original description utilized fascia lata (FL) autografts,[24] subsequent evolution of this procedure has commonly used dermal allografts especially among United States based surgeons.[8] Though these allografts are generally thinner, the lack of donor-site morbidity, reduced surgical time, simpler graft preparation, and maintained tensile strength has become advantageous adjunct to the technique.[5,12,14] Biomechanically, SCR is thought to work through centering the humeral head, reducing subacromial contact pressure, and/or helping restore the force couple of any remaining rotator cuff tissue.[22,27,34]

Clinically, various investigations on SCR have been conducted demonstrating improved outcomes specifically with pain relief, patient satisfaction, and overall shoulder function. Notably, graft healing rates have ranged from 45% to 90% and reoperation rates have also ranged from 15%-20% within the short term.[15,28] However, despite these promising early results, there is a paucity of intermediate- and longer-term outcome data. Therefore, the purpose of this study was to report intermediate-term outcomes of patients who underwent SCR with a dermal allograft for irreparable posterosuperior rotator cuff tears.

Methods

Data collection

This was a retrospective review of consecutive adult patients with an IRCT who underwent an arthroscopic SCR with a 3-mm–thick acellular dermal allograft between 2016 to 2020 at a single institution. Institutional review board approval was obtained before initiation of the investigation. All patients had irreparable posterosuperior rotator cuff tears with recalcitrant symptoms despite a course of nonoperative treatment. Exclusion criteria consisted of patients with severe glenohumeral osteoarthritis and less than 2 years of clinical follow-up.

Data collection consisted of a combination of electronic medical record review, magnetic resonance imaging (MRI) reviews, phone interviews, and email-based surveys to assess patient outcomes following surgery. Demographic information included patient age, sex, and body mass index. Preoperative data included shoulder range of motion which was performed as visual estimates, strength through manual motor testing, patient reported pain scores during visit, and presence of lag signs. Postoperative data included active shoulder range of motion and strength in all planes (forward elevation, external rotation, internal rotation), complications, postoperative pain scores, and reoperations. Pain scores from the patient chart were determined using the Numeric Rating Scale screening tool at the time of hospital contact. Retear and rotator cuff tear arthropathy were diagnosed on clinical evaluation in patients presenting with pain and lack of functional improvement postoperatively and were assessed using a combination of physical exam, radiographs, and MRI.

Surgical technique

The SCRs with dermal allograft were performed by 1 of 8 fellowship-trained sports medicine and shoulder specialists. Following placement in beach chair position and induction of anesthesia, diagnostic arthroscopy was performed for each patient via placement of lateral, Neviaser, and anterosuperior portals. Supraspinatus reparability was determined, and dermal graft SCR was aborted if the tendon was deemed repairable. Additionally, any repairable tears of the infraspinatus or subscapularis were repaired. Biceps tenotomy or tenodesis was performed concomitantly in those patients with biceps pathology. After deciding to proceed with SCR, the superior glenoid was prepared to preserve the superior labrum. Two suture anchors were placed in the superior glenoid for 29 (70.7%) shoulders while the other 12 (29.3%) had 3 glenoid anchors. The distances between the anchors were marked using a 3.0-mm acellular dermal allograft (ArthroFlex; Arthrex, Naples, FL, USA), including 5-10 mm of tissue around the margins. The sutures from each anchor were extracted through a lateral cannula and threaded through the corresponding openings in the graft. The sutures served to insert the graft into the subacromial space before being secured both medially to the glenoid and laterally to the greater tuberosity. To ensure lateral fixation of the graft, the arm was abducted at 30 degrees and a double-row repair was performed with additional suture anchors placed lateral to the greater tuberosity. Finally, the graft was repaired anteriorly and posteriorly to the infraspinatus with side-to-side sutures.

