RESEARCH ARTICLE

Five Year Follow up of Retrospective Cohort Comparing Structural and Functional Outcome of Arthroscopic Single-row versus Double-row Suture Bridge Repair of Large Posterosuperior Rotator Cuff Tear in Patients Less than or Equal to 70 Years

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Abstract

Background: High re-tear rates after repairing large-sized posterosuperior rotator cuff tears remain a significant concern which may affect the clinical outcome. The most optimal type of repair (single versus double-row suture bridge) suited for large size tear remains debatable.

Methods: In a retrospective cohort study with a minimum of five years follow up, the structural and functional outcome of 103 patients with large size cuff tear repaired with single row (SR) or double row suture bridge (DRSB) were evaluated. The structural outcome was assessed with ultrasonography whereas functional outcome was evaluated with Constant Murley (CM) and American shoulder elbow score (ASES).

Results: There were 55 patients in the SR group and 48 patients in the DRSB group with a mean follow-up of 74.2 months (range, 60-96 months). While comparing the structural integrity in two groups, we found significantly lower re-tear rates in the DRSB group as compared to the SR group (10.4% vs. 32.7%; *P=0.006*). Also, there were more focal defects in the SR group (25.4%) than the DRSB group (8.3%). Overall, there was no significant difference in CM and ASES scores when the SR group was compared to DRSB. However, subgroup analysis between those with intact and retorn tendon revealed significant difference (*P=0.0001*) in the clinical scores.

Conclusion: At a minimum of five years follow-up, the DRSB repair of large posterosuperior cuff tear resulted in superior structural healing over SR repair. Nevertheless, overall there was no significant functional difference between both the techniques. However, the functional outcome of the healed tendon subgroup was superior to retear tendon subgroup.

Level of evidence: III

Keywords: Large size, Outcome, Posterosuperior, Repair, Rotator cuff tear, Single row, Suture bridge

Introduction

Retear or failure to heal after the rotator cuff repair remains a significant concern as it may affect the functional outcome (1-3). The retear rates of the repaired rotator cuff continue to be varying from 5 % to 90 % (4-9). Multiple factors are responsible for failure to heal on to the footprint after the repair of the rotator

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cuff, such as the age of the patient, size of the tear, quality of the tendon and repair techniques (10, 11). Among various factors, tear size (especially large tear) remains a major concern resulting in a retear rate of up to 50% after the repair of large tears (11-13).

Currently, most surgeons either use arthroscopic single row (SR) or double row suture bridge (DRSB) technique to repair the torn cuff. Biomechanically, DRSB repair is superior over SR repair in restoring near-complete footprint, higher load to failure, and lesser gap formation on cyclic loading (14-16). Hence, it is logical to conclude that rotator cuff repair by the DRSB technique would result in better structural and clinical outcomes as compared to SR repair. However, a superior structural footprint restoration in DRSB as compared to SR has not always translated into better clinical and structural outcomes in the former group. The evidence in the literature remains conflicting regarding the clinical and structural outcome after the repair of large rotator cuff tears with two techniques. To date, there has been no consensus regarding the superiority of either technique which would provide a superior outcome in large tears.

Many authors gave different conclusions like similar structural and clinical outcome in both techniques or better clinical results with DRSB but no structural difference between the two or superior structural healing with DSRB but no superiority in the clinical outcome as compared to SR (17-20) or better clinical and structural outcome in double row technique in large tears (21). A recent meta-analysis by Xu et al concluded that the double-row technique results in improved functional outcomes in tear size more than 30 mm (22). Nevertheless, most individual studies had mixed data of small-medium, medium-large, large to massive, or mixed type tears with a fewer number of patients in each group and subgroup.

The objective of our study was to evaluate the clinical and structural outcome after the repair of large size rotator cuff tear with either SR or DRSB technique. We hypothesized that there would be no difference between the two techniques while comparing structural integrity and clinical outcomes.

Materials and Methods

Study Design and patient selection

This is a retrospective cohort study (Institutional ethical committee approved) of arthroscopic rotator cuff repair of large size posterosuperior cuff tear by SR or DRSB (transosseous equivalent), which were performed between 2011 to 2014, and the data were collected prospectively for a minimum of five years.

