The Effect of Concomitant Biceps Tenodesis on Reoperation Rates After Rotator Cuff Repair: A Review of a Large Private-Payer Database From 2007 to 2014

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Purpose: To determine if reoperation rates are higher for patients who underwent isolated rotator cuff repair (RCR) than those who underwent RCR with concomitant biceps tenodesis using a large private-payer database. **Methods:** A national insurance database was queried for patients who underwent arthroscopic RCR between the years 2007 and 2014 (PearlDiver, Warsaw, IN). The Current Procedural Terminology (CPT) 29,827 (arthroscopy, shoulder, surgical; with RCR) identified RCR patients who were subdivided into 3 groups—group 1: RCR without biceps tenodesis; group 2: RCR with concomitant arthroscopic biceps tenodesis (CPT 29827 and 29,828); group 3: RCR with concomitant open biceps tenodesis (CPT 29827 and 23,430). Reoperation rates (revision RCR, subsequent biceps surgeries) and complications at 30 days, 90 days, 6 months, and 1 year were analyzed. Multivariate logistic regression was used to compare reoperations and complications between groups. Rotator cuff tear size, whether the biceps was ruptured and whether a biceps tenotomy was performed, was not available. **Results:** Group 1: 27,178 patients. Group 2: 4,810 patients. Group 3: 1,493 patients. More patients underwent concomitant arthroscopic than concomitant open tenodesis ($P < .001$). A total of 2,509 patients underwent a reoperation for RCR or biceps tenodesis within 1 year after RCR. When adjusted for age, sex, and comorbidities, no significant differences in reoperation rates at 30 days or 90 days among the 3 groups, but significantly more patients who had a tenodesis, required a reoperation compared with those who did not have a tenodesis at 6 months and 1 year (both $P < .001$). Urinary tract infections were more common in patients who did not have a tenodesis, whereas dislocation, nerve injury, and surgical site infection were more common in tenodesis patients. **Conclusions:** Higher reoperation rates at 1 year were seen in patients who had concomitant biceps tenodesis. **Level of Evidence:** Level III, case-control database review study.

The number of rotator cuff repairs (RCR) performed in the United States and across the world is on the rise.[1-3] Despite retear rates after RCR ranging from 0% in small tears (<1 cm) to almost 80% in chronic massive tears, the clinical results are encouraging, especially if RCR occurs within 6 months of injury.[4-6] In a recent systematic review of 954 patients who underwent RCR for a chronic massive rotator cuff tear, Henry et al.[4] found an improvement in their visual analog scale from 5.9 to 1.7, Constant-Murley score from 49 to 74, and active range of motion from 125° to 169°. Despite good clinical results for RCR, there remains room for improvement.

One important variable during RCR is the management of the biceps tendon. Although the exact function of the long head of the biceps tendon (LHBT) is yet to be fully elucidated, its role as a pain generator in the shoulder is well known.[7-10] Options for the management of the biceps tendon include leaving it alone, simple tenotomy, or tenodesis. Numerous tenodesis techniques have been described that vary by location

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(proximal, suprapectoral, transfer to the conjoint, or subpectoral), by technique (arthroscopic or open), by fixation (soft tissue-to-soft tissue or soft tissue-to-bone), and by mode of fixation (anchor, button, suture, or interference screw).[11-20] Leroux et al.[21] performed a systematic review to compare outcomes in patients after RCR who underwent either a concomitant LHBT tenotomy or tenodesis. Although the authors found a significantly higher postoperative Constant score in the tenodesis group, the difference did not meet the minimal clinically important difference. They did not evaluate patients who underwent RCR alone, however, and did not investigate reoperation rates.

The purpose of this study was to determine if reoperation rates are higher for patients who underwent isolated RCR than those who underwent RCR with concomitant biceps tenodesis with the use of a large private-payer database. The authors hypothesized that reoperation rates would be higher for patients who underwent isolated RCR than those who underwent RCR with concomitant tenodesis.

