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What is the Optimal Construct to Reduce Failure in Arthroscopic Four Anchor Rotator Cuff Repair?

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Abstract

Background: Re-tear following rotator cuff repair (RCR) is a concerning complication that can lead to poor patient outcomes and necessitate the need for revision surgery. The purpose of our study was to look at the combined construct of knotted vs. knotless medial row and suture vs. suture tape, focusing primarily on re-tear rates following surgery.

Methods: A retrospective observational study of 343 consecutive patients undergoing arthroscopic double row, 4-anchor rotator cuff repair from February 2014 to March 2020 was conducted. Univariate and multivariate statistics were used to assess differences in demographics, comorbidities and tear characteristics between patients who experienced a symptomatic re-tear and those who did not.

Results: The overall symptomatic re-tear rate was 7.6%. Patients who had a knotted medial row repair had a significantly lower rate of re-tear (4.7 vs. 11.3%, $p = 0.022$). Patients that had a knotted medial row and suture tape repair were significantly less likely to experience a re-tear (OR: 0.180, $p = 0.001$).

Discussion: The use of suture tape and a knotted medial row repair decreases the incidence of symptomatic re-tear following rotator cuff repair. The combined construct of suture tape and a knotted medial row in rotator cuff repair decreases the risk for symptomatic re-tear following surgery.

Keywords

arthroscopic rotator cuff repair, shoulder surgery, rotator cuff repair failure, suture tape, knotted suture anchor, knotless suture anchor

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Introduction

Rotator cuff tears are a common injury leading to pain, discomfort and shoulder disability.[1,2] While certain populations with rotator cuff tear are managed effectively with non-operative treatment, a large number of patients benefit from, and elect to proceed with arthroscopic rotator cuff repair (RCR).[1,3,4] The ultimate goal of any RCR is to maximize healing by recreating the anatomic footprint of the shoulder and restoring normal biomechanical function. Double row and transosseous equivalent (TOE techniques) have shown greater strength and improved healing as compared to single row repairs due to maximizing the contact area at the rotator cuff footprint.[5–10] The medial row knots used in both the double row and double row TOE techniques improve the mechanical stability of the repair due to increased load sharing with the lateral anchor and suture.[11] Suture tape also appears to improve the tendon-bone contact and provides improved biomechanical strength when compared with traditional suture.[12,13] Despite the

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improvements in RCR techniques, tendon re-tear remains a concerning postoperative complication with reported failure rates from 8–44%.[14]

There are a number of different mechanisms of RCR failure including suture cutting through the suture anchor, suture anchor pullout, suture breakage, knot slippage or tendon failure at the suture-tendon junction. Revision RCR is a more complex surgery, with tendon loss and retraction of the rotator cuff tendons among the complicating factors, and results in a failure rate reported to be up to twice that of primary repairs.[15,16] While the mechanisms of failure of RCR have been well investigated in the literature, typically studies compare one repair construct at a time. The purpose of our study was to evaluate different methods of repair in four anchor RCR surgery by comparing symptomatic re-tear rates and risk factors in patients who had a knotted or knotless medial row repair and the use of suture or suture tape material.

Methods

Study population and setting

This study was deemed institutional review board exempt by the institution's clinical research committee. A retrospective observational study was conducted of patients undergoing arthroscopic double-row RCR with 4 suture anchors from February 1, 2014 to March 31, 2020. Procedures were performed by seven board certified orthopedic surgeons in a single hospital based outpatient surgery centre. Patients were excluded from the study if they underwent open RCR or if preoperative magnetic resonance imaging (MRI) was not available for review; no other exclusion criteria were used.

Double Row repair techniques

Arthroscopic double row RCR is a construct composed of two rows of anchors, a medial row and a lateral row, in order to provide anatomic footprint restoration. Double row repairs are more suitable for tears that are mobile and can be reduced to the rotator cuff footprint without undue tension; rotator cuffs repaired under tension are believed to have higher re-tear rates. The conventional double row technique places the medial row anchors at the articular margin and can consist of different stitch configurations. Subsequently, the lateral row anchors are placed and tied with the rotator cuff at the appropriate amount of tension. Then the medial row is tied last. The transosseous equivalent technique consists of a medial row of suture anchors with mattress sutures that are tied and then pulled laterally to a second row compressing the tendon to the footprint. Knotless transosseous equivalent technique uses the same method without knot fixation at the medial row. Repairs are performed using suture or suture tape.