The demographic data, history, preoperative clinical, preoperative magnetic resonance imaging (MRI) and intraoperative details of each patient who was operated for large size RC tear between 2011 and 2014 were obtained from offline and online medical records. A total of 128 patients were selected who matched the criteria. Twenty-five patients were excluded as they were lost to follow up, leaving 103 patients for the final assessment.

Inclusion and Exclusion criteria

The inclusion criteria were [1] patients between 40 years to 70 years, [2] presence of large, full-thickness posterosuperior cuff tear [tear size 3-5 cm in anteroposterior plane measured by a graduated probe] confirmed during arthroscopy which were either crescent, 'L' or 'reverse-L' shape, [3] repair technique either by SR or DRSB, [4] postoperative ultrasonographic imaging of repaired cuff at 3, 12 months and at a minimum final follow-up of five years and [5] and clinical follow up at a minimum of five years. The exclusion criteria were [1] patients with partial tears, medium and massive size tear, [2] radiographic features of cuff arthropathy, [3] mini-open repair of the cuff [4] associated frozen shoulder which required capsular release, [5] Lafosse Type 4 and 5 Subscapularis repairs as these repairs required different rehabilitation protocol, and would have affected the overall outcome, [6] irreparable cuff or partial repair of the cuff or cases where more than 80% of mediolateral footprint coverage could not be performed after the repair, and [7] 'Deep U' shape tears were excluded from the study as coverage of the repaired tendon after the repair was often less than 80% of the footprint and Goutallier grade IV fatty infiltration and severe atrophy of the Supra- and Infraspinatus muscles (23-25).

Choice of Repair technique

The repair technique, SR or DRSB, performed for large tear, was dependent on two factors. If the patient was insured, rotator cuff repair was performed with the DRSB technique. However, if the patient was not insured and where the patient had to pay for the surgery, the decision to perform SR or DRSB repair was preoperatively decided by the patient based upon the information provided to him by the treating senior surgeon. The surgeon discussed the variable nature of structural and clinical outcomes after the SR and DRSB repair reported in various studies (retrospective, prospective, or randomized trials), which existed before 2014 (26-29). The final decision had to be taken by the patient as uninsured patients had to pay for the higher cost involved with more anchors required in DRSB. Mihata et al too adopted a similar policy wherein repair technique (SR or Double row) was decided by the patient after the operating surgeon gave a detailed account of previously published data (29).

The minimum sample size

The minimum sample size calculation was performed taking the data from conclusions of Park et al, wherein a statistically significant difference in constant score among single row and double row repair of only large-massive rotator cuff tears has been reported to be 7.75 (21). Power analysis suggested that the total sample size required for detecting an anticipated difference of at least six in the constant score among two groups of repair technique (SR and DRSB) would be a total of 96 (48 patients in each group) to provide a statistical power of 0.8 with a 5 % level of significance.

Operative Technique

All cases were operated by the single senior surgeon.

The patients were operated under general anaesthesia or interscalene block or both in sloppy lateral decubitus position with the affected upper limb attached to the limb positioner (Spider 2 limb positioner, Smith and Nephew, USA). After standard skin preparation and draping, diagnostic arthroscopy of the affected shoulder joint was performed from the standard posterior portal. The anterior portal was made just above the subscapularis tendon in the rotator interval. The Biceps tendon was tenotomised if it was found to be significantly frayed, flat, split, or damaged. Open Subpectoral tenodesis was performed if the patient had demanded it preoperatively, in a manual laborer, or when the patient was less than 50 years. Regarding subscapularis tendon, Lafosse Type 1 tear was debrided while Type 2 and 3 tears were repaired with a single anchor (double or triple loaded) by modified Mason allen repair. After completing subscapularis repair and evaluation of the glenohumeral joint, the scope was shifted to the subacromial space. Standard subacromial bursa excision was done using a power shaver and radiofrequency device. Bony acromioplasty was performed only if there was an acromial spur or Bigliani type III acromion. After bursectomy and acromioplasty, supra- and infraspinatus tendons were assessed for the following characteristics (shape, size, retraction, and reparability on to the footprint) before the repair. Tear size was measured in an anteroposterior direction using a graduated probe and categorized as per the DeOrio and Cofield classification (30). Then, margin of the cuff was held with a suture retriever (Arthrex, Naples, Florida, US) to assess its reducibility, adequate coverage, and repairability over the footprint. If the cuff was found to be retracted, the standard releases were performed until optimum coverage of the footprint (>80%) was obtained. Apical traction suture was applied in the 'L or reverse L' shape cuff tear for traction while releasing the tendon from subacromial adhesions or paralabral capsule. The sclerosed bone over the greater tuberosity was gently dusted using burr till minimal bleeding ensued.

