

Complications of Superior Capsule Reconstruction for the Treatment of Functionally Irreparable Rotator Cuff Tears: A Systematic Review



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Abstract:**Purpose:** The purpose of this systematic review is to characterize the complications associated with superior capsule reconstruction (SCR) for the treatment of functionally irreparable rotator cuff tears (FIRCTs). **Methods:** This systematic review was completed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Two independent reviewers completed a search of PubMed, Embase, and Medline databases. Studies were deemed eligible for inclusion if they reported postoperative outcomes of arthroscopic SCR for FIRCTs and considered at least 1 postoperative complication. Statistical heterogeneity was quantified via the I^2 statistic. Due to marked heterogeneity, pooled proportions were not reported. All complications and patient-reported outcomes were described qualitatively. **Results:** Fourteen studies met the inclusion/exclusion criteria. The overall complication rate post-SCR ranged from 5.0% to 70.0% ($I^2 = 84.9\%$). Image-verified graft retear ranged from 8% to 70%, $I^2 = 79.4\%$, with higher rates reported when SCR was performed using allograft (19%-70%, $I^2 = 76.6\%$) compared to autograft (8%-29%, $I^2 = 66.1\%$). Reoperation (0%-36%, $I^2 = 73.4\%$), revision surgeries (0%-21%, $I^2 = 81.2\%$), medical complications (0%-5%, $I^2 = 0.0\%$), and infections (0%-5%, $I^2 = 0.0\%$) were also calculated. **Conclusions:** SCR carries a distinct complication profile when used for the treatment of FIRCTs. The overall rate of complications ranged from 5.0% to 70.0%. The most common complication is graft retear with higher ranges in allografts (19%-70%) compared to autografts (8%-29%). The majority of studies reported at least 1 reoperation (range, 0%-36%), most commonly for revision to reverse shoulder arthroplasty. **Level of Evidence:** Level IV, systematic review of Level IV or better investigations.

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Chronic massive rotator cuff tears are often disabling for patients and difficult to manage for surgeons. These tears account for up to 40% of all rotator cuff tears evaluated in clinic,¹⁻³ resulting in significant patient

morbidity that can progress to rotator cuff arthropathy.⁴⁻⁶ Patients often present with severe pain, weakness, and loss of range of motion, which interferes with their activities of daily living and quality of life.^{1,7} As a result, many patients with chronic massive rotator cuff tears fail nonoperative management and eventually undergo surgery. Traditional open and arthroscopic repair has resulted in disappointing outcomes, with tears being either irreparable intraoperatively or resulting in unacceptably high retear rates postoperatively, ranging from 25% to 94%.⁸⁻¹² These tears are now commonly referred to as functionally irreparable rotator cuff tears (FIRCTs).

Reverse total shoulder arthroplasty (RSA) is a suitable treatment for elderly, lower-demand patients with FIRCTs. However, in younger, active patients, RSA has demonstrated reduced long-term survivorship and higher complication rates,¹³⁻¹⁸ favoring joint-preserving treatments such as debridement,^{19,20} biceps tenotomy or tenodesis,^{21,22} partial rotator cuff tendon repair,²³⁻²⁵

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bridging techniques,²⁶⁻²⁹ tendon transfers,³⁰⁻³⁴ or superior capsule reconstruction (SCR).³⁵⁻³⁹ First described by Mihata et al.,⁴⁰ SCR is proposed to restore superior stability to the shoulder and improve function while reducing the progression to rotator cuff arthropathy.^{35,40-42} Initial reports using autografts for SCR demonstrated significantly improved pain and function with limited complications.^{38,40,43} Subsequent reports have described high rates of graft retear, reoperations, and revision surgery.^{37,44-52} The variability in outcomes has been attributed to differences in surgical indications, technical considerations such as graft choice (allograft vs autograft), and surgeon experience.^{37,52} However, there remains a paucity of data on the true complication profile following SCR for the treatment of FIRCTs. This information is essential to assist surgeons and patients in the surgical decision-making process when treating this difficult pathology. The purpose of this systematic review is to characterize the complications associated with SCR for the treatment of FIRCTs.

We hypothesized that (1) SCR is associated with highly variable rates of complications, including graft

retear, reoperation, and revision surgery; (2) SCR is a medically safe intervention; and (3) allograft and autograft studies have similar complication profiles.

