Systematic Review

Does the Literature Support Double-Row Suture Anchor Fixation for Arthroscopic Rotator Cuff Repair? A Systematic Review Comparing Double-Row and Single-Row Suture Anchor Configuration

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Purpose: The purpose of this study was to compare the clinical outcome of single-row (SR) and double-row (DR) suture anchor fixation in arthroscopic rotator cuff repair with a systematic review of the published literature. **Methods:** We searched all published literature from January 1966 to December 2008 using Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and the Cochrane Central Register of Controlled Trials for the following key words: shoulder, rotator cuff, rotator cuff tear, rotator cuff repair, arthroscopic, arthroscopic-assisted, single row, double row, and transosseous equivalent. The inclusion criteria were cohort studies (Levels I to III) that compared SR and DR suture anchor configuration for the arthroscopic treatment of full-thickness rotator cuff tears. The exclusion criteria were studies that lacked a comparison group, and, therefore, case series were excluded from the analysis. **Results:** There were 5 studies that met the criteria and were included in the final analysis: 5 in the SR group and 5 in the DR group. Data were abstracted from the studies for patient demographics, rotator cuff tear characteristics, surgical procedure, rehabilitation, range of motion, clinical scoring systems, and imaging studies. **Conclusions:** There are no clinical differences between the SR and DR suture anchor repair techniques for arthroscopic rotator cuff repairs. At present, the data in the published literature do not support the use of DR suture anchor fixation to improve clinical outcome, but there are some studies that report that DR suture anchor fixation may improve tendon healing. **Level of Evidence:** Level III, systematic review of Levels I to III studies. **Key Words:** Rotator cuff—Rotator cuff tear—Arthroscopic rotator cuff repair—Single row—Double row—Transosseous equivalent.

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The treatment of rotator cuff tears continues to evolve with improved instrumentation and suture anchor fixation. Over the past several years, there has been intense interest in optimizing biomechanical fixation constructs to improve tendon-to-bone healing. Specifically, a number of investigators have conducted biomechanical studies to determine which suture anchor row configuration may improve initial fixation strength. A number of studies have shown that double-row (DR) suture anchor fixation requires a greater ultimate load to failure and improved restoration of the supraspinatus footprint compared with single-row (SR) suture anchor fixation,[1-4] whereas other studies have not been able to show a significant difference in in vitro biomechanical strength.[5,6]

Case series of arthroscopic rotator cuff repair have reported significant improvement in shoulder functional outcome and a high rate of patient satisfaction with both SR and DR suture anchor configurations.[7-17] Several studies in the literature have not shown a difference in postoperative tendon healing between DR and SR repairs.[15,18] Clinical studies with postoperative imaging modalities have reported that the rate of tendon defects after SR fixation can range from 22% to 94%.[8-11,14,17] Recent case series of arthroscopic rotator cuff repair with DR fixation have shown tendon defects in 11% to 22% of cases.[7,12,13,16] Although there may be an apparent difference in tendon healing, it is difficult to compare across several case series with wide variations in patient demographics, rotator cuff tear characteristics and associated pathology, surgical technique, clinical outcomes, and imaging studies.

To compare SR and DR suture anchor fixation for the arthroscopic repair of rotator cuff tears, we used qualitative systematic review, which uses a defined methodology to collect the most relevant information to answer a specific clinical question. The purpose of this study was to compare the clinical outcome of SR and DR suture anchor fixation in arthroscopic rotator cuff repair with systematic review of the published literature. Our hypothesis is that clinical studies comparing SR and DR arthroscopic rotator cuff repair do not show a significant difference between subjective and objective outcome measures.

METHODS

Before conducting the literature search, we established the study design and specific objectives. The objectives were to compare the clinical outcomes of SR and DR suture anchor configuration for arthroscopic rotator cuff repairs and to compare the postoperative appearance in studies that included radiographic outcomes. The inclusion criteria were cohort studies (Levels I to III) that compared SR and DR suture anchor configuration for the arthroscopic treatment of full-thickness rotator cuff tears. The exclusion criteria were studies that lacked a comparison group, and, therefore, case series were excluded from the analysis. Studies were also excluded if the 2 study cohorts displayed a significant difference in age, gender, tear size, associated pathology, and postoperative rehabilitation protocol. In addition, the technical aspects of the surgical procedure were meticulously reviewed, and the 2 techniques, other than the row configuration (SR or DR), should not differ dramatically in terms of anchor type, suture, and arthroscopic knot between the 2 groups. Patient demographic information, rotator cuff tear characteristics, operative technical details, objective and subjective outcome measurements, radiographic studies, and complications were abstracted from the studies.

