The Relationship Between All-Suture and Solid Medial-Row Anchors and Patient-Reported Outcomes for Double-Row Suture Bridge Rotator Cuff Repair

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Background: The use of all-suture anchors for rotator cuff repair is increasing. Potential benefits include decreased bone loss and decreased damage to the chondral surface. Minimal evidence exists comparing outcomes among medial-row anchor fixation methods in double-row suture bridge rotator cuff repair.

Purpose: To compare the clinical outcomes between all-suture and solid medial-row anchors in double-row suture bridge rotator cuff repair.

Study Design: Case series; Level of evidence, 4.

Methods: A total of 352 patients (mean age at surgery, 60.3 years) underwent double-row suture bridge rotator cuff repair at our institution. Patients were separated into 2 groups based on whether they underwent all-suture (n = 280) or solid (n = 72) anchor fixation for the medial row. Outcomes data were collected via an ongoing longitudinal data repository or through telephone calls (minimum follow-up time, 2.0 years; mean follow-up time, 3.0 years). Outcomes were evaluated using the American Shoulder and Elbow Surgeons (ASES) standardized shoulder assessment form and the visual analog scale (VAS). The same rehabilitation protocol was administered to all patients. The proportions of patients meeting previously published Patient Acceptable Symptom State (PASS) thresholds were calculated for the outcome measures, and outcome scores and the proportions of patients meeting PASS thresholds between groups were compared using linear and logistic regression, respectively.

Results: The groups did not differ in terms of age at surgery, sex distribution, rotator cuff tear size, or number of medial-row anchors used. The solid anchor group had a longer follow-up time compared with the all-suture anchor group (3.6 $\pm$ 0.7 vs 2.8 $\pm$ 0.8 years, respectively; $P < .01$). After controlling for follow-up time, the solid and all-suture anchor groups did not differ in ASES scores (89.6 $\pm$ 17.8 vs 88.8 $\pm$ 16.7, respectively; $P = .44$) or VAS scores (1.1 $\pm$ 2.1 vs 1.2 $\pm$ 2.1, respectively; $P = .37$). Similarly, after controlling for follow-up time, the solid and all-suture anchor groups did not differ in the proportions of patients meeting PASS cutoffs for the ASES (84.7% vs 80.7%, respectively; $P = .44$) or the VAS (80.6% vs 75.0%, respectively; $P = .83$).

Conclusion: Double-row suture bridge rotator cuff repair using all-suture anchors for medial-row fixation demonstrated similar excellent clinical outcomes to rotator cuff repair using solid medial-row anchors.

Keywords: shoulder; rotator cuff; rotator cuff repair; soft anchor; hard anchor; clinical assessment/grading scales; clinical outcomes

Several factors are important in determining outcomes after rotator cuff surgery, some of which can be controlled by the surgeon and clinical team and others that cannot. Factors outside the control of the clinical team include tear size, retraction, and the degree of fatty

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infiltration.[5,8,21] Among several key factors under the control of the clinical team include the operative technique and, more specifically, the type of implant used. Arthroscopic rotator cuff repair is considered the gold standard for treating rotator cuff tears, resulting in lower pain and less deltoid dysfunction compared to open techniques.[23] Over the past 20 years, advancements in suture anchor technology and arthroscopic instruments have allowed for the refinement of arthroscopic techniques in rotator cuff repair. One such advancement is the advent of the all-suture anchor. Compared to a traditional solid anchor, there are several potential benefits of an all-suture anchor. All-suture anchors can be implanted using a smaller diameter drill, displacing less bone than larger diameter solid anchors.[2,15] This may prove advantageous if there is a need for revision rotator cuff repair in which residual bone for anchor implantation is at a premium. Lastly, the anchor material appears to be more forgiving to intra-articular structures. If an anchor pulls out, the soft nature of the anchor may be less noxious to the chondral surface.[4,6,9]