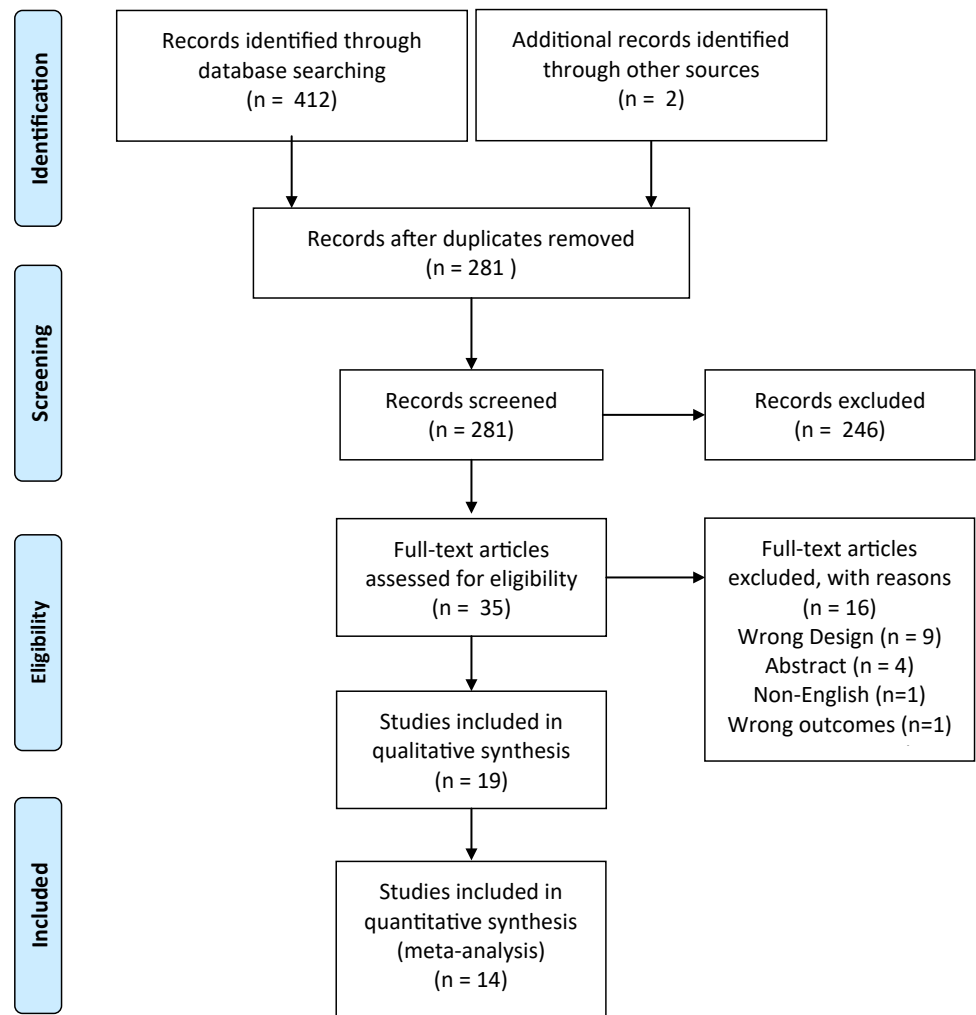
Methods

This systematic review was completed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses.⁵³

Search Strategy

An English-language search of the PubMed (1966 to present), Embase (1947 to present), and Medline (1946 to present) databases was completed on May 5, 2020. Combinations of the terms “superior capsular reconstruction,” “tissue scaffold,” and “rotator cuff” were combined with the use of wildcard modifiers and medical subject headings (MeSH) such as “reconstructive surgical procedure” to identify relevant articles ([Appendix 1](#)). A secondary search was completed of the reference lists of the included studies as well as prior systematic reviews to ensure a complete data set was obtained.⁵⁴ Titles, abstracts, and full-text articles were reviewed independently

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram of the search process.⁵³



by 2 investigators (M.S. and D.O.). If there was disagreement between the 2 reviewers, these were resolved by the senior author (J.W.).

Inclusion Criteria

Studies were deemed eligible for inclusion if they satisfied the following criteria: reported postoperative outcomes of arthroscopic SCR for irreparable rotator cuff tears and considered at least 1 postoperative complication. Case reports, review articles, editorials, commentary or gray literature source (ie, conference abstract or proceeding), animal or cadaveric studies, technique papers, and non-English-language publications were excluded. When multiple studies were published on the same patient cohort, all but 1 study (with the longest follow-up or most robust data set) representing that patient population were excluded.

Data Extraction and Quality Analysis

Data extraction was completed by 2 independent investigators (M.S. and S.Z.). Demographic data included the number of patients evaluated, patient age (mean and range), sex (proportion female), and length of follow-up (mean and range; [Table 1](#)). Preoperative parameters and clinical outcomes extracted included American Shoulder and Elbow Surgeons Shoulder score, pain as measured on a visual analog scale, Subjective Shoulder Value, Constant-Murley Shoulder Outcome Score (Constant), and radiographic or imaging outcomes as described by the authors. The surgical parameters analyzed included graft type (ie, dermal), graft source (autograft or allograft), graft thickness (mm), previous surgery and the number of tendons involved (supraspinatus, infraspinatus, subscapularis).

The postoperative complications analyzed included graft retear, image verified graft retear, reoperation, revision surgery, infection, contracture, arthritis progression/humeral head elevation, persistent pain, thrombotic/pulmonary embolism (PE), and donor site morbidity.

“Reoperation” was defined as any surgical intervention during postoperative follow-up. This consisted of both “revision surgery,” defined as an intervention performed to address a clinical failure of the procedure, and “other complications,” where surgery was performed leaving the SCR intact (eg, irrigation and debridement for infection, biceps tenodesis). The “image verified graft retear” rate included only studies that routinely performed postoperative magnetic resonance imaging (MRI) with greater than 80% of the patient population at a minimum of 6 months. Adverse outcomes were defined as unique negative outcomes reported by individual studies that did not require specific treatment or further investigation. Adverse outcomes were extracted and reported but were not included in the overall rate of complications.