Perioperative protocol

All surgeries were performed on an outpatient basis under general anesthesia; regional anesthesia for postoperative pain control used at the discretion of the surgeon and anesthesiologist All procedures were performed in the beach chair position. Medial row anchors were placed adjacent to the humeral head articular margin. A sliding locking knot or alternating half hitches were utilized for knotted medial row fixation based on surgeon preference. Lateral row fixation was obtained using knotless anchors. Patients receive instruction for a home exercise programme including hand, wrist and elbow range of motion (ROM) and shoulder pendulums to begin the day after surgery and formal physical therapy begins 10–14 days after surgery; formal physical therapy may be delayed based on intraoperative findings (large or massive tear or poor tissue quality). Rehabilitation protocols advance from passive shoulder ROM starting at 2 weeks, active assist ROM starting between 4 and 6 weeks and active ROM starting between 6 and 8 weeks postoperatively. All patients are discharged with a sling/shoulder immobilizer which is used at least for the first 6 weeks postoperatively. No lifting > 5 pounds for at least the first 6 weeks following surgery.

Data collection and analysis

Demographics, comorbidities and details of the tear and primary repair were manually recorded from the electronic medical record (EMR). The primary endpoint of the study was symptomatic re-tear confirmed by a non-contrast MRI (read by the radiologist and reviewed by the surgeon) or intraoperatively during repeat surgical treatment. Postoperative MRI was only ordered on symptomatic patients; no routine postoperative imaging was performed. Symptomatic re-tears were then grouped by medial row fixation and suture type. Univariate statistics (two-sided independent samples t-tests and chi-square tests) were performed to evaluate differences in demographics, comorbidities and tear characteristics between patients who had a knotted or knotless medial row of sutures and those that had repairs with suture or suture tape. Multivariate logistic and linear regression was performed to evaluate for risk factors for symptomatic re-tear based on knot fixation type at the medial row and by suture type after controlling for potentially confounding variables. All statistical analysis was performed in SPSS version 27 (IBM, Armonk, NY) and statistical significance was assessed at $\alpha = 0.05$.

Results

Three hundred forty three patients were included in this study. The average age of patients was 58.8 ± 9.0 years

old, with a BMI of 30.6 ± 5.9 kg/m^2, 40.5% of patients was female and 17.2% non-white race. Patients had an average follow up time of 1.3 ± 1.2 years postoperatively. Thirty eight patients (11.1%) had a postoperative MRI performed during the study period. Twenty six patients experienced a symptomatic re-tear (7.6%); 19.2% (5 patients) of these tears were a medial row failure. The average time to re-tear was 298.2 ± 306.7 days.

When comparing patients that had a knotted rather than knotless medial row repair, a significantly lower percentage of these patients had a small tear (21.9 vs. 33.8%, $p = 0.014$) and a significantly higher percentage had a medium tear (49.5 vs. 33.1%, $p = 0.002$) (Table 1). When comparing patients that had a suture repair to patients that had a suture tape repair, a significantly higher percentage of these patients had osteoarthritis (42.6 vs.

Table 1. Demographics, risk factors for Re-tear, and tear characteristics by fixation and suture type.