Methods

A retrospective review of the PearlDiver Humana database was performed to capture all RCR performed between 2007 and 2014. The PearlDiver Humana database is a commercially available Health Insurance Portability and Accountability Act-compliant national database. The database uses supercomputer technology to collate individual patient records associated with Current Procedural Terminology (CPT) and International Classification of Diseases, Ninth Revision (ICD-9) codes related to orthopaedic procedures. Prior studies from high impact factor journals have used this database to analyze ulnar collateral ligament reconstructions, distal biceps ruptures, Achilles tendon ruptures, mortality after femoral neck fractures, and others.[22-26]

Patients who underwent arthroscopic RCR were queried using CPT code 29,827 (arthroscopy, shoulder, surgical; with RCR). This group of patients was further scrutinized to determine the number of patients who had a concomitant biceps tenodesis done on the same surgical date as their RCR. This was done by isolating all patients with CPT code 29,827 and then identifying those who also had CPT code 29,828 (arthroscopy, shoulder, surgical; biceps tenodesis) or 23,430 (open tenodesis of long tendon of biceps) performed on the same date as 29,827. This effectively divided the overall group of patients who underwent an RCR into 3 groups: group 1 was RCR alone (CPT 29827); group 2 was RCR with arthroscopic biceps tenodesis (CPT 29827 and 29,828); group 3 was RCR with open biceps tenodesis (CPT 29827 and 23,430). Biceps tenotomy could not be included because there was no CPT code for this.

The primary data points that were extracted included patient age at the time of surgery (broken down into the following age ranges: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, 85-89, 90 or older), year of surgery, and patient sex. Patient comorbidities were also determined based on ICD-9 codes (Appendix Table 1, available at www.arthroscopyjournal.org). The occurrence of a repeat rotator cuff surgery was determined at the following intervals: 30 days, 90 days, 6 months, and 1 year. Revision arthroscopic rotator cuff surgery was determined using CPT code 29,827. Revision RCR therefore included procedures with and without tenodesis.

In addition, the occurrence of complications after each procedure was determined. The complications assessed included acute kidney injury, cardiac arrest, deep vein thrombosis, nerve injury, surgical site infection, urinary tract infection, wound dehiscence, hematoma, capsulitis, and dislocation. These complications were extracted based on ICD-9 diagnosis codes, which can be found in Appendix Table 2 (available at www.arthroscopyjournal.org).

Statistical Analysis

Statistical analyses were conducted using *R* (*R* Foundation for Statistical Computing, Vienna, Austria). Pearson's chi-squared analyses were used to compare patient demographics and comorbidities. Reoperations and complications were compared using multivariate logistic regression, using cases without tenodesis as the reference. Multivariate analyses were controlled for all patient demographics and comorbidities. Odds ratios were calculated. All tests were 2-tailed, and the statistical difference was established at a 2-sided α level of 0.05 ($P < .05$).

Results

A total of 33,481 patients in the database underwent an RCR between 2007 and 2014. Group 1 (RCR without concomitant biceps tenodesis) included 27,178 patients. Group 2 (RCR with arthroscopic biceps tenodesis) included 4,810 patients. Group 3 (RCR with open biceps tenodesis) included 1,493 patients (Table 1). Among all patients, 52.7% of were male. Significantly more males underwent no tenodesis compared with either arthroscopic ($P < .001$) or open tenodesis ($P < .001$), whereas no difference existed for females. More males underwent arthroscopic tenodesis than open tenodesis ($P < .001$), whereas no difference existed for females. The majority of patients in all 3 groups were in the 65- to 69-year-old age group (range of 25.3% to 27.8% of patients in that group). The number of each type of biceps tenodeses increased over time, with the greatest percentage increase seen in arthroscopic tenodesis (Table 1).