Following data extraction, assessment of methodologic quality of the included studies was completed by a single reviewer (M.S.) using the Methodological Index for Non-Randomized Studies.⁵⁵ This scale scores articles across 10 criteria compatible with the Consolidated Standards of Reporting Trials statement for randomized controlled trials yet allows for the inclusion of differing study designs ([Table 3](#)).⁵⁶

Statistical Analysis

A total complication rate was defined as the total number of complications divided by the total sample

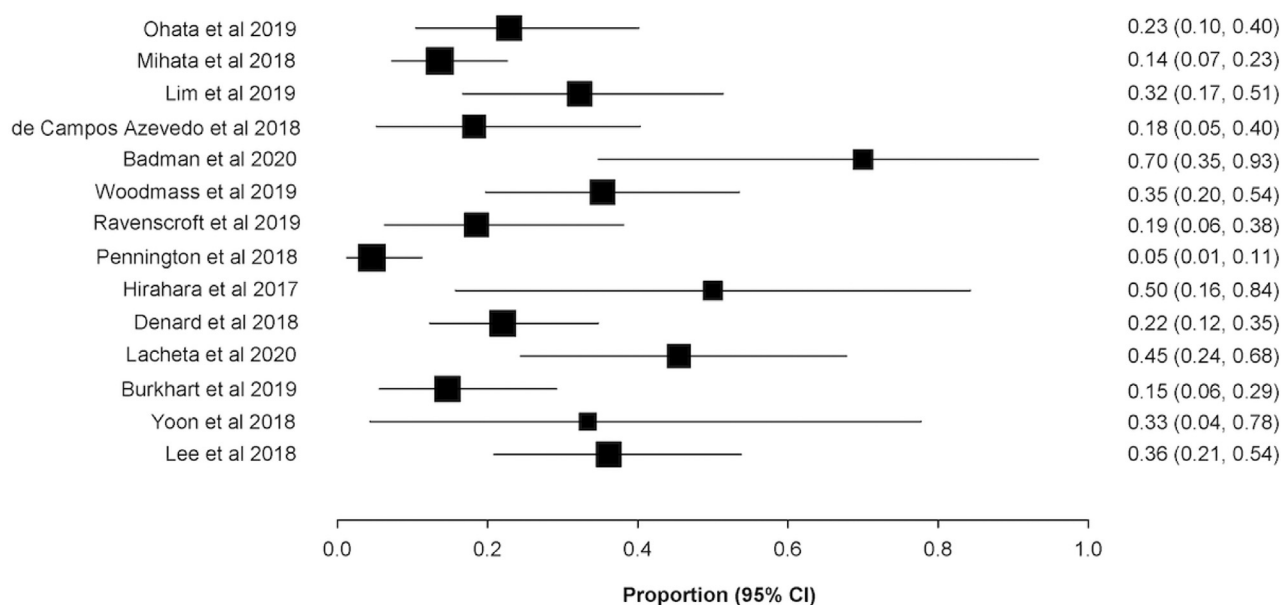


Fig 2. Overall complications.

Table 1. Demographics

Study	Study Population (Shoulders)	Mean Age, y	% Female	Mean Follow-up, mo	% Follow-up	Graft Type	Graft Thickness, mm	Study Design (Level of Evidence)	MINORS Score
Burkhardt et al. ⁵⁹	41	64.0	20.0	34	89.0	Dermal allograft	3	Retrospective case series (IV)	6
de Campos Azevedo et al. ⁶³	22	64.8	68.2	23	95.5	Fascia lata autograft	5-8	Prospective case series (IV)	15
Lacheta et al. ⁵¹	22	56.0	42.9	25	100.0	Dermal allograft	3	Prospective case series (IV)	13
Denard et al. ³⁶	59	62.0	33.9	18	88.1	Dermal allograft	1, 2, and 3	Multicenter prospective case series (IV)	9
Hirahara et al. ⁶⁵	8	61.3	25.0	32	89.0	Dermal allograft	1.5 and 3.5	Prospective case series (NR)	11
Lee et al. ⁶¹	32 (36)	60.9	31.3	25	94.7	Mixed	>6 and <6	Retrospective case control study (IV)	12
Lim et al. ⁶⁷	31	65.3	71.0	15	100.0	Fascia lata autograft	≥6	Retrospective case series (IV)	14
Mihata et al. ⁴²	88	66.2	NR	60	NR	Fascia lata autograft	6-8	Retrospective case series (IV)	9
Ohta et al. ⁶⁴	35	75.3	48.6	41	NR	Mixed autograft	6-8	Retrospective comparative study (NR)	9
Pennington et al. ³⁸	86 (88)	59.4	39.0	12	100.0	Dermal allograft	3	Retrospective case series (IV)	11
Ravenscroft et al. ⁶²	27	60.0*	63.0	NR	NR	Dermal allograft	3.5	Histologic case study (NR)	9
Woodmass et al. ³⁷	34	60.0	38.2	12	52.3	Dermal allograft	3	Retrospective case series (IV)	9
Badman et al. ⁴⁴	10	58.6	50.0	12†	NR	Dermal allograft	NR	Prospective case series (IV)	10
Yoon et al. ⁶⁰	6	59.5	0.0	27	NR	Mixed	2	Retrospective case series (NR)	11

MINORS, Methodological Index for Non-Randomized Studies; NR, not reported.

*Given as a median age instead of mean.

†Given as a minimum instead of mean.

size for each study. Individual complication rates were calculated by the number of patients who experienced the complication against the total sample size of each study. Heterogeneity analysis was completed through consideration of the I^2 statistic⁵⁷ that ultimately precluded formal meta-analyses on complication proportions due to the high heterogeneity. Forest plots were generated for visual interpretation and ranges with the associated I^2 statistic were presented in text for the complication proportions. All analyses were completed using StatsDirect software, version 3.2.8 (StatsDirect Ltd, Birkenhead, UK).