Literature Search

We searched all published literature from January 1966 to December 2008 using Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and the Cochrane Central Register of Controlled Trials for the following key words: shoulder, rotator cuff, rotator cuff tear, rotator cuff repair, arthroscopic, arthroscopic-assisted, single row, double row, and transosseous equivalent. General search terms were chosen to prevent the possibility of missing potential studies. Studies that were only presented as abstracts were not included in the final analysis.[19] To ensure that all possible articles were considered, the references of all relevant articles and review articles were manually cross-referenced.

Data Abstraction

The data were abstracted from each of the studies that met the study criteria by 2 independent reviewers. The demographic data collected included the type of study, level of evidence, number of patients enrolled, number of patients in final follow-up, age, gender, dominant extremity, follow-up, and duration of symptoms. Using the classification of rotator cuff tear size of DeOrio and Cofield,[20] we divided patients into treatment groups as follows: small (<1 cm), medium (1 to 3 cm), large (3 to 5 cm), and massive (>5 cm). Rotator cuff tear patterns were also classified as crescent, L shaped, reverse L shaped, V shaped, and U

shaped.[21] In addition, the rotator cuff characteristics were collected including size, width, length, and area. Intraoperative data were recorded including the surgical technique, number of anchors, anchor type, type of arthroscopic knot, suture size, suture type, margin convergence, and concomitant procedures. The percentage of satisfied or very satisfied patients for each group was collected. Preoperative and postoperative data included range of motion, strength, clinical outcome scales (Constant-Murley[22]; University of California, Los Angeles [UCLA][23]; and American Shoulder and Elbow Surgeons [ASES][24]), and complications were extracted. Postoperative imaging modality and outcome (complete healing, partial healing, and no healing) were also recorded. The complications were subcategorized to orthopaedic-related (revision, arthrofibrosis, ruptured bicep tendon, infection, hematoma) and medically related complications (pneumonia, myocardial infarction, deep venous thrombosis). The data are presented in tabular format, and no statistical comparisons were performed as part of the systematic review.

RESULTS

Literature Search

There were 4,575 articles. We eliminated those that were not published in the English language or not performed in human subjects. The abstracts of the remaining 3,451 studies were reviewed to determine the appropriateness to the study as determined by the inclusion and exclusion parameters. There were 45 articles that were appropriate for the analysis. Twenty-two studies on arthroscopic rotator cuff repair with SR fixation were excluded because they did not have a DR comparison group.[8,10,11,14,17,25-28] Four articles on arthroscopic rotator cuff repair with DR fixation were excluded because they did not have an SR comparison group.[7,12,13,16] Seven studies were technical articles on DR configuration without clinical follow-up.[29-35] There were 5 studies that met the criteria and were included in the final analysis: 5 in the SR group and 5 in the DR group.[18,36-39]

Patient Demographics

The study design, level of evidence, number of total patients, number of patients at follow-up, and percent of effective follow-up were included in the analysis (Table 1). There were 2 randomized controlled trials (Level I), 2 prospective cohort studies (Level II), 1 retrospective cohort study (Level III), and no case series (Level IV) or expert opinion (Level V). One of the Level I studies used a random-numbers table, whereas the other one used statistical software for randomization.[18,36] The number of patients in the SR group ranged from 30 to 40, with an effective follow-up between 71% and 94%, and the number of patients in the DR group also ranged from 30 to 40, with an effective follow-up between 80% and 90%. Each study compared the study groups and did not find any statistically significant differences in terms of age, dominant extremity, gender, follow-up, rotator cuff tear size, or fatty degeneration.