Table 1. Demographics of Patients Who Underwent a Rotator Cuff Repair (RCR) Between 2007 and 2014 in Regard to Age, Sex, and Year of the Operation Separated by Whether They Underwent a Concomitant Tenodesis of the Long Head of the Biceps (Open or Arthroscopic) at the Time of Their RCR or Not

	Open Tenodesis		Arthroscopic Tenodesis		No Tenodesis		Arthroscopic vs No Tenodesis *P* Value	Open vs No Tenodesis *P* Value	Open vs Arthroscopic Tenodesis *P* Value
	No.	%	No.	%	No.	%			
Overall	1,493		4,810		27,178				
Age							**<.001**	**<.001**	**<.001**
15 to 19	<11	<0.7	<11	<0.2	58	0.2			
20 to 24	<11	<0.7	<11	<0.2	70	0.3			
25 to 29	<11	<0.7	<11	<0.2	60	0.2			
30 to 34	<11	<0.7	14	0.3	124	0.5			
35 to 39	14	0.9	31	0.6	311	1.1			
40 to 44	57	3.8	96	2.0	682	2.5			
45 to 49	101	6.8	220	4.6	1,458	5.4			
50 to 54	171	11.5	406	8.4	2,307	8.5			
55 to 59	206	13.8	521	10.8	2,958	10.9			
60 to 64	200	13.4	560	11.6	3,089	11.4			
65 to 69	377	25.3	1337	27.8	7,225	26.6			
70 to 74	205	13.7	964	20.0	5,288	19.5			
75 to 79	122	8.2	488	10.1	2,534	9.3			
80 to 84	17	1.1	141	2.9	772	2.8			
85 to 89	<11	<0.7	14	0.3	126	0.5			
90 and over	<11	<0.7	12	0.2	114	0.4			
Male	992	66.4	2,771	57.6	13,860	51	**<.001**	**<.001**	**<.001**
Female	502	33.6	2,040	42.4	13,317	49	**<.001**	**<.001**	**<.001**
Year							**<.001**	**<.001**	**<.001**
2007	92	6.2	<11	<0.2	1,989	7.3			
2008	87	5.8	281	5.8	2,386	8.8			
2009	86	5.8	389	8.1	2,707	10.0			
2010	107	7.2	530	11.0	3,125	11.5			
2011	166	11.1	632	13.1	3,356	12.3			
2012	235	15.7	703	14.6	3,824	14.1			
2013	300	20.1	992	20.6	4,460	16.4			
2014	420	28.1	1,282	26.7	5,321	19.6			

NOTE. Chi-squared results are shown for each comparison on the right. Significant *P* values (<0.05) are bolded.

A total of 2,509 patients underwent a reoperation for RCR or biceps tenodesis within 1 year after RCR. There were no significant differences between any group in reoperation rates at 30 days or 90 days after RCR. As seen in Table 2, compared with no tenodesis, patients who underwent arthroscopic tenodesis had increased rates of RCR at 6 months and 1 year (odds ratio [OR] 1.3-1.4, $P < .001$) after a multivariate analysis was conducted. Similarly, following a multivariate analysis, open tenodesis was associated with increased rates of RCR at the same time points (OR 1.4-1.6, $P < .001$). These values were significant following the multivariate analysis despite the percentages being similar between the groups. Arthroscopic tenodesis was associated with increased rates of nerve injury (OR 2.4, $P = .005$) and dislocation (OR 1.3, $P < .001$) and decreased rates of urinary tract infection (OR 0.8, $P = .001$). Open tenodesis was associated with increased risk of surgical site infection (OR 1.6, $P = .021$) and dislocation (OR 1.1, $P = .005$).

In group 1, less than 11 patients required a reoperation within 30 days for a biceps tenodesis (Table 3). In group 1, a total of 53 patients (0.20%) required a reoperation for a biceps tenodesis during the first postoperative year.

Discussion

No difference in reoperation rates was identified among the 3 groups (group 1: RCR without biceps tenodesis, group 2: RCR with concomitant arthroscopic biceps tenodesis, group 3: RCR with concomitant open biceps tenodesis) at 30 days or 90 days. Significantly more patients who had a concomitant biceps tenodesis (open or arthroscopic) required a reoperation at 6 months and 1 year. There were differences seen between the groups in regard to several complications.