	Medial Row Fixation			Suture Type		
Variable	Knotted Medial Row N = 192	Knotless Medial Row N = 151	P-Value	Suture N = 47	Suture Tape N = 296	P-Value
Demographics						
Age – yrs.	58.6 ± 8.8	59.1 ± 9.2	0.575	58.6 ± 8.8	59.1 ± 9.2	0.575
BMI – kg/m2	30.7 ± 6.1	30.4 ± 5.7	0.710	30.7 ± 6.1	30.4 ± 5.7	0.710
Female	80 (41.7)	59 (39.1)	0.627	17 (36.2)	122 (41.2)	0.513
Non-white Race	38 (19.8)	21 (13.9)	0.152	7 (14.9)	52 (17.6)	0.652
Risk Factors for Re-tear						
Current or Former Smoker	72 (37.5)	55 (36.4)	0.838	20 (42.6)	107 (36.1)	0.398
Diabetes Mellitus	20 (10.4)	17 (11.3)	0.803	3 (6.4)	34 (11.5)	0.295
Rheumatoid Arthritis	1 (0.5)	1 (0.7)	1.000	0 (0.0)	2 (0.7)	1.000*
Osteoarthritis	44 (22.9)	46 (30.5)	0.115	20 (42.6)	70 (23.6)	**0.006**
ASA ≥ 3	52 (27.1)	36 (23.8)	0.495	16 (34.0)	72 (24.3)	0.156
Steroid Injection 3 to 6 Months Preop.	7 (3.6)	8 (5.3)	0.458	7 (14.9)	8 (2.7)	**0.002***
Steroid Injection 0 to 3 Months Preop.	10 (5.2)	13 (8.6)	0.211	3 (6.4)	20 (6.8)	1.000
Tear Characteristics						
Chronic Tear	130 (67.7)	111 (73.5)	0.243	34 (72.3)	207 (69.9)	0.737
Full Tear	158 (82.3)	133 (88.1)	0.138	46 (97.9)	245 (82.8)	**0.007**
Small Tear	42 (21.9)	51 (33.8)	**0.014**	17 (36.2)	76 (25.7)	0.133
Medium Tear	95 (49.5)	50 (33.1)	**0.002**	12 (25.5)	133 (44.9)	**0.012**
Large Tear	41 (21.4)	31 (20.5)	0.852	13 (27.7)	59 (19.9)	0.227
Massive Tear	5 (2.6)	6 (4.0)	0.545*	4 (8.5)	7 (2.4)	**0.049***
Goutallier ≥ 3	7 (3.6)	1 (0.7)	0.083*	3 (6.4)	5 (1.7)	0.082

P-values <0.05 in bold.
*Fisher's Exact Test.
BMI – body mass index.
ASA – American Society of Anesthesiologists Score.

23.6%, $p = 0.006$) and a steroid injection in the 3–6 months prior to surgery (14.9 vs. 2.7%, $p = 0.002$). When examining tear characteristics, a significantly higher percentage of these patients had a full tear (97.9 vs. 82.8, $p = 0.007$) or a massive tear (8.5 vs. 2.4%, $p = 0.049$) and a significantly lower percentage had a medium tear (25.5 vs. 44.9, $p = 0.012$) (Table 1). When examining the symptomatic re-tear rate in both groups, patients who had a knotted medial row had a significantly lower rate of re-tear (4.7 vs. 11.3%, $p = 0.022$). Patients who had a suture repair had a higher rate of re-tear although this was not statistically significant (14.7 vs. 6.4%, $p = 0.067$) (Table 2).

Table 3 contains the multivariate analysis examining the effect of medial row fixation on the risk for symptomatic re-tear. After controlling for other factors, patients with a Goutallier Classification ≥ 3 (OR: 7.367, $p = 0.034$) and a knotless medial row repair (3.511, $p = 0.006$) had a significantly increased risk of re-tear. Table 4 examines the effect of suture type on the risk for re-tear. A repair with suture tape provided a significant protective effect when controlling for other characteristics (OR: 0.309, $p = 0.028$). Table 5 looks at the risk of re-tear in patients that had both a knotted medial row and suture tape construct used in the primary repair. These patients were more likely to have a medium tear (OR: 2.908, $p = 0.042$) and this repair construct was significantly less likely to result in a re-tear (OR: 0.180, $p = 0.001$).