Postoperatively, patients underwent an immobilization regimen using an abduction pillow or sling for a duration of 6 weeks to facilitate proper healing. Subsequently, patients advanced to passive forward flexion and external rotation exercises. Approximately 10 to 12 weeks postsurgery, patients initiated active forward flexion and passive internal rotation exercises, alongside a targeted program to restore the strength of the scapular stabilizer muscles and deltoid. The final phase of the rehabilitation process, spanning from 6 to 12 months postsurgery, included overhead strengthening exercises, advanced closed-chain movements, and proprioceptive and plyometric exercises.

Table I
Demographic and clinical characteristics of the study group.

Variables	SCR cohort N = 41
Age, y	67 ± 7
Sex	
Female	11 (28%)
Male	29 (72%)
Body mass index	28.4 ± 5.0
Laterality	
Right	27 (67%)
Left	13 (33%)
Prior surgery	19 (48%)
Biceps management	
Tenotomy	0 (0%)
Tenodesis	4 (10%)

SCR, superior capsular reconstruction.
Data are presented as mean ± standard deviation or number (percentage).

Statistical analysis

For the entire sample, general data were summarized with routine descriptive statistics. Continuous variables were assessed with the Student's *t* test. Categorical variables were assessed with the chi-square test or the Fishers exact test when necessary. Paired t tests were used to determine changes between preoperative and postoperative variables. *P* values < .05 were considered to be statistically significant.

Results

The final cohort included 41 dermal allograft SCR performed in 40 patients with a mean follow-up period of 5.3 years ± 1.4 years (range, 2.7-7.3 years). The cohort was predominantly male with a mean age of 67 ± 7 years, and a body mass index of 28.4 ± 5.0 (Table I).

Table II
Range of motion following arthroscopic SCR with dermal allograft.

Variables	Preoperative	Postoperative	Postoperative to preoperative difference	*P*
Pain score	5.0 ± 2.3	1.8 ± 1.8	−3.2 ± 1.9	<.001
Forward elevation, °	133 ± 50	145 ± 33	12 ± 16	.618
Abduction, °	122 ± 53	117 ± 52	−5.0 ± 9.3	.822
External rotation, °	56 ± 28	48 ± 21	−8.0 ± 2.5	.323
Internal rotation score	9.9 ± 3.7	9.9 ± 3.9	0 ± 0.7	.995

SCR, superior capsular reconstruction.
Data are presented as mean ± standard deviation.

Clinically, there was no significant differences between preoperative and postoperative forward flexion (145° vs. 133°, $P = .268$), abduction (122° vs. 117°, $P = .822$), external rotation (56° vs. 48°, $P = .323$), or internal rotation score (9.9 vs. 9.9, $P = .995$) (Table II). Patient-reported pain scores decreased significantly between preoperative (5.0 ± 2.3) and postoperative (1.8 ± 1.8) timepoints ($P < .001$) (Table II). The postoperative mean American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score was 66 ± 28 and mean Single-Assessment Numeric Evaluation score was 59 ± 30 (Table III).

There were 8 (19.5%) complications, which consisted primarily of symptomatic graft failure in 6 (14.6%) shoulders and progression of rotator cuff arthropathy in 2 (4.9%) shoulders. MRI review of the symptomatic graft failures demonstrated 2 (4.9%) dissolved grafts, 2 (4.9%) glenoid-sided graft failures, and 2 (4.9%) tuberosity-sided graft failures. Reoperations occurred in 6 (14.3%) shoulders: 4 (9.8%) were conversion to reverse total shoulder arthroplasty (rTSA) and 2 (4.9%) were arthroscopic revision SCR with partial repair and reattachment of the torn graft.

A subanalysis was performed on patients with a minimum of 5 years of follow-up. Clinically, there was no significant differences between preoperative and postoperative forward flexion (146° vs. 139°, $P = .643$), abduction (126° vs. 99°, $P = .359$), external rotation (50° vs. 48°, $P = .803$), or internal rotation score (11.0 vs. 9.9, $P = .505$) (Table IV). Patient-reported pain scores decreased significantly between preoperative (5.5 ± 2.6) and postoperative (1.5 ± 1.3) time points ($P < .001$) (Table IV). The postoperative mean American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score was 65 ± 27 and mean Single-Assessment Numeric Evaluation score was 61 ± 29 (Table V). Six of these patients had either graft disruption or further rotator cuff arthropathy, 4 of which required reoperation. Overall, this subgroup fared similarly to the total cohort.