As the number of RCR continues to rise, it is imperative that the orthopaedic surgery community critically evaluates all aspects of this procedure, including management of the LHBT, to optimize outcomes in both the short and long term.[3] Several studies to date have evaluated biceps tenotomy versus tenodesis in the setting of a repairable rotator cuff tear.[21,27,28] Meraner et al.[27] recently compared 53 consecutive patients who underwent RCR with concomitant biceps tenotomy (29 patients) or biceps tenodesis (24 patients) and found no differences in clinical outcome scores or patient satisfaction between the groups. Similarly, Zhang et al.[28] compared 151 patients who underwent

Table 2. Comparison of Event Rates Including Reoperations and Complications in Patients Who Underwent Rotator Cuff Repair With and Without a Concomitant Open or Arthroscopic Long Head of the Biceps Tenodesis

	Open Tenodesis		Scope Tenodesis		No Tenodesis		Scope Tenodesis Multivariate Analysis		Open Tenodesis Multivariate Analysis	
	No.	%	No.	%	No.	%	Odds Ratio	*P* Value*	Odds Ratio	*P* Value*
Cuff repair within 30 d	12	0.80	32	0.67	205	0.75	1.0	.668	1.3	.668
Cuff repair within 90 d	14	0.94	52	1.08	317	1.17	1.1	.059	1.1	.651
Cuff repair within 6 mo	36	2.41	92	1.91	565	2.08	1.3	**<.001**	1.4	**<.001**
Cuff repair within 1 yr	55	3.68	160	3.33	895	3.29	1.4	**<.001**	1.6	**<.001**
Cuff repair at any time	81	5.43	163	3.39	1430	5.26	1.6	**<.001**	1.4	**<.001**
Complications										
AKI	<11	<0.74	26	0.54	212	0.78	1.0	.775	1.0	.905
Cardiac arrest	<11	<0.74	<11	<0.23	29	0.11	0.7	.339	0.8	.731
DVT/PE	0	0.00	<11	<0.23	27	0.10	1.6	.088	0.9	.983
Nerve injury	0	0.00	<11	<0.23	16	0.06	2.4	**.005**	0.9	.989
Surgical site infection	13	0.87	21	0.44	116	0.43	1.2	.162	1.6	**.021**
UTI	40	2.68	146	3.04	1050	3.86	0.8	**.001**	1.0	.776
Wound dehiscence	<11	<0.74	<11	<0.23	33	0.12	0.8	.473	0.8	.953
Hematoma	<11	<0.74	<11	<0.23	48	0.18	1.4	.055	1.0	.964
Capsulitis	253	16.95	854	17.75	4210	15.49	0.8	.383	1.5	.274
Dislocation	13	0.87	32	0.67	167	0.61	1.3	**<.001**	1.1	**.005**

NOTE. When multivariate analysis was utilized to control for several variables, no significant differences existed in reoperation rates at 30 and 90 d. However, significantly more patients with a concomitant tenodesis (both open or arthroscopic) required a reoperation at 6 mo and 1 yr. Significant *P* values (<0.05) are bolded.

Columns stating cuff repair within 90 d include all patients who had an RCR within 90 d, not just those who had on between 30 and 90 d. The same goes for all other columns.

AKI, acute kidney injury; DVT, deep venous thrombosis; PE, pulmonary embolus; RCR, rotator cuff repair; UTI, urinary tract infection.

*No tenodesis used as reference.

RCR with either a biceps tenodesis (74 patients) or tenotomy (77 patients) and found no significant difference in clinical results, patient satisfaction, or rate of Popeye deformity. The authors did note a significantly shorter operative time in the tenotomy group (40.4 ± 4.0 minutes) compared with the tenodesis group (50.4 ± 5.9 minutes). Two issues with these studies are that they failed to compare patients with no biceps intervention with those who underwent tenodesis and did not evaluate reoperation rates for either patient group.[21,27,28]