Discussion

There were no clinically significant differences in patient demographic factors among the different fixation types. Unadjusted comparison of injury and surgery specifics such as Goutallier classification and tear characteristics did reveal a few significant differences with medium sized tears being more likely to have a knotted medial row repair and a repair using suture tape. Small tears were more likely to be repaired with a knotless medial row. Full tears and massive tears were more likely to be repaired with suture as opposed to suture tape. After controlling for tear size, thickness, and patient health factors, patients with a knotless medial row repair and Goutallier classification ≥ 3 were more likely to experience a symptomatic re-tear and patients who had a repair with suture tape were less likely to experience a re-tear. Patients that had a knotted medial row repair along with suture tape were significantly less likely to experience a re-tear when controlling for the same factors which suggests that this may be the preferred construct for use in four anchor RCR.

Studies have consistently shown that double row RCR provides a superior biomechanical construct to single row RCR and demonstrate better restoration of the rotator cuff footprint.[8–10,14,17–19] Within the double row RCR, there is debate whether a knotted or a knotless medial row provides superior outcomes. Bovine and human cadaveric in vitro studies have shown that a knotted medial row provides increased mechanical stability with the medial knots improving load sharing with the lateral anchors.[11,20,21] Despite the improved stability of medial row knots there a concern that this construct causes reduced blood flow to the tendon and may result in increased medial row failure.[22] Knotless medial row increases pressurized tendon bone contact which may improve healing.[23,24] A systematic review by Elbuluk et al. demonstrated that both knotted and knotless RCR improved function in patients and there was not sufficient evidence that a knotted medial row contributed to repair failure.[25] In our study patients that had a RCR with a knotless medial row repair were more than three times more likely to experience a symptomatic re-tear than patients with a knotted medial row repair, although the overall re-tear rate was low in both groups.

Suture tape is a more recent addition to the fixation options for RCR and can be used in both a knotted and knotless construct. The wider suture tape can increase contact pressure of the tendon to the rotator cuff footprint which may improve healing, with a recent study demonstrating a three times higher footprint contact pressure in repairs with tape as opposed to suture.[13] A knotless suture tape also has intraoperative advantages with reduced operative time due to easier suture limb management.[26] While there are relatively few clinical studies looking at the use of suture tape, it appears to have at least equivalent results to suture in short and medium term follow up.[27,28] Consistent with the study by Pogorzelski et al. there was no significant difference in this study in the re-tear rates when comparing suture repairs to suture tape repairs, although when we did a regression analysis we demonstrated that RCR with suture were nearly 70% more likely to experience a re-tear than RCR with suture tape.[27] The majority of clinical studies that examine the difference between suture and suture tape repairs are limited to comparing knotted suture repairs and knotless suture tape repairs. It is possible that the significant differences we found in our study were more a factor of the knotted vs. knotless repair rather than the use of suture vs. suture tape.

There have been a number of biomechanical human and animal cadaveric studies evaluating RCR with suture tape and either a knotted or a knotless medial row repair. Self-reinforcement, which is the conversion of a potentially destructive force due to muscle contraction into a protective compressive force of frictional resistance by the use of tendon bridging sutures, is improved in knotless suture tape repairs. While the medial row knots improve biomechanical stability at the time of the repair, the knots may have a tenodesis effect and have been shown to decrease self-reinforcement of the repair.[26,29,30] A recent biomechanical study by Mijares et al. showed no significant difference between a knotted or knotless TOE using suture tape in medial row fixation point displacement, construct stiffness

Table 2. Re-tear rates by fixation and suture type.

	Medial Row Fixation			Suture Type		
Outcome	Knotted Medial Row $N = 192$	Knotless Medial Row $N = 151$	P-Value	Suture $N = 47$	Suture Tape $N = 296$	P-Value
Follow Up Time – Avg. Years	1.3 ± 1.2	1.5 ± 1.3	0.055	1.6 ± 1.4	1.3 ± 1.2	0.176
Re-tear – n (%)	9 (4.7)	17 (11.3)	**0.022**	7 (14.9)	19 (6.4)	0.067*
Medial Row Failure – n (% of total re-tears)	3 (33.3)	2 (11.8)	0.302*	2 (28.6)	3 (15.8)	0.588*
Time to Re-tear – Avg. Days	229 ± 170	335 ± 358	0.041	223 ± 194	326 ± 339	0.046

P-Values <0.05 in bold.