Single Row (SR) Repair technique

For single-row repair, double-loaded suture anchors (4.5 mm Cork screw anchor or 5.0 mm PEEK, Arthrex, Naples, Florida) were deployed in the middle of the tuberosity. Two or three suture anchors were used depending on the size of the tear. The tear was repaired in a standard, modified Mason-Allen fashion. In case of L- or reverse-L shape tear, one to three side to side intratendinous sutures were placed and tied, and traction suture was removed.

Double Row Suture bridge (DRSB) repair [transosseous equivalent] technique

For DRSB repair, two to three double-loaded suture anchors (4.5 mm Corkscrew anchor or 5.0 mm PEEK, anchor, Arthrex, Naples, Florida) were used for the medial row and were inserted just lateral to the cartilage margin. Mattress bite was taken in the cuff just lateral to the musculotendinous junction. Once sutures were passed, it was tied in a mattress fashion. These limbs were then brought laterally down to the lateral aspect of the greater tuberosity to create a suture bridge construct (transosseous equivalent) using one or two lateral row knotless anchors (4.75 mm Swivel lock, Arthrex, Naples, Florida) in the standard fashion. In the case of L- or reverse-L shape tear, one to three side to side intratendinous sutures were placed and tied.

All the intraoperative findings were recorded in a standardized form.

Postoperative Rehabilitation

All the patients were started on a structured rehabilitation protocol after repairing large cuff tear. Post-operatively, the shoulder was immobilized in an arm sling for six weeks, and only elbow and finger movements were encouraged along with scapular isometrics. After six weeks, passive mobilization of the shoulder was started. At the end of eight weeks, active assisted movements were initiated, followed by active movements. At the end of three months, an ultrasound of the shoulder was performed in all the cases to ascertain the healing status of the cuff over the footprint. Further, cuff strengthening exercises were initiated with theraband. Return to full and sports activity was reserved at the end of 6-8 months.

Post-Operative tendon integrity

The assessment of the healing status of the repaired tendon was performed using ultrasound (US) examination at the end of three months, 12 months, and then at the final follow up. The final follow-up ultrasonography was performed on Philips epic 5G (The Netherlands) with a linear probe (12-5 Mhz) by a single qualified senior musculoskeletal radiologist. We classified the ultrasound report broadly into three categories. Type I, normal thickness with homogeneously hyperechoic tendon or partial hypoechogenicity or heterogenicity or insufficient thickness without discontinuity indicating 'complete healing'; type II, the presence of a minor discontinuity or a focal partial defect indicating 'partial tear'; and type III, the presence of a significant discontinuity or a 'full-thickness tear.' While performing statistics, Type I was considered healed and type II and III were considered torn. Gartsman et al and Gwark et al also deployed similar criteria for ultrasound assessment of postoperative healing status of the cuff (31, 32). Gilat et al proved that the US showed a sensitivity of 80.8% and specificity of 100% in the diagnosis of rotator cuff retear (33). Further, excluding partial rotator cuff retears resulted in an increase in sensitivity to 94.7%, with 100% specificity.

Functional outcome analysis

At a minimum follow-up of five years, the functional outcomes were assessed with Constant Murley (CM) and American Shoulder and elbow score (ASES) by an independent assessor who was not aware of the technique used in each case.