Advancements in suture anchor technology have coincided with and enabled improvements in rotator cuff repair techniques. Newer anchors can incorporate sutures that have been placed through tissue independently or that originate from other anchors. Specific to rotator cuff repair, the transosseous-equivalent or suture bridge repair technique takes advantage of this by incorporating suture limbs from a medial-row anchor into a lateral-row anchor.[5] In doing so, the suture bridge compresses the tendon to the rotator cuff footprint, theoretically aiding healing.[5] Indeed, recent studies have shown improved healing rates using the double-row suture bridge rotator cuff repair technique compared to the single-row technique.[18,24] To date, several studies have compared the biomechanical properties of all-suture anchors and solid anchors in cadaveric models.[7,15,22] These studies have not only shown that all-suture anchors demonstrate comparable pull-out strength compared with traditional solid anchors but have also shown variable biomechanical properties observed among the different all-suture anchors available on the market.[7,15,22] To our knowledge, there have not been any studies comparing pain and patient-reported functional outcomes between patients treated with all-suture anchors and those treated with solid anchors after rotator cuff repair. The purpose of our study was to compare the outcomes of patients who underwent double-row suture bridge rotator cuff repair with either all-suture medial-row anchors or traditional solid medial-row anchors. Our hypothesis was that there would be no difference in outcomes between the all-suture and solid anchor groups.

METHODS

Before the initiation of this study, we obtained institutional review board approval from our institution. We performed a retrospective review of rotator cuff repair procedures performed by 4 fellowship-trained orthopaedic surgeons (E.L.C., J.R.D., B.A.E., M.K.R.) at Andrews Sports Medicine and Orthopaedic Center between 2014 and 2018 via billing code database searches. We included potential patients in the study if they (1) underwent primary double-row suture bridge rotator cuff repair with either solid or all-suture medial-row anchors, (2) were between the ages of 18 and 85 years at the time of surgery, and (3) were at least 2 years postoperatively at the time of outcomes data collection. We excluded potential patients in the study if they (1) did not undergo double-row rotator cuff repair, (2) underwent revision rotator cuff repair, (3) had a mix of solid and all-suture medial-row anchors, or (4) had/underwent isolated subscapularis tears/repair.

Patient Selection, Surgical Technique, and Postoperative Rehabilitation

All patients had a high-grade partial-thickness (>50% thickness, measured intraoperatively) or full-thickness rotator cuff tear. Patients were considered an operative

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candidate if they had failed nonoperative treatment (in the case of atraumatic tears) or if they sustained a traumatic tear and met operative criteria based on the surgeon's discretion. All surgical procedures were performed using arthroscopic techniques in the lateral position, as previously described.[13] A transosseous-equivalent (suture bridge) technique was used in all patients in which medial-row anchors were placed at the articular margin of the rotator cuff footprint. The sutures were passed through the rotator cuff and tied. The suture limbs were then incorporated into lateral-row anchors (one or two 5.5-mm SwiveLock anchors; Arthrex), compressing the rotator cuff back to the footprint. The number of medial-row anchors and lateral-row anchors were determined based on the size of the tear and at the surgeon's discretion. For the medial-row anchors, we gradually switched from solid to all-suture anchors during the study period for the advantages described above: particularly, the ability to use smaller drill holes in the humeral head and the use of curved guides, allowing for ease of placement. However, not all surgeons with patients surgically treated in this study changed to all-suture anchors at the same time, and all continued to occasionally use solid anchors based on the individual patient's clinical scenario. Specific solid medial-row anchors used included Healix (DePuy Synthes) and Healicoil (Smith + Nephew), with a range of drill hole sizes between 3.0 and 3.5 mm. Specific all-suture medial-row anchors used included FiberTak (Arthrex), JuggerKnot (Zimmer Biomet), Y-Knot (ConMed), and Q-Fix (Smith + Nephew), with a range of drill hole sizes between 2.6 and 2.9 mm.

All patients in the study underwent a uniform institutional rehabilitation protocol after rotator cuff repair. This included early progressive passive range of motion exercises and isometric strengthening for the first 6 weeks, followed by the progression to active range motion and a gradual dynamic strengthening program by 3 months. All patients wore an abduction sling for the first 6 weeks postoperatively.

Clinical and Outcomes Data Collection

For the patients who were included, we performed chart and operative note reviews from our electronic health record to obtain patient and clinical data including age, sex, rotator cuff tear size, number of medial-row anchors utilized, and specific type of medial-row anchor utilized. We categorized rotator cuff tear sizes as small (<1 cm), medium (1-3 cm), large (3-5 cm), or massive (>5 cm).[1] To evaluate outcomes, we utilized the American Shoulder and Elbow Surgeons (ASES) standardized shoulder assessment form. The ASES standardized shoulder assessment form is a 100-point scale designed to measure limitations in shoulder-related function and includes sections evaluating pain, instability, and activities of daily living.[19] The ASES form is a valid, reliable, and responsive tool to measure shoulder function in patients with rotator cuff abnormalities and has a minimal clinically important difference value of 6.4 points.[17] A visual analog scale (VAS) is contained within the ASES pain-related questions, and in addition to the overall ASES score, we utilized the VAS to evaluate shoulder-related pain (scored 0-10). To collect outcomes data from patients at least 2 years postoperatively, we used an ongoing electronic data repository (OBERD; Universal Research Solutions). OBERD distributed surveys electronically using automated emails and/or short message service text messages. For patients who did not respond to the electronic survey request, we contacted them via telephone, and patients answered survey questions orally. Before the collection of outcomes data, all patients provided either written electronic informed consent (data repository data collection) or verbal consent (telephone data collection).