Results

A total of 414 studies met the search criteria, with 133 duplicates removed. Abstract screening of 281 studies resulted in 35 being considered for full-text review, and 19 studies were initially included (Fig 1). Mihata et al.⁵⁸ and Burkhardt et al.⁵⁹ were included, whereas Mihata et al.^{35,40,42} and Burkhardt et al.³⁹ were excluded due to overlapping patient populations. The series reported by Burkhardt et al.⁵⁹ contributed patients to a multicenter prospective study by Denard et al.,³⁶ accounting for a small proportion of the total cohorts, so both studies were ultimately included, resulting in a total of 14 studies in our analysis.

Frequently reported complications following SCR included graft retear (graft rupture, anchor loosening), revision surgery, reoperation, and infection. Less commonly, patients experienced "other" complications such as stiffness or medical complications such as stroke or deep vein thrombosis. The overall rate of complications post-SCR ranged from 5.0% to 70.0% ($I^2 = 77.3\%$; Fig 2) (507 shoulders; Table 2).^{36-38,44,51,52,58-65} The complication rate in the 8 studies using allografts (289 shoulders)^{36-38,44,51,59,62,65} ranged from 5% to 70% ($I^2 = 84.9\%$) while the complication rate of the 4 studies using autografts (176 shoulders)^{52,58,63,64} ranged from 14% to 32% ($I^2 = 42.1\%$).

Fourteen studies reported graft retear, making it the most commonly reported complication associated with SCR.^{36-38,44,51,52,58-65} The image-verified graft retear rate (8 studies, 271 shoulders) showed relatively higher rates of graft retear using allograft (19%-70%, $I^2 = 76.6\%$; Fig 3B) when compared to those that used autografts (8%-29%, $I^2 = 66.1\%$; Fig 3C), respectively. The study by Lee et al.⁶¹ was excluded from graft-type analyses due to the unclear delineation between patients receiving either graft type.

Twelve studies reported reoperations (n = 53) with reoperation rates ranging from 0% to 36% ($I^2 = 73.4\%$; Fig 4A).^{36-38,44,51,58-62,64,65} Of the 53 reoperations, 38 were revision surgeries that consisted of 19 RSAs,^{36-38,59,62,64,65} 4 revision SCRs,^{36,51,59} 2 latissimus dorsi transfers (LDTs),³⁷ and 13 unspecified revisions⁶¹ (Table 2). The rate of revision surgeries ranged from 0%

to 21% ($I^2 = 81.2\%$; Fig 4B). Reoperation procedures included revision surgery for graft tear^{36-38,51,59,61-65} and persistent shoulder pain,^{37,38} removal of loose suture anchors,⁵⁸ biceps tenodesis repair for biceps pain and tenodesis tear,^{36,59} arthroscopic capsular release for shoulder contracture,⁵⁸ arthroscopic debridement for infection and inflammatory synovitis,^{36,58,63} and diagnostic arthroscopy³⁷ (Table 2). Two studies reported no reoperation surgeries.^{44,60}

Eight studies reported on infection,^{36,51,52,58-60,63,64} with 3 reporting at least 1 infection,^{36,58} while the other 5 reported zero infections.^{51,52,59,60,64} The overall rate for infection ranged from 0% to 5% ($I^2 = 0\%$). All 4 infections required reoperation with arthroscopic irrigation and debridement,^{36,58,63} including the insertion of an antibiotic spacer for 1 patient (Table 2).³⁶

Eight studies reported medical complications following SCR, with rates ranging from 0% to 5% ($I^2 = 0\%$).^{36,51,52,58-60,63,64} Of the 3 medical complications reported, there was 1 cerebrovascular accident (CVA),⁵⁹ 1 PE,⁵² and 1 deep vein thrombosis (DVT).⁶³ The CVA occurred in the immediate postoperative period and was due to withheld warfarin prior to the operation in a patient with a mechanical heart valve.⁵⁹ The patient who developed a PE was successfully treated with anticoagulation and the patient with a DVT was described as experiencing "donor-site claudication," for which no treatment was listed.^{52,63}

Three studies reported "other" complications that were included in the overall complications data (Table 2).^{37,60,65} These included shoulder dislocation,³⁷ infraspinatus re-tear,⁶⁵ and progressive arthritis.⁶⁰

Five studies listed adverse outcomes that were not included in the overall complications. Adverse outcomes were unique to the individual study and required no treatment or further investigation.^{36,37,58,59,63} These included reports of unsatisfactory outcomes,^{36,59} clinical failure,³⁷ and harvest site pain/changes^{58,63} (Table 2). Unsuccessful clinical outcomes were reported by both Denard et al.³⁶ and Burkhart et al.,⁵⁹ defined as less than a 17-point improvement in American Shoulder and Elbow Surgeons Shoulder score, with 19 of 59 and 6 of 41 patients experiencing an unsuccessful outcome, respectively. In comparison, Woodmass et al.³⁷ reported 22 of 34 patients as clinical failures using the modified Neer classification. De Campos Azevedo et al.⁶³ described donor site-related morbidity, with 12 of 21 patients reporting harvest site pain and 16 of 21 patients reporting harvest site changes (eg, deformity, numbness, pain).