Table III
Clinical outcomes following arthroscopic SCR with dermal allograft.

Variables	SCR cohort N = 41
ASES	66 ± 28
SANE	59 ± 30
Complications	8 (19.5%)
Symptomatic graft disruption	6 (14.6%)
Rotator cuff arthropathy	2 (4.9%)
Reoperations	6 (14.3%)
rTSA	4 (9.8%)
Graft reattachment	2 (4.9%)

SCR, superior capsular reconstruction; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SANE*, Single-Assessment Numeric Evaluation; *rTSA*, reverse total shoulder arthroplasty.
Data are presented as mean ± standard deviation or number (percentage).

Table IV
Range of motion following arthroscopic SCR with dermal allograft with minimum 5-year follow-up.

Variables	Preoperative	Postoperative	*P*
Pain Score	5.5 ± 2.6	1.5 ± 1.3	<.001
Forward elevation, °	146 ± 47	139 ± 33	.643
Abduction, °	126 ± 60	99 ± 49	.359
External rotation, °	50 ± 29	48 ± 17	.803
Internal rotation score	11.0 ± 2.6	9.9 ± 3.9	.505

SCR, superior capsular reconstruction.
Data are presented as mean ± standard deviation.

Table V
Clinical outcomes following arthroscopic SCR with dermal allograft with minimum 5-year follow-up.

Variables	Subcohort N = 26
ASES	65 ± 27
SANE	61 ± 29
Complications	6 (23.1%)
Symptomatic graft disruption	2 (7.7%)
Rotator cuff arthropathy	4 (15.4%)
Reoperations	4 (15.4%)
rTSA	3 (11.5%)
Graft Reattachment	1 (3.8%)

SCR, superior capsular reconstruction; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SANE*, Single-Assessment Numeric Evaluation; *rTSA*, reverse total shoulder arthroplasty.
Data are presented as mean ± standard deviation or number (percentage).

Discussion

The main findings of this study were that patients undergoing a dermal allograft SCR for IRCTs did experience pain relief but may not experience a significant change in shoulder function over time. Additionally, 20% of the cohort sustained a postoperative complication which led to a 14% reoperation rate. These findings should be considered when counseling patients about the challenges of managing IRCTs and the possible outcomes of utilizing a SCR with dermal allograft as a surgical modality.

The present study builds on the evolving literature of SCR. Initial investigations on SCR showed promising results with significant improvement in pain and overall function, while preventing progression of rotator cuff arthropathy.[1,6,11,23] More recent reports present outcomes similar to our investigation, with multiple reports of less favorable clinical outcomes, graft healing issues, and elevated need for subsequent reoperation or conversion to arthroplasty.[7,13,20] Furthermore in 2022, Hankins et al surveyed 260 American and international shoulder surgeons where 51% reported a decrease in the volume of SCR use in their practice over the prior 5 years.[13] Within this cohort of surgeons, published reports of suboptimal outcomes, limited perceived benefit to their personal patients' outcomes, and technical complexity of performing a SCR were cited as reasons for decreased use of the procedure.