Statistical Analysis

Statistical analysis was performed using SPSS 16.0 software (IBM, USA). Descriptive analysis was performed to assess the various demographic factors. Chi-square test was used to compare tendon integrity, whereas student t-test to compare the differences in clinical scores (ASES and CM score) between groups. The level of significance was set at *P< .05*.

Results

A total of 103 patients with large rotator cuff tears were included in the study. There were 55 patients in the SR group and 48 patients in the DRSB group. The primary demographic details including age, gender, side, type of posterosuperior tear (Crescent, L or reverse L shape), number of anchors used, mean preoperative clinical scores (CM and ASES), mean follow up in both groups, and type of subscapularis tear are mentioned in Table 1, and are well-matched. The overall mean follow-up of patients in both groups was 74.2 months (range, 60-96 months).

While comparing the structural integrity, there were significantly lower retear rates in the DRSB group than the SR group (10.4% vs. 32.7%; *P=0.006*) [Table 2]. Further, there were more focal defects in the SR group than in the DRSB group (25.4% vs. 8.3%] [Table 3].

Table 1. Patient demographics, pre-operative mean clinical scores, mean follow up (months), shape and size of tear, number of anchor used to repair posterosuperior cuff and type of subscapularis tear

Basic characteristics		SR group (n=55)	DRSB group (n=48)	*P value*
Mean age (Range), y		60.2 (43-69)	57.14 (40-70)	0.2
Sex, Male: female, n		39,16	26,22	0.07
Side, Right:Left		45, 10	42,6	0.42
Mean Constant Murley Score (±SD)		31.42 (5.39)	29.70 (5.42)	0.11
Mean ASES Score (±SD)		42.36 (5.25)	39.76 (4.18)	0.11
Mean follow up (in months)		78.7	69.7	0.2
Shape of tear	Crescent	43	33	0.37
	L- or reverse- L	12	15	
Size of tear (mean in cm)		4.2	4.4	0.42
Number of anchors used		2-3	3-5	
Subscapularis tear	None	22	26	0.48
	Type 1	11	09	
	Type 2	16	10	
	Type 3	06	03	

ASES, American shoulder and elbow; SD, standard deviation; SR, single row; DRSB, double row suture bridge

Table 2. Summary of Postoperative tendon healing status based upon ultrasonographic appearance

	Healed tendon (Type I); (n=80)	Retorn tendon (Type II, III); (n=23)	*P value*
SR group (55)	37 (67.3%)	18 (32.7%)	0.006
DRSB group (48)	43 (89.6%)	5 (10.4%)	

Note: Type I was considered healed whereas Type II and III were considered torn. SR, Single row; DRSB, double row suture bridge

Table 3. Summary of postoperative tendon healing with respect to type I, II and III ultrasonographic appearance.

	Type I (Completely Healed tendon) (n=80)	Type II (Focal defect) (n=18)	Type III Complete tear (n=5)	*P value*
SR group (55)	37 (67.3%)	14 (25.4%)	4 (7.3%)	0.02
DRSB group (48)	43 (89.6%)	4 (8.3%)	1 (2.1%)	

SR, Single row; DRSB, double row suture bridge

Table 4. Summary of the Postoperative Clinical Outcome Scores

Functional Scores	SR group (n=55)	DRSB group (n=48)	*P value*
CM (±SD)	82.65 (8.43)	83.93 (5.15)	.38
ASES (±SD)	86.87 (8.75)	88.31 (4.88)	.31

SD, standard deviation; CM, Constant Murley; ASES, American shoulder and elbow; SR, Single row; DRSB, double row suture bridge

Compared to the preoperative functional scores, there was a clinically significant improvement in postoperative CM and ASES scores in both groups (*P<0.0001*). However, there was no significant difference in CM and ASES scores when the SR group was compared to DRSB [Table 4]. Nevertheless, subgroup analysis between combined healed [type I] and re-torn tendons [type II, III] (irrespective of repair type) revealed that there was a significant difference (*P=0.0001*) in the clinical scores (CM and ASES) between the two group [Table 5]. The type of subscapularis tear and its repair did not influence the clinical outcome at the final follow-up.