Discussion

SCR is associated with a highly variable rate of complications, ranging from 5.0% to 70%. The most common complication following SCR included image verified graft re-tear, with higher ranges among those treated with

Table 2. Complications and Reoperations

Citation	Shoulders (No.)	Overall Complication Rates, % (No.)	Graft Retear Rates, % (No.)	Reoperation Rates, % (No.)	Revision Surgery Rates, % (No.)	Infection Rates, % (No.)	"Other Complication" Rates, % (No.)	Adverse Outcome Rates, % (No.)	Medical Complication Rates, % (No.)
Allograft studies									
Burkhart et al. ⁵⁹	41	15% (6)	10% (4)	7% (3)	5% (2)	0% (0)	2% (1)	15% (6)	2% (1)
Lacheta et al. ⁵¹	22	45% (10)	45% (10)	5% (1)	5% (1)	0% (0)	NR	NR	NR
Denard et al. ³⁶	59	22% (13)	19% (11)	18% (11)	15% (9)	2% (1)	2% (1)	32% (19)	NR
Hirahara et al. ⁶⁵	8	50% (4)	39% (3)	25% (2)	13% (1)	NR	12.5% (1)	NR	NR
Pemington et al. ³⁸	88	5% (4)	3% (3)	1% (1)	1% (1)	NR	NR	1% (1)	NR
Ravenscroft et al. ⁶²	27	19% (5)	19% (5)	11% (3)	11% (3)	NR	NR	NR	NR
Woodmass et al. ³⁷	34	35% (12)	9% (3)	24% (8)	21% (7)	NR	26% (9)	65% (22)	NR
Badman et al. ⁴⁴	10	70% (7)	70% (7)	NR	NR	NR	NR	NR	NR
Autograft studies									
Lim et al. ⁵²	31	32% (10)	29% (9)	NR	NR	0% (0)	NR	NR	3% (1)
Mihata et al. ⁴²	88	14% (12)	23% (7)	9% (8)	NR	2% (2)	3% (3)	1% (1)	NR
Ohta et al. ⁶⁴	35	23% (8)	20% (7)	11% (2)	3% (1)	0% (0)	3% (1)	NR	NR
de Campos Azevedo et al. ⁶³	22	18% (4)	9% (2)	5% (1)	NR	5% (1)	NR	55% (12)	5% (1)
Mixed-graft studies									
Lee et al. ⁶¹	36	36% (13)	36% (13)	36% (1)	36% (13)	NR	NR	NR	NR
Yoon et al. ⁶⁰	6	33% (2)	17% (1)	NR	NR	0% (0)	33% (2)	NR	NR

*In Hirahara et al.,⁶⁵ "glenoid fixation was obtained with 2 anchors and a double surgeon knot."

Table 3. Outcome Measurements

Study	Preoperative Mean–Postoperative Mean				
	ASES	Pain VAS	SSV	Constant Shoulder Score	AHD, mm
Burkhart et al. ⁵⁹	52.0-89.0	4.6-0.7	39.0-83.0	NR	7.0-8.0
de Campos Azevedo et al. ⁶³	NR	NR	33.0-70.0	17.5-64.9	6.4-7.1
Lacheta et al. ⁵¹	54.0-83.9	4.0*	NR	NR	7.0-8.3
Denard et al. ³⁶	43.6-77.5	5.8-1.7	35.0-76.3	NR	6.6-6.7
Hirahara et al. ⁶⁵	41.8-86.5	6.3-0.4	NR	NR	4.5-7.7
Lee et al. ⁶¹	50.3-82.7	5.8-1.3	NR	56.3-81.1	4.9-8.1
Lim et al. ⁵²	54.4-73.7	6.0-2.5	NR	51.7-63.7	5.3-6.4
Mihata et al. ⁴²	35.1-94.3	NR	NR	NR	4.4-9.5
Ohta et al. ⁶⁴		NR	NR	NR	4.0-6.2
Pennington et al. ³⁸	52.2-81.6	4.0-1.5	NR	NR	7.1-9.7
Ravenscroft et al. ⁶²	NR	NR	NR	NR	NR
Woodmass et al. ³⁷	NR	4.9-5.0	26.6-45.8	NR	NR
Badman et al. ⁴⁴	43.0-87.0	6.5-1.0	NR	NR	6.8-6.2
Yoon et al. ⁶⁰	60.4-81.6	3.7-1.6	NR	59.9-63.0	4.8-3.8

ADH, acromial humeral distance; ASES, American Shoulder and Elbow Surgeons Score; NR, not reported; SSV, Subjective Shoulder Value; VAS, visual analog scale.

*Reported as a median score.

allografts (19%-70%) compared to those treated with autografts (8%-29%). Other complications included reoperation (0%-36%) and medical complications (0%-5%).

