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Increased reoperation rates among patients undergoing shoulder arthroscopy with concomitant biceps tenodesis

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Background: The purpose of this study was to determine whether patients undergoing any shoulder arthroscopic procedure with concomitant biceps tenodesis have higher reoperation and complication rates vs. patients undergoing shoulder arthroscopy without concomitant biceps tenodesis.

Methods: A large database was queried for patients undergoing shoulder arthroscopy, identified by Current Procedural Terminology code. Only records indicating the laterality of the procedure were included. Patients were divided into 3 cohorts: arthroscopic shoulder surgery without concomitant biceps tenodesis (group 1), surgery with arthroscopic biceps tenodesis (group 2), and surgery with open biceps tenodesis (group 3). Reoperations on the same shoulder, as well as medical or surgical complications (by *International Classification of Diseases, Ninth Revision* code) during the 30-day postoperative period, were determined. Multivariate logistic regression was used to control for differences in age, sex, and Charlson Comorbidity Index between groups.

Results: We identified 62,461 patients (54.3% male patients) in the database who underwent shoulder arthroscopy, with 51,773 patients in group 1, 7134 patients in group 2, and 3554 patients in group 3. Overall, 3134 patients (5.0%) underwent a shoulder arthroscopy reoperation. With adjustment for age, sex, and Charlson Comorbidity Index, the biceps intervention groups demonstrated a significantly higher overall reoperation rate (odds ratio, 1.3 [95% confidence interval, 1.2-1.5]; $P < .001$). Patients undergoing biceps tenodesis had a lower adjusted overall 30-day complication rate vs. those not undergoing tenodesis (odds ratio, 0.82 [95% confidence interval, 0.79-0.86]; $P < .001$).

Conclusion: Reoperation rates were significantly higher in patients undergoing shoulder arthroscopy with biceps tenodesis than in patients undergoing shoulder arthroscopy without biceps tenodesis. Both the arthroscopic and open tenodesis groups had significantly lower complication rates.

Shoulder pain is a common condition, affecting between 14% and 26% of adults.[6,34] One potential cause of shoulder pain and dysfunction is disorders of the long head of the biceps (LHB) tendon.[1,20,41] Pain-generating conditions of the LHB tendon include tendinopathy, tearing, and subluxation,[41] with increasing age correlated to LHB tendon pathology.[43]

Despite the prevalence of LHB tendon pathology, controversy exists regarding the treatment choice for addressing LHB tendon–related pain.[3,16,17,28] Part of this controversy may lie in a lack of a complete understanding of the relevance of LHB pathology to the setting of shoulder pain.[29,40] Despite this, current treatment options include nonoperative management, tenotomy, or tenodesis.[39] In a survey of the American Shoulder and Elbow Surgeons, members favored biceps tenodesis over tenotomy for surgical management of pathology of the LHB tendon.[11] Comparing tenotomy with tenodesis, previous reports have found similar and favorable outcomes for both procedures; however, tenotomy can lead to increased rates of cramping and cosmetic deformity.[3,9,18,24,30,41,42] In addition, biceps tenodesis procedures can be performed using either an arthroscopic or open technique, with both approaches providing satisfactory outcomes.[1,7,43] It has been noted by multiple authors that the performance of biceps tenodesis has been increasing with time.[15,43]

LHB tendon pathology often occurs in conjunction with other shoulder conditions including rotator cuff tears, unstable superior labrum anterior-posterior (SLAP) tears, subacromial impingement, and anterior capsule disorders.[1,38] Prior literature has shown increased reoperation rates after rotator cuff repairs performed

Institutional review board approval was not required for this retrospective treatment study.

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with concomitant arthroscopic or open tenodesis compared with rotator cuff repairs performed with no tenodesis.[15] Because LHB tendon pathology can occur in non–rotator cuff shoulder disorders, the purpose of this study was to determined whether reoperation and complication rates were increased following the performance of shoulder arthroscopic procedures that included biceps tenodesis vs. arthroscopic shoulder procedures in which biceps tenodesis was not performed. We hypothesized that there would be no difference in reoperation rates when comparing patients who underwent arthroscopic shoulder procedures without tenodesis vs. those who underwent arthroscopic shoulder procedures and concomitant biceps tenodesis.

Materials and methods

A retrospective review of the PearlDiver Humana Patient Records Database (PearlDiver, Colorado Springs, CO, USA) was used for the study. The PearlDiver Humana database is a commercially available database of insurance billing records that contains patient record information associated with *International Classification of Diseases, Ninth Revision* or Current Procedural Terminology (CPT) codes related to orthopedic procedures. All claims data are deidentified for Health Insurance Portability and Accountability Act compliance. The PearlDiver Humana database includes approximately 25 million patient records from 2007 to 2017.