Table 3. Multivariate regression analysis: effect of medial Row fixation on risk for Re-tear.

		OR 95% CI		
Variable	Odds Ratio	Lower	Upper	P-Value
Medium Tear	2.591	0.932	7.206	0.068
Large Tear	1.204	0.324	4.469	0.782
Massive Tear	0.000	0.000	0.000	0.999
Full Tear	1.293	0.354	4.721	0.697
Goutallier ≥ 3	7.367	1.159	46.812	**0.034**
Osteoarthritis	0.987	0.366	2.662	0.979
ASA ≥ 3	1.341	0.511	3.519	0.551
Steroid Injection 3 to 6 Months Preop.	0.847	0.098	7.341	0.881
Knotless Medial Row	3.511	1.422	8.670	**0.006**

P-Value <0.05 in bold.
ASA – American Society of Anesthesiologists Score.

Table 4. Multivariate regression analysis: effect of suture type on risk for Re-tear.

		OR 95% CI		
Variable	Odds Ratio	Lower	Upper	P-Value
Medium Tear	2.263	0.822	6.230	0.114
Large Tear	1.000	0.265	3.782	1.000
Massive Tear	0.000	0.000	0.000	0.999
Full Tear	1.267	0.344	4.668	0.722
Goutallier ≥ 3	4.135	0.681	25.114	0.123
Osteoarthritis	0.939	0.344	2.563	0.902
ASA ≥ 3	1.240	0.468	3.283	0.665
Steroid Injection 3 to 6 Months Preop.	0.583	0.064	5.338	0.633
Suture Tape	0.309	0.109	0.879	**0.028**

P-Value <0.05 in bold.
ASA – American Society of Anesthesiologists Score.

or load to failure in human cadaveric shoulders.[31] In our study there was a significant decrease in symptomatic re-tear rate in patients that had a suture tape RCR with a knotted medial row, with this group being 82% less likely to experience a re-tear.

This study does have a number of limitations. First, it is a retrospective study and there is an inherent selection bias, though we attempted to correct for that by using multivariate analysis to control for some of these factors. Second, the study was performed at a single institution, so it may not be generalizable to a larger patient population. However, it is currently the largest study comparing the clinical outcomes of the four anchor RCR using suture or suture tape and a knotted or knotless medial row repair and we believe this a valuable contribution to the literature. Third, at this institution we do not routinely re-image shoulders or continue routine follow up appointments beyond one year following RCR, so we may not have identified all re-tears in this population. We also did not collect data on additional procedures (biceps tenodesis, acromioplasty, etc.) performed at the time of the RCR which could have impacted recovery and post-operative symptoms. Further studies should investigate patient reported outcomes to evaluate functional outcomes and quality of life of patients undergoing these procedures.

The use of suture tape rather than suture and a knotted rather than knotless medial row repair both decrease the incidence of symptomatic re-tear following RCR. The combined construct of suture tape and a knotted medial row in RCR significantly decreases the risk for symptomatic re-tear following surgery.

Table 5. Multivariate regression analysis: effect of fixation and suture type on risk for Re-tear.

Variable	Odds Ratio	OR 95% CI		P-Value
		Lower	Upper	
Medium Tear	2.908	1.041	8.130	**0.042**
Large Tear	1.123	0.293	4.298	1.123
Massive Tear	0.000	0.000	0.000	0.999
Full Tear	1.124	0.306	4.134	0.860
Goutallier ≥ 3	6.006	0.915	39.421	0.062
Osteoarthritis	0.924	0.341	2.502	0.924
ASA ≥ 3	1.304	0.487	3.487	0.597
Steroid Injection 3 to 6 Months Preop.	0.817	0.093	7.189	0.855
Knotted Medial Row and Suture Tape	0.180	0.066	0.487	**0.001**

P-Value <0.05 in bold.
ASA – American Society of Anesthesiologists Score.

Declaration of Conflicting Interests

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