FIRCTs represent a challenging pathology with multiple treatment options, including debridement and subacromial decompression,^{19,66} partial repair,⁶⁷⁻⁶⁹ LDT or lower trapezius tendon transfer,^{31,32,34,70-72} tissue augmentation,⁷³⁻⁷⁵ and RSA.^{13,18,76-79} Primary repair can result in high retear rates (often exceeding 50%) when used to treat FIRCTs⁸⁰⁻⁸² while young age (<60) is an independent risk factor for poor functional improvement¹³ and increased complications¹⁷ following RSA. SCR was described by Mihata et al.⁴⁰ in 2013 as a joint-preserving treatment option for patients with FIRCTs demonstrating promising postoperative clinical outcomes. Subsequent studies have reported highly variable rates of complications, including graft retears, reoperations, and revision surgeries.^{40,83,84} This systematic review characterized the risk profile of SCR for the treatment of FIRCTs. A total of 14 studies (507 shoulders) met the study criteria, yielding an overall complications rate ranging from 5% to 70% ($I^2 = 77.3\%$).^{36-38,44,51,52,58-65}

In the current study, graft retear was the most common complication following SCR, with at least 1 retear occurring in each of the 14 studies analyzed (5%-70%; Table 2). This high variability is at least partially explained by the differences in methodology and reporting. For instance, while some studies only imaged patients who presented with persistent pain or poor function, other studies performed routine MRI on 100% of their patients at final follow-up. In an effort to reduce this bias, an “image-verified graft retear” rate was calculated by evaluating only studies where >80% of patients had undergone a postoperative MRI at a

minimum 6-month follow-up. The majority of studies demonstrated an image-verified graft retear rate of 20% or greater (Fig 3A). Variability in graft retear rates can also be explained by differences in fixation techniques utilized by the studies included in our analysis. For example, some studies found that anchor loosening primarily occurred at the glenoid,^{44,51,62} whereas while others found that loosening at the humeral side^{36,52,61} was more common. This variability can be attributed in part to differences in surgical technique. Although patients who experience a graft retear may demonstrate an improvement in pain and function when compared to their preoperative status, patients with healed SCR grafts demonstrate improved patient-reported outcomes at 2 years, highlighting the continued need to improve healing rates.³⁹

Proposed risk factors for graft retear included graft type (allograft vs autograft) and thickness.^{36,37,60} When controlling for graft type, the range of image-verified graft retear was higher in patients who underwent an allograft reconstruction (19%-70%) when compared to autograft reconstructions (8%-29%). This may reflect graft incorporation with autograft tissue, allowing for more reliable integration and durability.^{37,85,86} Athanasiou et al.⁸⁵ demonstrated that autografts show increased tissue incorporation on histologic analysis compared to allografts. Similarly, Wang et al.⁸⁶ reported autografts to have superior maximum tensile strength with regard to soft tissue bone healing when compared to allografts. The difference in failure rates may also be attributed to the difference in graft thickness that typically parallels graft type. Currently, dermal allografts are available in thicknesses ranging from 1 to 3 mm.³⁶ Conversely, iliotibial band autografts are harvested intraoperatively and typically shaped to measure 8 mm in thickness. Biomechanical data have demonstrated that 8-mm fascia lata