Surgical Technique

All groups described all-arthroscopic rotator cuff repair with suture anchor fixation (Table 2). The number of suture anchors ranged from 1 to 4 in the SR group and 2 to 5 in the DR group; however, none of the studies performed statistical analysis comparing the mean number of anchors between the SR and DR groups. Two studies used bioabsorbable suture anchors,[18,37] and three studies used metallic suture anchors.[36,38,39] The anchor material was consistent between groups within a study, and, therefore, studies that used bioabsorbable anchors for the SR configuration also used bioabsorbable anchors for the DR configuration. The SR construct and the lateral row of the DR suture anchor fixation construct were similar between groups within a single study. For the DR cohort, the medial row used mattress tendon stitch with the same anchor type as the lateral row in 3 of 5 groups. Park et al.[38] used the TwinFix Ti (Smith & Nephew Endoscopy, Andover, MA) for the medial row and Super Revo (Linvatec, Largo, FL) for the lateral row, but they did not specify the sizes of the anchors. Charousset et al.[37] used the Cuff Tack (Mitek, Raynham, MA) for the medial row, which was a bioabsorbable device that provided single-point fixation without a suture in the medial row; however, the device was discontinued. Three studies performed margin convergence for U-shaped or L-shaped tears.[18,36,39] None of the studies were performed with a transosseous-equivalent suture bridge fixation.

Subacromial decompression was performed in all patients in 4 of the 5 studies, and the fifth study did not mention whether subacromial decompression was performed.[18] Park et al.[38] performed acromioclavicular joint coplaning in conjunction with the acromioplasty because the authors suspect that it can also be a cause of impingement. Sugaya et al.[39] reported that patients also underwent distal clavicle resection and/or acro-

TABLE 1. *Study and Patient Demographic Information*

Source	Level of Evidence	Total No. of Shoulders	No. of Shoulders Evaluated	Effective F/U	Randomization	No. of Surgeons	% Dominant	Mean Age (yr)	Mean F/U (mo)	% Male	% WC	Small RCT (<1 cm)	Medium RCT (1-3 cm)	Large RCT (3-5 cm)	Massive RCT (>5 cm)
SR															
Sugaya et al.,[39] 2005	III	39	39	70.90%	No	1	77.50	57.7	41.3	71.00	N/R	6	17	14	2
Charousset et al.,[37] 2007	II	35	35	94.29%	No	1	77.14	58.0	27.6	43.00	11.43	N/R	N/R	N/R	N/R
Franceschi et al.,[18] 2007	I	30	30	86.60%	Yes	1	77.00	63.5	22.5	46.00	N/R	N/R	N/R	18	8
Park et al.,[38] 2008	II	40	40	93.02%	No	1	N/R	57.0	25.1	50.00	N/R	N/R	N/R	N/R	N/R
Grasso et al.,[36] 2009	I	40	40	92.50%	Yes	2	73.00	58.3	24.8	43.20	N/R	N/R	N/R	N/R	N/R
DR															
Sugaya et al.,[39] 2005	III	41	41	80.40%	No	1	77.50	58.1	28.2	68.00	N/R	10	17	11	3
Charousset et al.,[37] 2007	II	31	31	90.32%	No	1	74.19	60.0	28.7	52.00	6.45	N/R	N/R	N/R	N/R
Franceschi et al.,[18] 2007	I	30	30	86.60%	Yes	1	74.00	59.6	22.5	62.00	N/R	N/R	N/R	21	5
Park et al.,[38] 2008	II	38	38	90.48%	No	1	N/R	54.4	25.1	57.89	N/R	N/R	N/R	N/R	N/R
Grasso et al.,[36] 2009	I	40	40	87.50%	Yes	2	82.86	55.2	24.8	51.40	N/R	N/R	N/R	N/R	N/R

Abbreviations: F/U, follow-up; WC, Workers' Compensation; RCT, rotator cuff tear; N/R, not recorded.