For the search query, the number of patients with records of CPT codes denoting arthroscopic shoulder procedures (Table I) was extracted. Within this population, the first instance of these CPT codes for each patient in the data set was recorded. Only patients with records specifying whether the procedure was performed on the right or left shoulder were included. This was done for more accurate reoperation statistics by removing any cases of patients who had undergone a procedure on one shoulder and a subsequent procedure on the opposite shoulder. The remaining group of patients was further divided into 3 groups. Group 1 consisted of patients who underwent arthroscopic shoulder surgery without concomitant LHB tenodesis, group 2 included patients who received arthroscopic shoulder surgery and arthroscopic biceps tenodesis (CPT code 29828) on the same date, and group 3 comprised patients who underwent arthroscopic shoulder surgery and open biceps tenodesis (CPT code 23430) on the same date.

Patient age at the time of index surgery and patient sex were collected for each group. The Charlson Comorbidity Index (CCI) was also available for each individual in the group, as calculated by diagnostic codes within the database. The occurrence of a repeated shoulder arthroscopy procedure on the same shoulder was determined at the following time points: 30 days, 90 days, 6 months, 1 year, and any time point. Reoperation procedures consisted of the CPT codes in Table I, as well as CPT codes 29828 and 23430 to include both arthroscopic and open biceps tenodesis procedures. The occurrence of complications within 30 days after the shoulder arthroscopy procedures was also determined using *International Classification of Diseases, Ninth Revision* diagnostic codes (Supplementary Table S1). These complications included capsulitis, urinary tract infection (UTI), dislocation, acute kidney injury, surgical-site infection, hematoma, deep vein thrombosis, cardiac arrest, wound dehiscence, and nerve injury.[15]

Statistical analysis

We used χ^2 analyses to compare patient demographic characteristics, reoperation rates, and complication rates. One-way analysis of variance and the Tukey HSD (honestly significant difference) post hoc test were used to compare CCI values for the 3 groups. Multivariate logistic regression was used to evaluate reoperation rates between patients with and without biceps treatment, controlling for differences in age, sex proportion, and medical comorbidities (CCI) between groups. Regression data are presented as odds ratios (ORs) with 95% confidence intervals (CIs). All statistical analysis were 2 tailed with an α value of .05 defined as significant.

Results

We identified 62,461 patients in the database who underwent shoulder arthroscopy between 2007 and 2017 and had records of laterality. Group 1 included 51,773 of these patients (median age, 60-64 years) who underwent shoulder arthroscopy (CPT codes

Table I
CPT codes used to denote patients who underwent shoulder arthroscopic procedures

CPT code	Procedure	No tenodesis (n = 51,773)		Arthroscopic tenodesis (n = 7134)		Open tenodesis (n = 3554)	
		n	% of initial operations	n	% of initial operations	n	% of initial operations
29805	Arthroscopic shoulder diagnostic procedure with or without synovial biopsy (separate procedure)	338	0.7	<11	<0.1	23	0.6
29806	Arthroscopic shoulder surgery with capsulorrhaphy	3442	6.6	151	2.1	96	2.7
29807	Arthroscopic shoulder surgery with repair of SLAP lesion	4332	8.4	479	6.7	272	7.7
29819	Arthroscopic shoulder surgery with removal of loose body or foreign body	682	1.3	87	1.2	27	0.8
29820	Arthroscopic shoulder surgery with partial synovectomy	448	0.9	21	0.3	29	0.8
29821	Arthroscopic shoulder surgery with complete synovectomy	419	0.8	89	1.2	27	0.8
29822	Arthroscopic shoulder surgery with limited débridement	5543	10.7	277	3.9	507	14.3
29823	Arthroscopic shoulder surgery with extensive débridement	7855	15.2	805	11.3	587	16.5
29824	Arthroscopic shoulder surgery with distal claviculectomy including distal articular surface (Mumford procedure)	13,826	26.7	2235	31.3	968	27.2
29825	Arthroscopic shoulder surgery with lysis and resection of adhesions with or without manipulation	1105	2.1	51	0.7	18	0.5
29826	Arthroscopic shoulder surgery with decompression of subacromial space with partial acromioplasty with or without coracoacromial release	29,324	56.6	4765	66.8	1911	53.8
29827	Arthroscopic shoulder surgery with rotator cuff repair	24,826	48.0	5150	72.2	1626	45.8

CPT, Current Procedural Terminology; *SLAP*, superior labrum anterior-posterior.
The number of initial operations is broken down by CPT code. The percentage of initial operations is calculated using the total patient population, as a patient may have multiple CPT codes for 1 operation.