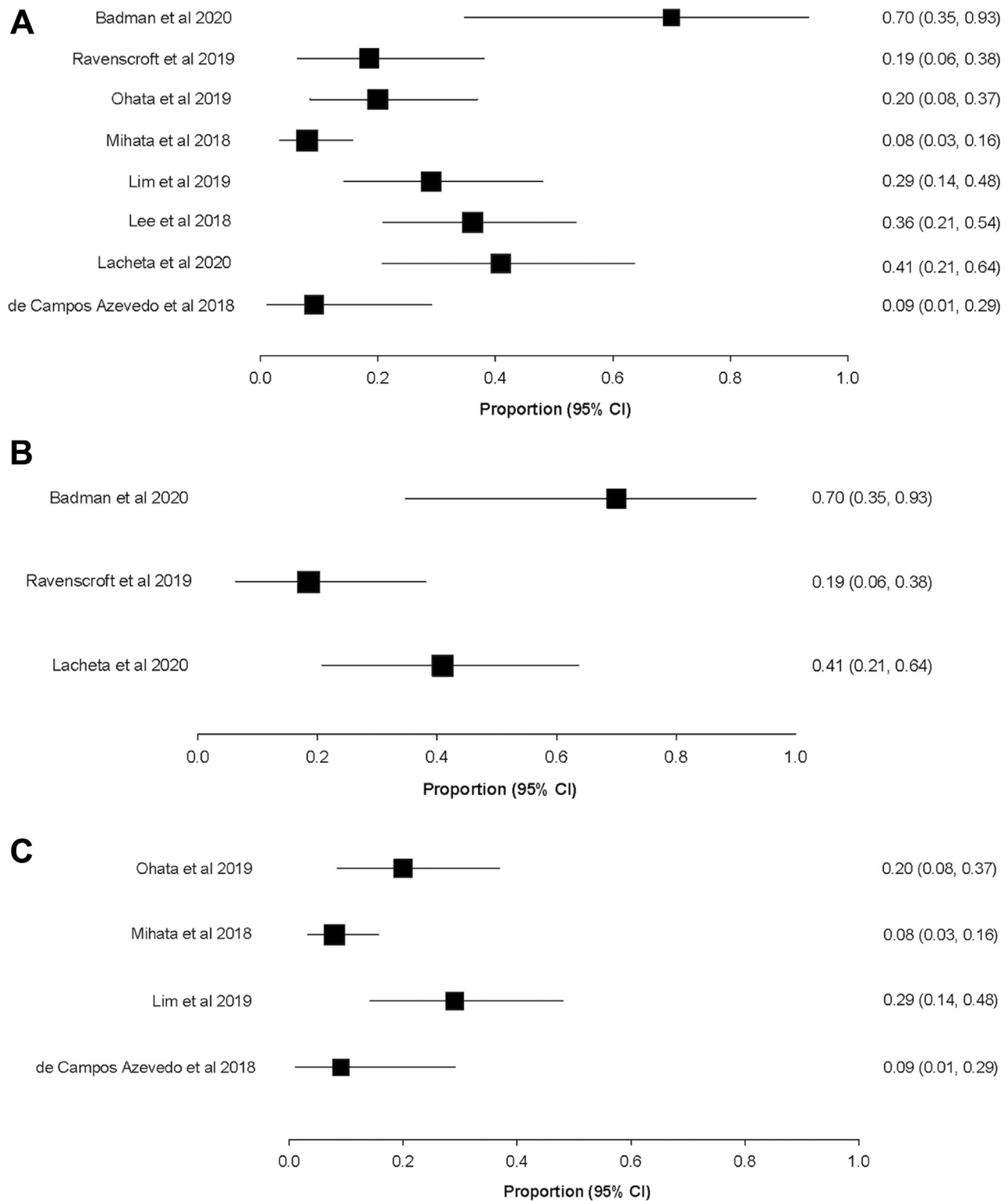


Fig 3. Magnetic resonance imaging (MRI) graft retear. (A) Overall retear. (B) Allograft retear. (C) Autograft retear. *More than 80% patients receiving MRI at minimum 6 months postoperatively.

autografts provide greater rotator cuff stability via a reduction in both superior peak contact pressure and superior translation, compared to 4-mm fascia lata autografts.⁴¹ The importance of graft thickness is supported in

clinical observation by Denard et al.,³⁶ who reported that thinner grafts (1 mm) are more susceptible to failure (60%) when compared to reconstructions performed using thicker (3-mm) grafts (32%).

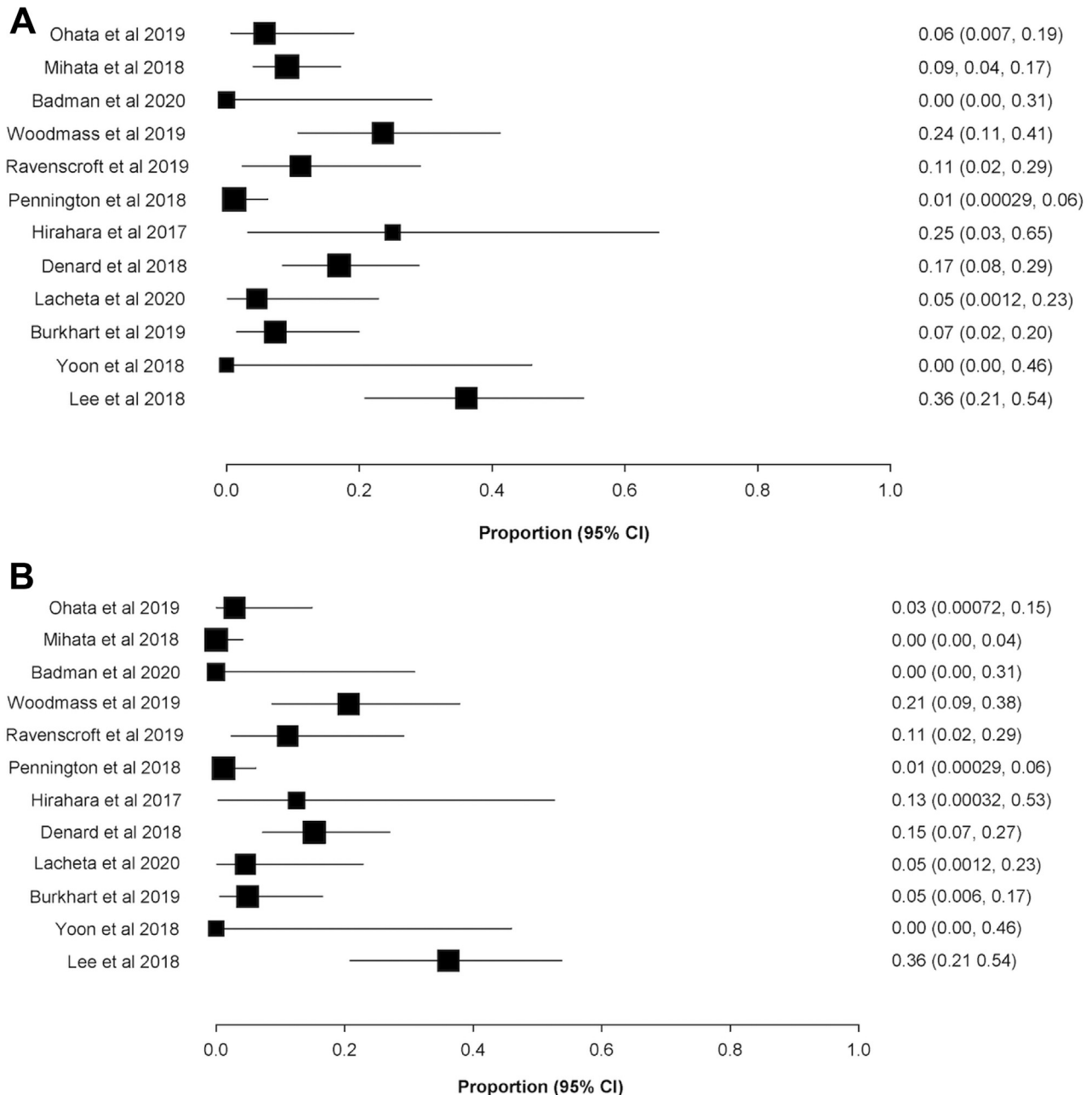


Fig 4. (A). Total reoperations. (B) Total revisions.