TABLE 2. *Surgical Technique and Concomitant Procedures*

Source	Total No. of Anchors	Anchor Material	Type of Anchor in Medial Row	No. of Anchors in Medial Row	Medial Knot	Medial Tendon Stitch	Type of Anchor in Lateral Row	No. of Anchors in Lateral Row	Lateral Knot	Lateral Tendon Stitch	TOE (Yes or No)	Suture Size and Type	Concomitant Procedures
SR													
Sugaya et al.,[39] 2005	1-3 (2.4)	Metal					N/R	1-3 (2.4)	Self-locking sliding	Simple	No	No. 2 "permanent suture"	SAD ± DCR
Charousset et al.,[37] 2007	2-4	Bioabsorbable					Panaloc RC (Mitek)	Variable	Fisherman's knot	Simple	No	No. 2 Panacryl (Ethicon)	SAD; 5, TTY; 3, repair of upper one third of subscapularis
Franceschi et al.,[18] 2007	1-2 (1.9)	Bioabsorbable					Biocorkscrew (Arthrex)	1-2 (1.9)	N/R	Mattress	No	No. 2 FiberWire (Arthrex)	N/R
Park et al.,[38] 2008	1-3	Metal					Twinfix Ti (Smith & Nephew) or Super Revo (Linvatec)	1-3	SMC	N/R	No	No. 2 Ultrabraid (Smith & Nephew)	SAD/AC coplaning
Grasso et al.,[36] 2009	1-4	Metal					5.0-mm metal Corkscrew (Arthrex)	1-4	Duncan loop + 3 alternating half-hitches	Simple	No	No. 2 FiberWire	SAD, Deb, 8, TD with two 5.0-mm metal Corkscrews in patients aged <50 yr; 12, TTY in patients aged >50 yr
DR													
Sugaya et al.,[39] 2005	2-5 (3.2)	Metal	N/R		N/R	Mattress	N/R		Self-locking sliding	Simple	No	No. 2 "permanent suture"	SAD ± DCR
Charousset et al.,[37] 2007	2-6	Bioabsorbable	Cuff Tack	1 to 2	Tack	N/A	Panaloc RC	2-4	Fisherman's knot	Simple	No	No. 2 Panacryl	SAD; 9, TTY; 5, repair of upper one third of subscapularis
Franceschi et al.,[18] 2007	2-4 (2.3)	Bioabsorbable	Biocorkscrew	N/R	N/R	Mattress	Biocorkscrew	N/R	N/R	Simple	No	No. 2 FiberWire	N/R
Park et al.,[38] 2008	2-8	Metal	Twinfix Ti	1 to 3	SMC	N/R	Super Revo	2-4	SMC	N/R	No	No. 2 Ultrabraid	SAD/AC coplaning
Grasso et al.,[36] 2009	2-5	Metal	5.0-mm metal Corkscrew	1 to 2	Revo	Mattress	5.0-mm metal Corkscrew	1-3	Duncan loop + 3 alternating half-hitches	Simple	No	No. 2 FiberWire	SAD, Deb, 7, TD with two 5.0-mm metal Corkscrews in patients aged <50 yr; 13, TTY in patients aged >50 yr

Abbreviations: TOE, transosseous equivalent; SAD, subacromial decompression; DCR, distal clavicle resection; TTY, tenotomy; N/R, not recorded; SMC, Seoul Medical Center; AC, acromioclavicular; Deb, debridement; TD, tenodesis.

mioclavicular joint coplaning if necessary. In the study by Grasso et al.,[36] 8 patients (20%) underwent a biceps tenodesis and 12 underwent biceps tenotomy (30%) in the SR group and 7 patients (18%) underwent a biceps tenodesis and 13 (33%) underwent biceps tenotomy in the DR group. Charousset et al.[37] reported that 5 patients (14%) underwent biceps tenotomy and 3 (9%) also underwent subscapularis tendon repair in the SR group and 9 patients (29%) underwent biceps tenotomy and 5 (16%) underwent subscapularis tendon repair in the DR group, but statistical analysis was not performed.

Rehabilitation Protocol

The postoperative rehabilitation was the same for the SR cohort and the DR cohort in each study and, therefore, limits performance bias.

Range of Motion and Strength

Only 1 study reported range-of-motion measurements but did not find a significant difference between the SR and DR groups.[18] Three studies provided strength measurements as an outcome[36-38]; two of these studies used an instrumented device to quantify strength, and the other did not report the strength methodology. Park et al.[38] devised the Shoulder Strength Index (SSI), which is the muscular strength of the affected shoulder divided by the strength of the contralateral shoulder. There were no differences in strength measurements in any study when comparing the entire SR and DR cohorts. However, Park et al. reported that shoulder abduction for the SR cohort had an improved SSI compared with the DR cohort ($P = .04$).