Table 5. Summary of postoperative clinical scores in healed versus re-tear group

Functional score	Healed Tendon (n=80)	Retorn Tendon (n=23)	*P Value*
CM (±SD) score	85.11 ± 5.71	76.78 ± 9.04	0.0001
ASES (±SD) score	89.24 ± 5.32	81.65 ± 9.22	0.0001

Type II and III is grouped as retorn tendon group. SD, standard deviation; CM, Constant Murley; ASES, American shoulder and elbow

Discussion

Our study demonstrated that the DRSB repair offers superior healing potential compared to SR repair in large tears and that the clinical scores are better in the healed tendon group versus the retear group.

Structural healing of large cuff tears after repair

Despite advancements in the understanding of the biology and improved rotator cuff repair techniques, the healing of the cuff over the footprint remains an Achilles heel, especially of the large size tears. Many authors have reported varying retear rates after the repair of a large tear ranging from 4.5% to 62.5% depending upon the type of repair [SR or DRSB] (12, 19, 20, 29, 34-36). Our study included patients with 'only large cuff tears' as recent systemic reviews and meta-analysis are inconclusive regarding the superiority of one technique over the other in this subgroup (22, 27, 37). In a systematic review of 23 studies incorporating a total of 1252 repairs, Duquin et al did not find any difference between the type of repair and any size of the tear (27). On the other hand, in a systematic review of 32 studies comprising 2048 repairs, Hein et al reported that double row or suture bridge repair resulted in lower retear rates for any tear size (37). Analyzing nine studies in a meta-analysis, Xu et al concluded that double-row repair produced superior healing outcomes compared to a single row for tear size more than three cm (22). Similarly, Mascarenhas et al analyzed three concordant high-quality meta-analyses and concluded that DR repair results in superior structural healing compared to a single row (38).

While reporting on clinical and structural outcomes of large tear repairs, almost all individual studies in the literature have considered the mixed type of tears; small-medium or medium-large or large to massive or all types of tear.

To our knowledge, ours is the only study that considered large posterosuperior tears managed by SR or DRSB technique in large numbers (n=103) at a mean follow-up of 74.2 months. Our results indicate that the DRSB technique results in significantly lesser re-tear rates of large posterosuperior tears (10.4 %) than the SR technique (32.7 %). The retear rate after repair of the large tear (managed by DRSB) reported by Choi et al was 18.4% (7 out of 38 patients), which was slightly higher than our results (35). However, their series had 147 patients with medium, large and massive tears managed by the DRSB technique without any comparison with a single row. In another study, Jeong et al reported a retear rate of 45.5% in large tears managed by the SR technique but lacked a comparison with DRSB (36). Hantes et al in a randomized controlled trial comprising 66 patients (younger than 55 years), reported that DR repair resulted in superior structural outcome than SR. However, they also had compared medium (n=37) and large size tear (n=29) with fewer in each subgroup of single row and DRSB technique. Furthermore, their study group had relatively younger patients. Mihata et al reported retear rates of 62.5% in a single row and 4.7% in the DRSB technique in large-massive size tear group (29). However, eight patients in the SR group and 40 patients in the DRSB technique were was not equally balanced. In another recent retrospective study published by Jeong et al comprising of partial (n=44), small (n=48), medium (n=224), and large tears (n=50); DRSB was found to be superior to the SR technique for large tears regarding better healing potential, and lesser retear rate (20). However, this study also considered repairing of the cuff into type I and type II, further bringing down the number of actual anatomical repairs for comparison.

Furthermore, our study revealed that partial re-tears are more common than complete retear in the SR group (25.4%, n=14) compared with the DRSB group (8.3%, n=4). It indicates a poor tendency of the cuff to heal completely over the footprint in the SR group as compared to the DRSB group. Noyes et reported 29% partial healing in a group of 17 patients with a large and massive tear when repaired with a single row technique (39). In their systematic review of seven studies, Millet et al concluded that SR repair results in statistically significant higher retear rates, especially the partial thickness tears (40). Since single-row repair results in lesser footprint contact, a partial thickness tear may also indicate an unhealed part of the cuff over the tuberosity. So, the partial thickness tear or an unhealed cuff could be considered an intermediate stage before it might become a full-thickness tear in the long-term follow-up, as suggested by Kartus et al (41).