Statistical Analysis

We calculated summary statistics for patient, clinical, surgical, and outcomes data across the entire cohort as well as within the solid and all-suture anchor groups. For the ASES and VAS scores, we further calculated the proportions of patients meeting Patient Acceptable Symptom State (PASS) cutoffs that have been reported in the literature specific to patients after rotator cuff repair (ASES $\geq$ 78.0; VAS $\leq$ 1.7).[10] We compared patient, clinical, surgical, and outcomes data between the solid and all-suture anchor groups using independent *t* tests for continuous variables and chi-square tests for categorical variables. For the PASS, we compared the proportions of patients meeting the cutoffs for the ASES and the VAS between groups using the chi-square test. Regarding potential covariates, we examined the association between follow-up time and the ASES score across the entire cohort using linear regression, finding that a longer follow-up time was associated with higher ASES scores (regression coefficient = 3.42; $P < .01$). In addition, because follow-up times differed between the solid and all-suture anchor groups (Table 2), we elected to perform sensitivity analyses, controlling for follow-up time in our comparisons of outcomes between the solid and all-suture anchor groups. In these sensitivity analyses, we entered anchor group (solid: 1; all-suture: 0) and follow-up time (continuous) into linear regression models (comparison of ASES or VAS scores) or logistic regression models (comparison of proportions of patients meeting PASS cutoffs for the ASES or VAS). We then examined the effect of group on outcomes with follow-up time in each model. Lastly, we used univariable regression to examine associations between age and outcomes (linear regression for ASES and VAS scores; logistic regression for PASS thresholds for the ASES and VAS) within the entire cohort (both anchor types) as well as within each anchor group (solid and all-suture). For all analyses herein, we considered group differences to be statistically significant when *P* values were <.05. All statistical analyses were perofrmed using SPSS software (Version 29.0; SPSS Inc.).

RESULTS

Characteristics of Entire Cohort

A total of 352 patients were included (n = 72 solid anchors; n = 280 all-suture anchors) (Figure 1). Patient, clinical,

TABLE 1
Characteristics and Outcomes for Entire Cohort[a]

	Value (n = 352)
Age at surgery, y	60.3 ± 10.0 (21.6-80.9)
Age at follow-up, y	63.1 ± 10.3 (25.1-85.2)
Follow-up time, y	3.00 ± 0.80 (1.98-4.65)
Sex	
Female	138 (39.2)
Male	214 (60.8)
Rotator cuff tear size	
Small (<1 cm)	180 (51.1)
Medium (1-3 cm)	75 (21.3)
Large (3-5 cm)	49 (13.9)
Massive (>5 cm)	48 (13.6)
No. of medial-row anchors	
1	66 (18.8)
2	256 (72.7)
3	28 (8.0)
4	2 (0.5)
ASES score at follow-up	89.0 ± 16.9 (10.0-100.0)
VAS score at follow-up	1.2 ± 2.1 (0.0-10.0)
Met PASS cutoff for ASES[b]	287 (81.5)
Met PASS cutoff for VAS[c]	268 (76.1)

[a]Data are presented as mean ± SD (range) or n (%). ASES, American Shoulder and Elbow Surgeons; PASS, Patient Acceptable Symptom State; VAS, visual analog scale.
[b]PASS value for ASES (≥78.0[10]).
[c]PASS value for VAS (≤1.7[10]).

surgical, and outcomes data for the entire cohort (solid and all-suture anchor groups combined) are shown in Table 1. Regarding specific solid medial-row anchors, 95.8% (n = 69) were Healix, and 4.2% (n = 3) were Healicoil. Regarding specific all-suture medial-row anchors, 70.0% (n = 196) were FiberTak, 22.9% (n = 64) were JuggerKnot, 6.1% (n = 17) were Y-Knot, and 1.1% (n = 3) were Q-Fix.