Literature comparing RCR with and without biceps tenodesis is quite limited. However, the available data suggest similar clinical outcomes for both groups (patients undergoing RCR with and without biceps tenodesis) in regard to postoperative shoulder scores and patient satisfaction.[29] The current study found no difference in reoperation rates at 30 days and 90 days, but a significantly higher reoperation rate for those who had a concomitant biceps tenodesis at 6 months and 1 year. This is a significant finding because it shows a lower reoperation rate in regard to RCR if the biceps is left alone at the time of the index RCR. This is not to say that a diseased biceps should be ignored; in fact, it is the exact opposite. If the biceps appears to be a pain generator, it should be addressed as the surgeon sees fit (typically a tenotomy or tenodesis), but if there is a question as to how much the biceps is contributing to the patient's overall symptoms, it may be worthwhile preserving it while performing the RCR. Given the changing landscape of medical reimbursement for orthopaedic surgeons, it is important to understand reoperation rates after common procedures, especially in the short term. If there were a way to prevent a reoperation at the time of the index procedure with minimal to no risk to the patient, some surgeons may err on the more aggressive side to prevent a problem later on whereas others may not; no data are available to show which option the majority of surgeons would choose. Based on the results of this study, it does not appear that concomitant biceps tenodesis during RCR is protective of a second rotator cuff surgery.

One interesting finding in this study was the drastically higher number of arthroscopic biceps tenodeses (4,810) performed compared with open biceps

Table 3. Rate of Subsequent Biceps Tenodesis (Open or Arthroscopic) Broken Down by Time to Reoperation in Patients Who Underwent an Index Rotator Cuff Repair Without an Arthroscopic or Open Biceps Tenodesis

	No.	%
Tenodesis within 30 d	<11	<0.04
Tenodesis within 90 d	<11	<0.04
Tenodesis within 6 mo	21	0.08
Tenodesis within 1 yr	53	0.20
Tenodesis at any time	115	0.42

tenodeses (1,493), which stands in contrast to other studies that have evaluated biceps tenodesis and reported more open than arthroscopic procedures.[30] Furthermore, there was an overall increase in the number of each type of biceps tenodeses over time, with the greatest percentage increase seen in arthroscopic tenodesis. Yi et al.[31] compared results of open and arthroscopic biceps tenodesis in patients who underwent RCR. The authors found no differences in clinical outcomes at final follow-up between the 2 groups. A recent systematic review by Abraham et al.[32] evaluated 16 studies that compared results of open (271 patients) and arthroscopic (205 patients) biceps tenodesis in patients who did not have a concomitant RCR. The authors found that 98% of patients in each of the arthroscopic and open tenodesis groups had a good/excellent outcome and concluded that both techniques were viable options when performing a biceps tenodesis. Furthermore, as expected, the complication rate for surgical site infection in this study was highest in the open biceps tenodesis group and lowest in the no tenodesis group. Given that the extra incision for an open biceps tenodesis is in a tenuous area, it is reasonable that the infection rate would be higher in the tenodesis group.[33]

Given the results of this study, if a patient is complaining of biceps-type symptoms, has positive physical examination maneuvers indicating biceps pathology (palpation of the bicipital tunnel, O'Brien sign, throwing test, speeds, Yergason, etc.), and/or has a biceps tendon that looks degenerative or inflamed at the time of his or her RCR, a biceps tenodesis should be considered.[34] It is in the patient with no localizing preoperative symptoms or physical examination findings to indicate biceps pathology that the surgeon should err on the conservative side. Saccomanno et al.[35] recently performed a systematic review of 64 studies in an attempt to identify prognostic factors influencing outcome after RCR. Although older age and larger tear size were shown to affect retear rates, the authors could not reach any definitive conclusion regarding the most relevant predictors of outcome of RCR. This study also supports that biceps tenodesis should only be performed when deemed necessary based on preoperative examination, imaging findings, and intraoperative examination of the biceps tendon.

The ideal treatment of the biceps tendon during an RCR surgery remains unknown. Perhaps the most important aspect of the preoperative workup remains identifying which patients have biceps tendinopathy by magnetic resonance imaging, or more importantly clinical examination, because these patients are the ones who would likely benefit the most from a tenodesis. There are several patient factors including age, activity level, comorbidities, expectations, and others that need to come into play when deciding on how best to treat the biceps.[36] Further prospective studies evaluating reoperation rates for the various treatment options for the biceps tendon, including no intervention, are necessary to better elucidate how best to treat these patients.