Reoperations were reported in 83% of the included studies (range, 0%-36%) with revision surgery accounting for the majority of reoperations (Fig 4A,B). The most common revision surgery following SCR was RSA followed by revision SCR and LDT (Table 2). While the rate of reoperation is high, FIRCTs are a challenging pathology, and the alternative reconstructive interventions (rotator cuff repair, tendon transfer, RSA) share a similar reoperation profile. According to Duralde et al.⁶⁸ and Sperling et al.,⁸⁷ revision rates following arthroscopic repair of FIRCTs range from 2.9% to 24.1%. Even less successful outcomes are observed in patients who have undergone prior failed

rotator cuff repair,¹ with 34.5% (128/371) of patients requiring revision surgery. Open LDT has slightly lower rates of reoperation³¹ and graft tear.⁸⁸⁻⁹⁰ Gerber et al.³¹ described 8.7% (4/46) patients undergoing reoperation with a minimum 10-year follow-up. Gerhardt et al.⁸⁹ published a 10.0% graft retear rate (2/20) when using solo LDT transfers while Lichtenberg et al.⁹⁰ described 0 of 20 patients with graft retears when using the modified L'Episcopo approach (latissimus dorsi and teres major transfer) after a 5-year follow-up. RSA is one of the primary methods used to treat massive irreparable rotator cuff tears.^{1,39,91} Reoperation rates following RSA after a 15-year follow-up period are

comparable to those following SCR at 1 to 2 years postoperatively⁷⁸ with reoperation rates ranging from 5%⁹² to 33%.^{77,78} However, younger age is a risk factor for poor outcome, with the complication rate rising to 39% of patients who were under 60 years.¹⁶ Furthermore, reoperation following RSA may have a higher morbidity.¹⁶ Thus, in young patients without glenohumeral arthritis, joint-preserving treatment options remain the favored intervention.

SCR is a relatively new and technically challenging intervention that has demonstrated a “surgeon learning curve,” where inexperienced surgeons observe a relatively inflated rate of complications while learning and optimizing their skills.^{37,52} According to Lim et al.,⁵² surgeons who were inexperienced with SCRs were more likely to see higher failure rates in early cases, with failures occurring in consecutive series. Similarly, in a case series of 34 patients, a failure rate of 77.3% was observed over a surgeon’s first 10 cases, which later decreased to 41.7% after a minimum of 10 cases had been performed.³⁷ Similar trends have been observed with arthroscopic rotator cuff repair,⁹³ reverse shoulder arthroplasty,^{94,95} arthroscopically assisted LDT,⁹⁶ and arthroscopic Latarjet⁹⁷ procedures. SCR is a technically challenging procedure that should be performed by experienced surgeons at a high volume. Given that the authors who publish on SCR are likely high-volume surgeons, the overall rate of complications identified in this review may underestimate that expected when SCR is performed in a community practice.

The medical complications associated with a procedure provide an important benchmark from which the safety of the procedure can be evaluated. The medical complications observed following SCR included CVA, PE, and DVT occurring with rates ranging from 0% to 5% postoperatively. When compared to the rates of medical complications of other procedures such as arthroscopic rotator cuff repairs (2.9%),⁸² RSA (9.6%-15.2%),^{76,79} and LDT (5.3%),³¹ SCR is a relatively safe procedure with a low medical complication rate.

Limitations

The main limitations of this systematic review are the overall low quality of evidence and the high degree of heterogeneity among the individual studies included. The heterogeneity was evident among the surgical indications, surgical technique, and ultimately the rate of complications (represented by the I^2 coefficient). The average Methodological Index for Non-Randomized Studies score for quality and bias assessment was 10.6/16, with the majority of studies consisting of grade 4 evidence (Table 1). Furthermore, it is important to recognize that only the short-term complications are evident in this review as only 1 study reported on a cohort with 5-year follow-up data (Table 1).⁵⁸

Conclusions

SCR carries a distinct complication profile when used for the treatment of FIRCTs. The overall rate of complications ranged from 5.0% to 70.0%. The most common complication is graft retear, with higher ranges in allografts (19%-70%) compared to autografts (8%-29%). The majority of studies reported at least 1 reoperation (range, 0-36%), most commonly for revision to reverse shoulder arthroplasty.

Appendix 1. Search Terms by Database

Medline (via Pubmed)	((superior AND capsul* AND repair) AND tissue scaffold) OR ((superior AND capsul* AND repair) AND rotator cuff) OR (tissue scaffold AND rotator cuff) OR (superior[All Fields] AND capsul*[All Fields] AND ("reconstructive surgical procedures"[MeSH Terms] OR ("reconstructive"[All Fields] AND "surgical"[All Fields] AND "procedures"[All Fields]) OR "reconstructive surgical procedures"[All Fields] OR "reconstruction"[All Fields])) NOT animal [mh].
Medline (via Ovid)	#1 AND #2 OR #3 #1 ("superior capsule repair" or "superior capsular repair" or "superior capsule reconstruction" or "superior capsular reconstruction").mp #2 Tissue Scaffold/ #3 Rotator Cuff/
Embase	#1 AND #2 OR #3 #1 ("superior capsule repair" or "superior capsular repair" or "superior capsule reconstruction" or "superior capsular reconstruction").mp #2 Tissue Scaffold.sh #3 Rotator Cuff.sh

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