Group Comparisons

The solid and all-suture anchor groups did not statistically differ in terms of age at surgery, age at follow-up, sex distribution, rotator cuff tear size, or number of medial-row anchors used (Table 2). The follow-up time was longer in the solid anchor group compared to the all-suture anchor group (3.6 vs 2.8 years, respectively) (Table 2). Additionally, the groups did not statistically differ in terms of ASES or VAS scores or the proportions of patients meeting PASS cutoffs for either the ASES or VAS scores (Table 2).

After controlling for follow-up time in linear regression models (sensitivity analyses for ASES and VAS scores), we found that the solid and all-suture anchor groups did not statistically differ in ASES scores (P = .44) or VAS scores (P = .37). Similarly, after controlling for follow-up time in logistic regression models (sensitivity analyses for meeting PASS cutoffs for the ASES and VAS), we found no group differences in the proportions of patients meeting PASS cutoffs for the ASES score (P = .44) and the VAS score

TABLE 2
Characteristics and Outcomes by Anchor Group[a]

	Solid (n = 72)	All-Suture (n = 280)	P
Age at surgery, y	59.8 ± 9.3 (41.1-74.8)	60.4 ± 10.2 (21.6-80.9)	.69[b]
Age at follow-up, y	63.4 ± 9.4 (45.5-78.9)	63.2 ± 10.3 (25.1-85.2)	.84[b]
Follow-up time, y	3.60 ± 0.70 (1.98-4.34)	2.80 ± 0.80 (2.00-4.65)	<.01[b]
Sex			.63[c]
Female	30 (41.7)	108 (38.6)	
Male	42 (58.3)	172 (61.4)	
Rotator cuff tear size			.75[c]
Small (<1 cm)	35 (48.6)	145 (51.8)	
Medium (1-3 cm)	18 (25.0)	57 (20.4)	
Large (3-5 cm)	11 (15.3)	38 (13.6)	
Massive (>5 cm)	8 (11.1)	40 (14.3)	
No. of medial-row anchors			.68[c]
1	17 (23.6)	49 (17.5)	
2	48 (66.7)	208 (74.3)	
3	7 (9.7)	21 (7.5)	
4	0 (0.0)	2 (0.7)	
ASES score at follow-up	89.6 ± 17.8 (21.6-100.0)	88.8 ± 16.7 (10.0-100.0)	.69[b]
VAS score at follow-up	1.1 ± 2.1 (0.0-10.0)	1.2 ± 2.1 (0.0-10.0)	.79[b]
Met PASS cutoff for ASES[d]	61 (84.7)	226 (80.7)	.43[c]
Met PASS cutoff for VAS[e]	58 (80.6)	210 (75.0)	.32[c]

[a]Data are presented as mean ± SD (range) or n (%). ASES, American Shoulder and Elbow Surgeons; PASS, Patient Acceptable Symptom State; VAS, visual analog scale.
[b]Comparison with independent t test.
[c]Comparison with chi-square test.
[d]PASS value for ASES (≥78.0[10]).
[e]PASS value for VAS (≤1.7[10]).

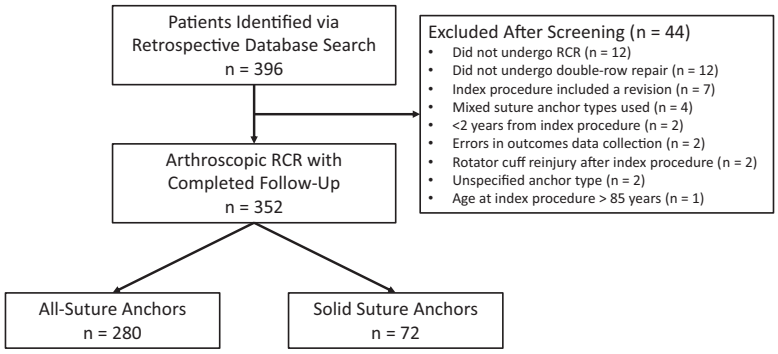

Figure 1. Flowchart of included patients. RCR, rotator cuff repair.