Limitations

Although this is the first large-scale study to compare reoperation rates at various time points after RCR in patients with and without a concomitant biceps tenodesis, there are several limitations. Because this is a database study, similar to prior high-level studies using this database, the study is subject to all limitations of a database including errors in reporting and inability to capture all patients.[22-26] The power of the analysis is dependent on the quality of the available data, which includes accuracy of billing codes and miscoding or noncoding by physicians. It is also likely that not all patients were coded properly. Because the complications we describe are based on reporting, this coding issue is worthy of mention but does not limit the applicability of the data reported. We also do not know the clinical symptoms patients presented with or the status of the biceps at the time of arthroscopy. Without knowledge of the true presenting patient symptoms, we cannot comment on the appropriateness of procedures performed. The subset of patients who may have undergone a SLAP repair were not included because there are multiple types of SLAP tears, multiple techniques to perform a SLAP repair, and so on that would have introduced great variability into the results.

Furthermore, patients who underwent concomitant biceps tenotomy could not be identified from the nontenodesis group, so there were patients included in the nontenodesis group who did have a tenotomy. Adding in a biceps tenotomy group was not possible given the database limitations. Because operative reports were not analyzed, patients who had spontaneous rupture of the biceps tendon would have been included under the no tenodesis group. Similarly, the rotator cuff tear pattern, size of the rotator cuff tear, RCR (single row, double row, etc.) technique as well as exact type and technique of tenodesis performed on each patient were not evaluated, although studies have shown similar results when comparing the various techniques.[11,31] Data before 2007 were unavailable, so patients before this time period could not be analyzed. Patient clinical outcomes including patient satisfaction were not available for analysis. Furthermore, prior surgical and nonsurgical interventions before the initial RCR in this group of patients were not available, and therefore were not analyzed. Finally, in this study, there is relatively short-term follow-up, the assumption of equality among the various tenodesis techniques, and an inability to identify patients in whom tenotomy was performed.

Conclusions

Higher reoperation rates at 1 year were seen in patients who had concomitant biceps tenodesis.

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Appendix Table 1. International Classification of Diseases, 9th Revision (ICD-9) Codes Corresponding to Patient Comorbidities

Comorbidity	ICD-9 Code
Obesity	278.00-278.03
Diabetes	249.00, 250.00, 250.01, 790.2-290.29, 791.5, 791.6
Coronary artery disease	414.0-414.9
Chronic kidney disease	585.1-585.9
Congestive heart failure	398.91, 428.0-428.9
Chronic obstructive pulmonary disease	491.0-491.9, 492.0-492.9, 493.00-493.92, 494.0, 494.1, 495.0-495.9, 496

Appendix Table 2. International Classification of Diseases, 9th Revision (ICD-9) Codes Corresponding to Postoperative Adverse Events

Event	ICD-9 Code
Acute kidney injury	584.5-584.9
Cardiac arrest	427.41, 427.5
Deep vein thrombosis	453.2, 453.3, 453.4, 453.82, 453.84, 453.85, 453.86
Peripheral nerve injury	955.0, 955.1, 955.2, 955.3, 955.4, 955.5, 955.6, 955.7, 955.8, 955.9, 907.4
Pneumonia	480.0, 480.1, 480.2, 480.3, 480.8, 480.9, 481, 482.0, 482.1, 482.30, 482.31, 482.32, 482.39, 482.40, 482.41, 482.42, 482.49, 482.81, 482.82, 482.83, 482.84, 482.89, 482.9, 483.0, 483.1, 483.8, 484.1, 484.3, 484.5, 484.6, 484.7, 484.8, 485, 486
Surgical site infection	998.51, 998.59, 996.66, 996.67, 730.01, 730.11, 730.21, 730.81, 730.91
Urinary tract infection	599
Wound dehiscence	998.30, 998.31, 998.32, 998.33
Hematoma	998.11, 998.12, 998.13
Capsulitis	726.0, 719.51
Dislocation	831.00, 831.09, 718.31, 718.21