Postoperative Shoulder Scores (Constant, UCLA, ASES, and Satisfaction)

In terms of shoulder functional outcome score, 3 studies used the Constant score, 2 used the UCLA score, and 2 used the ASES score (Table 3). There were significant differences within groups when comparing preoperative and postoperative scores, but there were no significant differences between the SR and DR cohorts for any study. Park et al.[38] analyzed the subset of patients with rotator cuff tears measuring greater than 3 cm and determined that the DR group had a significant improvement in ASES score (93 in DR group *v* 80 in SR group, $P = .01$) and Constant score (80 in DR group *v* 72 in SR group, $P < .01$) compared with the SR group. When the subset of rotator cuff tears measuring less than 3 cm was ana-

TABLE 3. *Clinical Outcomes*

Source	Constant			UCLA Shoulder Score			ASES Shoulder Score				Healing			
	Pre	Post	Significance (*P* Value)	Pre	Post	Significance (*P* Value)	Pre	Post	Significance (*P* Value)	Satisfaction (%)	Complete	Partial	No	Significance (*P* Value)
SR														
Sugaya et al.,[39] 2005	N/R	N/R	N/R	14.8 ± 5.8	32.4 ± 4.7	.44	45.8 ± 19.4	92.9 ± 12.1	.49	N/R	46.20% on MRI	30.10% on MRI	25.60% on MRI	<.01
Charousset et al.,[37] 2007	56.6 (33-77)	80.7 (62-95)	.35/.4	N/R	N/R	N/R	N/R	N/R	N/R	91 S or VS	40% on CTA	20% on CTA	40% on CTA	.03
Franceschi et al.,[18] 2007	N/R	N/R	N/R	11.5 (6-14)	32.9 (29-35)	>.05	N/R	N/R	N/R	N/R	53.8% on MRA	38.50% on MRA	7.70% on MRA	
Park et al.[38] 2008	41.63 ± 9.84	76.68 ± 8.56	.06	N/R	N/R	N/R	42.79 ± 19.23	91.6 ± 4.48	.09	N/R	N/R	N/R	N/R	N/R
Grasso et al.,[36] 2009	73.2 ± 19	100.5 ± 17.8	.378	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
DR														
Sugaya et al.,[39] 2005	N/R	N/R	N/R	14.4 ± 4.5	33.1 ± 3.4	.44	40.4 ± 12.3	94.6 ± 9.3	.49	N/R	73.20% on MRI	17.10% on MRI	9.80% on MRI	<.01
Charousset et al.,[37] 2007	53.6 (17-75)	82.7 (58-94)	.35/.4	N/R	N/R	N/R	N/R	N/R	N/R	87 S or VS	61% on CTA	16% on CTA	23% on CTA	.03
Franceschi et al.,[18] 2007	N/R	N/R	N/R	10.1 (5-14)	33.3 (30-35)	>.05	N/R	N/R	N/R	N/R	69.2% on MRA	26.90% on MRA	3.80% on MRA	
Park et al.[38] 2008	44.16 ± 6.96	79.66 ± 4.52	.06	N/R	N/R	N/R	40.82 ± 16.8	92.97 ± 2.27	.09	N/R	N/R	N/R	N/R	N/R
Grasso et al.,[36] 2009	77.5 ± 14.7	104.9 ± 21.8	.378	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R

Abbreviations: Pre, preoperative; Post, postoperative; N/R, not recorded; MRI, magnetic resonance imaging; CTA, computed tomography arthrogram; MRA, magnetic resonance arthrogram; S, satisfied; VS, very satisfied.

lyzed, there were no significant differences between the SR and DR groups in terms of clinical score and SSI.

Imaging Studies

There were 3 studies that included postoperative imaging studies as an additional outcome measure.[18,37,39] In the study of Sugaya et al.,[39] magnetic resonance imaging was performed at a mean of 14.4 months for the SR group and 13.6 months for the DR group. The authors reported a higher rate of tendon healing after DR repairs compared with SR repairs ($P < .01$). In the study by Charousset et al.,[37] computed tomography arthrograms were obtained at 6 months after surgery and interpreted by 2 radiologists and 2 orthopaedic surgeons; they determined that the DR group had an improved structural appearance compared with the SR group ($P = .03$). Franceschi et al.[18] performed postoperative magnetic resonance arthrography at 2 years' follow-up, but there was no statistical difference between treatment groups ($P > .05$).