Graft selection in SCR is one of the key technical considerations of the procedure. FL autograft was the original graft of choice when proposed by Mihata et al in 2012.[24] The harvested FL autograft is frequently folded multiple times into a 6-8 mm-thick graft that is

often two to three times the size of the superior capsular defect.[25] Although SCR with FL autograft has demonstrated some of the best SCR results in the literature, the use of acellular human dermal allografts developed as a popular alternative based on an effort to expedite surgery and minimize donor-site morbidity.[1,19,30,33] Comparative analyses between FL autograft and human dermal allografts have been performed noting general improvement in clinical and radiological outcomes with both grafts. However, recent systematic reviews noted a higher rate of graft retear with human dermal allografts compared to FL autografts at ranges of 3.4%-55% and 4.5%, respectively.[1] These findings are supported by prior work associating graft thickness to improvement of postoperative acromiohumeral interval distance; it was demonstrated that inadequate acromiohumeral interval distance improvement was a predictive factor for graft tear and that thicker, 8-mm FL autografts permitted complete restoration of shoulder stability compared to thinner 3-mm human dermal grafts.[18] As such, some of the notable graft tear rate differences may not only be due to the difference in structural properties of graft materials, but also due to differences in graft thickness.

While the recent literature and the present study highlight some of the challenges with SCR over time, it is important to assess the comparative outcomes of alternate management strategies for IRCTs. In 2020, Kovacevic et al performed a systematic review and meta-analysis of current management strategies for IRCTs.[17] Their findings aligned with the 2019 clinical practice guidelines by the American Academy of Orthopaedic Surgeons, which demonstrated limited comparative evidence to support for or against use of physical therapy, partial repair, tendon transfer, SCR, rotator cuff débridement, allograft augmentation, or rTSA on managing IRCTs. Additionally, they observed high failure rates with physical therapy as definitive treatment (60%), high retear rates with partial repair (45%), and high failure rate with tendon transfers (77%). More recent comparative data by Marigi et al evaluated 32 SCR patients and 72 with a LTT performed for IRCTs. They observed that both SCR and LTT led to improved clinical outcomes with no statistically significant differences in complication rate (9.4% vs. 12.5%, $P = .645$) or reoperation rate (3.1% vs. 10%, $P = .231$).[20]

These findings call attention to the complexities of managing patients with an IRCT and the disabling effect that the native shoulder girdle experiences with functional loss of the rotator cuff musculature. Moreover, as we consider current treatment options and generate novel approaches, we should conceptually attempt to target pain generators, restore the shoulder force coupes, recreate a stable glenohumeral fulcrum, and establish a smooth subacromial articulation for the humeral head.[32] Accomplishing this with current joint preservation techniques has been difficult, leading to consideration of combined approaches such as arthroscopic-assisted LTT and dermal graft SCR or a joint sacrificing approach such as a rTSA.[21,29] There are currently limited data on the combination of an LTT and dermal graft SCR, but rTSA has been demonstrated to be a cost-effective approach to improving pain, function, and satisfaction after IRCTs.[4,21] Concerns remain about the reoperation rate and prosthesis failure rate with rTSA, especially without significant improvement over the alternative joint sparing options.[16] In light of this, if patients present with glenohumeral osteoarthritis or with pseudoparalysis secondary to an IRCT it may be beneficial to consider rTSA.[17]

Our study has several limitations. First, this was a single-institution, retrospective, nonrandomized investigation which was open to the possibility of selection bias across the patients indicated for a dermal allograft SCR. Second, the aim of the investigation was to present longer follow-up than has been traditionally presented in the literature; this led to difficulty contacting patients and thus a relatively small sample size that was also open to recollection biases. Moreover, we did not perform an a priori power analysis, further leaving our investigation at risk of a type II error and potential under-reporting of differences that may be present within the cohort. This is especially relevant with regard to our preoperative and postoperative analyses, as we were unable to detect statistical differences with clinical outcomes. Third, our study lacks a control group of patients treated with an alternative treatment for IRCTs which makes us unable to assess the challenges of managing IRCTs through a comparative analysis of our SCR cohort.

Conclusions

At a mean of 5.3 years after arthroscopic SCR for IRCTs, patients experienced sustained pain relief but no significant improvement in shoulder function. Additionally, 20% sustained a postoperative complication with a 14% reoperation rate. These findings should be considered when counseling patients about the challenges of managing IRCTs and the possible outcomes of utilizing a SCR with dermal allograft as a surgical modality.

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