(P = .83). Across the entire cohort and 2 groups, we did not find that age at surgery was associated with any patient-reported outcome (ASES and VAS scores; PASS thresholds for the ASES and VAS). Specifically, within the entire cohort (n = 352), we found that age was not associated with ASES scores (P = .22), meeting the PASS threshold for the ASES (P = .53), VAS scores (P = .77), or meeting the PASS threshold for the VAS (P = .35). Within the solid anchor group (n = 72), we found that age was not associated with ASES scores (P = .95), meeting the PASS threshold for the ASES (P = .63), VAS scores (P = .95), or meeting the PASS threshold for the VAS (P = .68). Lastly, and similarly, within the all-suture anchor group (n = 280), we found that age was not associated with ASES scores (P = .13), meeting the PASS threshold for the ASES (P = .49), VAS scores (P = .72), or meeting the PASS threshold for the VAS (P = .24).

DISCUSSION

This study compared the clinical outcomes of patients who underwent rotator cuff repair with either all-suture or solid medial-row anchors. We found that there were no significant differences in patient-reported outcomes between the anchor types, including when controlling for differences in the follow-up time between the 2 groups. Both the all-suture anchor group and the solid anchor group had excellent patient-reported outcomes at a minimum 2-year follow-up, with patients in the all-suture anchor group demonstrating a mean ASES score of 88.8 and a mean VAS score of 1.2 and the solid anchor group demonstrating a mean ASES score of 89.6 and a mean VAS score of 1.1. Findings from both the all-suture and solid anchor groups in our study compare favorably to patient-reported outcomes after suture bridge rotator cuff repair previously published in the literature.[11,12]

There are few studies that have examined the performance and outcomes of all-suture anchors used in rotator cuff repair.[3,14,16,20,25] Of these, 1 study focused solely on all-suture anchor settling/migration, evaluated with magnetic resonance imaging,[20] and 4 studies examined both imaging and clinical outcomes.[3,14,16,25] Among studies evaluating clinical outcomes, Dhinsa et al[3] assessed 31 patients who underwent rotator cuff repair with all-suture anchors using a double-row technique, finding a mean Constant-Murley score of 77.1 (maximum of 100), with a mean follow-up time of 10.2 months. Similarly, Van der Bracht et al[25] examined both the clinical outcomes and magnetic resonance imaging findings of 20 patients who underwent rotator cuff repair with all-suture anchors at a mean follow-up time of 1.6 years, reporting a mean Constant-Murley score of 79 and 1 rotator cuff retear in their cohort. To our knowledge, our study is the first to compare clinical outcomes between all-suture and solid medial-row anchors. Additionally, we enrolled a significantly larger cohort than previous studies and obtained patient-reported data at least 2 years after surgery for all patients. Compellingly, we found excellent patient-reported outcomes at a mean follow-up time of 3.0 years (mean ASES score across the entire cohort [n = 352] of 89.0 of a maximum of 100; 81.5% of the entire cohort meeting the PASS cutoff for the ASES score) but did not find any anchor group differences in clinical outcomes. As more surgeons consider incorporating all-suture anchors into their rotator cuff repair technique, an important interpretation from the current study is that this approach yields similar patient-reported outcomes to those with traditional solid medial-row anchors. Thus, all-suture anchors appear to be a viable clinical alternative to solid anchors for rotator cuff repair while demonstrating potential advantages as previously described.

Limitations

There are several limitations that should be recognized in our study. First, our study relied only on patient-reported outcomes data to compare anchor groups. We currently do not have complete follow-up images (magnetic resonance imaging or ultrasound) on this cohort and therefore cannot evaluate and compare tissue healing or the proportions of rotator cuff retears between the 2 groups. Similarly, our follow-up data do not include objective physical examination, strength, and range of motion data, which would serve to further strengthen our understanding of clinical outcomes between these anchor type groups. Lastly, our study is observational and retrospective in nature and does not allow us to control all potential

confounders that might contribute to group differences in outcomes. While we found group differences in the follow-up time and controlled for this in our analyses, without randomization, we are unable to control unknown factors that might differ between groups and affect group outcomes. Future research should examine the effect of anchor type on rotator cuff repair outcomes in randomized prospective studies and identify the clinical predictors of outcomes after rotator cuff repair with all-suture anchors to better inform the prognosis for patients undergoing this procedure. In addition, future research should evaluate the proportions of rotator cuff retears and the need for revision surgery as well as the cost-effectiveness of medial-row anchor types used during rotator cuff repair.

CONCLUSION

Using all-suture anchors for the medial row of double-row suture bridge rotator cuff repair resulted in similar patient-reported outcomes to those using solid medial-row anchors. Regardless of the anchor type, our study demonstrated excellent clinical outcomes at midterm follow-up in patients after undergoing double-row suture bridge rotator cuff repair.

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