Complications

The occurrence of complications was unusual in either the SR or DR patients. In total, there were 2 cases of arthrofibrosis, 1 anchor pullout, and 1 superficial infection in the SR group.[37,38] The DR group had 2 cases of superficial infection and 1 anchor pullout.[38]

DISCUSSION

As the repair constructs continue to evolve, the orthopaedic surgeon must objectively evaluate the published literature to provide evidence to justify a change in repair strategies. This study is a qualitative description of the clinical results of published cohort studies on arthroscopic treatment of full-thickness rotator cuff tears comparing SR and DR suture anchor configurations. On the basis of short-term cohort studies, there are no apparent differences between these 2 techniques in terms of clinical outcome scores; however, DR suture anchor fixation may provide increased tendon healing.

Selection Bias

All of the studies included in the systematic review were cohort studies (Levels I to III), and most of the studies provided statistical analysis to ensure homogeneity between comparison groups, thus limiting the potential for selection bias. In addition, 2 of the 5 studies were randomized prospective clinical studies that should dramatically limit bias. The factors that have been shown to affect clinical outcome including age, gender, rotator cuff tear size, and acromioclavicular joint pathology were similar between groups in most studies.[15] Sugaya et al.[39] found small rotator cuff tears in 6 of 39 shoulders (15%) in the SR group compared with 10 of 41 (24%) in the DR group, but there was no statistical calculation provided to compare preoperative tear size. Numerous studies in the open, mini-open, and arthroscopic literature show that tear size is an important determinant of outcome and healing.[9,17,40-44] Although there was no difference in UCLA score or ASES score between the SR and DR groups, there was a significant difference between the number of retears postoperatively, with 10 (26%) in the SR group compared with 4 (10%) in the DR group ($P < .01$).[39] There were only 2 studies that showed a significant difference in postoperative tendon healing.[37,39]

Performance Bias

The method of arthroscopic repair was consistent between the SR and the lateral row of the DR between groups within a single study. By definition, the number of suture anchors per case in the DR group was greater than that in the SR group. The SR cohorts reported a range between 1 and 4, whereas the DR cohorts reported a range between 2 and 8. There were only 2 studies that provided the mean number of anchors per case (1.9 in SR group and 2.3 in DR group[18] and 2.4 in SR group and 3.2 in DR group[39]), but no statistical comparisons were provided. With more double-loaded suture anchors, the number of points of fixation is 2 times per every anchor inserted, and the stronger fixation was likely related, at least in part, to the number of anchors rather than the row configuration. The ideal comparison would have been to have an equal number of anchors and to position them in a randomly assigned row configuration. Of note, there were no studies that used a transosseous-equivalent suture bridge technique for the DR cohort.

Performance bias may occur in studies where a disproportionate number of concomitant procedures were performed, but bias was largely limited because of homogeneity between cohorts. There was only 1 study with a slightly higher number of biceps tenotomies performed in the DR group (29%) over the SR group (14%).[37] Biceps pathology has been shown to be associated with a decreased rate of tendon healing; however, this particular study did not show a clinical

difference but did find an increased rate of structural appearance in the DR group despite having a high proportion of cases that required biceps tenotomy.[15] In addition, there were only 2 studies that were randomized controlled trials, and the other 3 studies were nonrandomized studies. In most of these studies the surgeons started performing arthroscopic rotator cuff repairs with the SR technique but then transitioned to the DR technique, and, therefore, they were more experienced in managing rotator cuff tears arthroscopically when they transitioned to the DR technique. Rehabilitation protocol is another potential variable that may influence performance bias, but the same rehabilitation was implemented for each group in a single study.

Exclusion Bias

Of the studies in the final analysis, there was only 1 study with less than 80% follow-up, and, therefore, exclusion bias was minimized in the present study. The range of follow-up was between 71% and 94% in the SR group and between 80% and 90% in the DR group.