Hence, many studies conclude that DRSB repair results in superior structural healing in large tears, while SR repair resulting in higher rates of partial re-tears. However, one must remain cautious about catastrophic type 2 failure with the over-enthusiastic DRSB repair. In a systematic review of 40 cadaveric studies, Shi et al concluded that a higher number of suture limbs and transosseous equivalent repair increases construct's chance of type 2 failure (42).

Functional outcome after large cuff tear repair

Our analysis of functional scores revealed no difference between either score (CM or ASES) of the two groups, SR and DRSB. In a recently conducted randomized controlled trial (RCT) by Nicholas et al in patients with medium (n=15), large (n=12), and massive tears (n=9), no difference was observed between ASES scores of SR and DRSB group (43). However, separate subgroup analysis was not performed for each type of tear repaired due to fewer patients in each subgroup. In another RCT in patients with medium and large size tears managed by SR and DR, Carbonel et al concluded that clinical scores (CM and ASES) were similar in two groups (single versus double row) in patients with tear size less than 3 cm, whereas superior in patients with tear size more than 3 cm managed by double row technique (44). However, Millet et al in their systemic review of seven studies, concluded that clinical scores are similar in both groups (40).

However, we encountered statistically superior clinical results in patients with intact tendons compared to retorn ones when both groups were combined. Many studies have reported inferior clinical outcome scores in retorn tendons compared to healed tendons (19, 20, 29).

Strengths and limitations of the study

We had a single senior operating surgeon for all the patients, and hence the operational conditions and the skill remains the same in each case. The biggest strength of the study is the inclusion of only large posterosuperior rotator cuff tear with a large number of patients (103) and a reasonable mean follow-up of 74.2 months, enabling a robust statistical analysis. Another strength of the study is the utilization of an independent clinical score assessor and a single sonologist assessing the integrity of the tendon throughout the study.

However, this study, too, carries several limitations.

One, this is a retrospective cohort study. Potential bias, including patient's occupation, hand dominance, physical demands, smoking, diabetes mellitus, and its influence on the clinical outcome cannot be ignored. Most of it could not be considered as some of the data was missing. Two, selection bias would have occurred while the patient chose the type of repair as a single or double row suture bridge according to what they understood after discussing with the surgeon. Also, the higher cost involved with the DRSB technique would have forced some patients to opt for the SR technique as many patients were paying for their treatment. Third, the use of ultrasonography (USG) to assess postoperative cuff healing status may raise questions regarding operator dependence, sensitivity and specificity in detecting a retear as most other studies have performed MRI for the diagnosis of post-operative re-tear (45). However, Lee et al in their review have found both MRI and US to be comparable in the diagnosis of the postoperative full-thickness retear. Still, both carry lower sensitivity for partial tears (46). Magee et al reported that the USG carries 100% sensitivity and 87% specificity for the diagnosis of full or partial thickness re-tear (47). Motamedi et al concluded that MRI could over-diagnose the postoperative retears while Schroder et al concluded that the presence of metal anchors could adversely affect the diagnosis of the rotator cuff retear by artifacts during MRI (48, 49). Hence, the USG remains a validated tool for the diagnosis of postoperative retear of the rotator cuff with similar sensitivity and specificity to the MRI. It also has an added advantage of the dynamic component to diagnose impingement and is free from 'artifacts.'

Despite a robust conclusion of the superiority of DRSB repair versus SR repair of a large cuff tear, given potential limitations and biases in the study, we recommend a randomized controlled trial on the repair of only large posterosuperior tears by the single and DRSB technique with clinical and MRI evaluation of patients. The conclusion of such a study would benefit a surgeon in decision-making regarding the type of repair of large repairable posterosuperior tears.

Our study revealed that double-row suture bridge repair of large posterosuperior rotator cuff tears resulted in superior structural healing compared to single-row repair without any functional superiority. Furthermore, the healed tendons resulted in superior functional results over the retorn tendons.

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