Detection Bias

In terms of the clinical outcome scores, each study used either the Constant Score, UCLA score, or ASES score. All of these outcome scores have been validated as shoulder-specific outcome instruments.[22-24] All of the studies reported significant improvement between baseline and postoperative scores within each group. None of the studies were able to detect a significant difference between the SR and DR cohorts when comparing the entire group. However, Park et al.[38] were able to detect a significant improvement in the Constant score, ASES score, and SSI score in abduction between the SR and DR groups in rotator cuff tears measuring greater than 3 cm. There was no difference in terms of clinical outcome or strength measurements between the 2 techniques in rotator cuff tears measuring less than 3 cm. Size of the rotator cuff tear has been known to be a significant prognostic indicator of clinical outcome in both the open and arthroscopic literature. Rotator cuff tears that extend beyond the supraspinatus tendon have been shown to have a significant association with both clinical outcome and tendon healing.[15]

Three of the five studies used postoperative imaging as an outcome measurement, but the imaging modality varied from computed tomography arthrography to magnetic resonance imaging to magnetic resonance arthrography. Comparing the radiographic outcomes between studies may be difficult because of differing techniques and observers. However, each study performed statistical analysis between the SR and DR cohorts and reported the finding as either "completely healed," "partially healed," or "defect." Two of the three studies reported a statistically significant improvement in the structural appearance with the DR technique compared with the SR technique for rotator cuff repair, but interestingly, these two studies were not able to detect a difference in clinical outcomes.[18,39]

These findings raise the often debated question of the effect of tendon healing after rotator cuff repair on the clinical outcome. Most of the published literature on rotator cuff pathology has comprised short-term studies, and the findings have been controversial. Some studies have reported a significant improvement in healed tendons in terms of range of motion and strength, but still others have reported significant improvement in clinical outcome, pain relief, and satisfaction even in rotator cuff tears that have not healed. Longer-term studies will be critical to determine the relation between the tendon healing and clinical outcome.

There are many strengths of our study related to the design resulting in homogeneity between the study groups. By use of strict inclusion and exclusion criteria, only cohort studies met the study criteria, and each of these studies ensured homogeneity between the 2 study groups. In addition, the concomitant procedures, repair techniques, rehabilitation protocol, and outcome instruments were consistent between the 2 cohorts for each study. There were a number of case series that were excluded from the study, which may have increased the number of patients but at the expense of introducing bias. The final analysis included 184 patients in the SR group and 180 patients in the DR group, which allowed us to compare the outcome of the SR and DR techniques with a larger sample size.

There are a number of other limitations in this study. In terms of the surgical technique, each surgeon used a consistent technique between SR and DR suture anchor fixation. There appear to be a greater number of anchors that were required per case with the DR technique compared with the SR technique, and the difference was consistent for each study. Future studies should compare the same number of anchors and only differ in terms of suture anchor row configuration. Although all studies used validated shoulder-specific functional outcome instruments, the

clinical outcome score was not identical between each study, therefore limiting the number of variables in the analysis. There was only 1 study that used satisfaction data as an outcome measure, which have also been shown to have a high association with a successful clinical outcome.[15,45] Range-of-motion data were incomplete and could not be reliably used to compare the 2 groups.

Systematic reviews are limited by the quality of the published studies, but the study criteria ensured that the highest-quality studies were included in the analysis. After we reviewed the literature, there were 2 randomized controlled trials (Level I), 1 prospective cohort study (Level II), and 2 retrospective cohort studies (Level III) that met the inclusion and exclusion criteria at the time of the literature search. A quantitative systematic review, or meta-analysis, was not able to be performed because only 2 studies were randomized controlled trials; this indicates the needs for an improvement in the quality of published studies on the treatment of rotator cuff repairs. If there were more Level I studies, a meta-analysis could potentially be performed; however, a difference in clinical outcome would likely be difficult to detect in the short-term studies. In addition, the data for the imaging studies would be difficult to combine because of differing methodology and interpretations. To attempt to answer the question "Is there a clinical difference between SR and DR repair techniques?", there needs to be a consistent, validated postoperative imaging modality with longer-term clinical follow-up. Because the effect of tendon healing on clinical outcome has not been clearly elucidated, the data do not support the use of DR suture anchor fixation to improve clinical outcome at present.

CONCLUSIONS

This systematic review shows that both SR and DR rotator cuff repair will result in significant improvement in baseline shoulder function and satisfactory clinical outcome. There were no studies in this investigation that evaluated a transosseous-equivalent suture bridge repair construct, so conclusions regarding this technique cannot be made until additional studies have been published. Presently, the data in the published literature do not support the use of DR suture anchor fixation to improve clinical outcome, but there are some studies that report that DR suture anchor fixation may improve tendon healing. Because the association between clinical outcome and tendon healing has not been established in the short term, longer-term studies with consistent imaging evaluation may provide additional information on the efficacy of the DR repair technique.

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