Table II
Demographic characteristics of patients who underwent arthroscopic shoulder surgery between 2007 and 2017 including median age and sex

	No tenodesis	Arthroscopic tenodesis	Open tenodesis	*P* value		
				Arthroscopic vs. no tenodesis	Open vs. no tenodesis	Arthroscopic vs. open
Patient population	51,773	7134	3554			
Sex, n (%)						
Male	27,465 (53.0)	4102 (57.5)	2341 (65.9)	<.001*	<.001*	<.0001*
Female	24,309 (47.0)	3032 (42.5)	1213 (34.1)	<.001*	<.001*	<.001*
Median age, yr	60-64	65-69	60-64			
CCI, mean ± SD	1.4 ± 2.1	1.5 ± 2.1	1.2 ± 1.9	.002*	<.001*	<.001*

SD, standard deviation; *CCI*, Charlson Comorbidity Index.
Patients were separated according to whether they underwent shoulder arthroscopy without biceps tenodesis, shoulder arthroscopy and concomitant arthroscopic biceps tenodesis, or shoulder arthroscopy and concomitant open biceps tenodesis.
* Statistically significant ($P \leq .05$).

listed in Table I) without LHB tenodesis, group 2 included 7134 patients (median age, 65-69 years) who underwent shoulder arthroscopy and concomitant arthroscopic biceps tenodesis, and group 3 consisted of 3554 patients (median age, 60-64 years) who received shoulder arthroscopy and concomitant open biceps tenodesis (Table II). Overall, 54.3% of patients receiving shoulder arthroscopy were male patients. The CCI was significantly higher in the arthroscopic tenodesis group than in the other 2 cohorts (Table II). Arthroscopic shoulder decompression (CPT code 29826) was the most common procedure in both group 1 (56.6%) and group 3 (53.8%). Arthroscopic rotator cuff repair (CPT code 29727) was the most common procedure (72.2%) in group 2 patients (Table I).

In total, 3134 patients (5.0%) underwent a reoperation procedure for shoulder arthroscopy. The majority of reoperations occurred less than 1 year after initial surgery. Unadjusted data indicated that there was no significant difference in reoperation rates between any groups at 30 days, 90 days, 6 months, 1 year, and overall (Table III). Two percent of patients in group 2 underwent an arthroscopic tenodesis reoperation, and 2.5% of patients in group 3 underwent an open tenodesis reoperation (Table IV). In addition, when unadjusted reoperation rates were broken down by CPT code, only CPT code 29826 (arthroscopic shoulder decompression of subacromial space) demonstrated a significantly higher reoperation rate in the arthroscopic tenodesis group vs. no tenodesis ($P = .05$) and open tenodesis ($P = .02$) (Table IV). However, within the regression model adjusted for age, sex, and CCI, the biceps intervention groups (groups 2 and 3) demonstrated a significantly higher overall reoperation rate (OR, 1.3 [95% CI, 1.2-1.5]; $P < .001$) (Table V). No significant difference in adjusted reoperation rates was found between male and female patients (OR, 0.96 [95% CI, 0.88-1.03]) (Table V).

The most common complications in patients in all groups were capsulitis, UTI, and dislocation (Table VI). Shoulder arthroscopy patients who did not undergo tenodesis had higher overall complication rates than both the arthroscopic tenodesis ($P < .001$) and open tenodesis ($P < .001$) groups, with capsulitis ($P = .003$, arthroscopic; $P = .003$, open), UTI ($P = .003$, arthroscopic; $P = .05$, open), and dislocation ($P < .001$, arthroscopic; $P = .04$, open) reaching significance (Table VI). Shoulder arthroscopy patients who underwent concomitant arthroscopic tenodesis did not have significant differences in complication rates compared with patients undergoing concomitant open tenodesis. After adjustment for age, sex, and CCI differences, patients undergoing arthroscopic or open tenodesis had lower overall complication rates vs. those not undergoing tenodesis (OR, 0.82 [95% CI, 0.79-0.86]; $P < .001$) (Table V). Male patients also has significantly lower overall adjusted complication rates vs. female patients (OR, 0.51 [95% CI, 0.49-0.53]; $P < .001$) (Table V).

Discussion

The purpose of this study was to report reoperation and complication rates between shoulder arthroscopy patients with and without concomitant biceps tenodesis. After controlling for age, sex, and CCI, we found a significantly increased reoperation rate in those undergoing biceps tenodesis. In both the unadjusted and adjusted data, significantly increased complications rates were found in patients without tenodesis. This information can be used by patients and health care providers to allow for a more robust informed decision-making process in deciding how to treat LHB tendon pathology.

Our study compares complication and reoperation rates for a cohort of patients undergoing any type of shoulder arthroscopy with and without concomitant biceps tenodesis. Erickson et al[15] investigated reoperation rates in patients undergoing arthroscopic rotator cuff repair with and without biceps tenodesis. They reported that more patients underwent reoperation if they had a biceps tenodesis (arthroscopic or open) performed compared with those patients who did not have a tenodesis performed with their rotator cuff repair. In addition, Erickson et al found differences in several complications among the groups. These findings are in agreement with our results, as we found that adjusted reoperation rates were higher in patients undergoing biceps tenodesis.

Although biceps tenodesis is often performed with rotator cuff repair, it is also performed with other procedures including intra-

Table III
Comparison of reoperation rates at different time points in patients who underwent shoulder arthroscopy with and without concomitant arthroscopic or open biceps tenodesis

Time	No tenodesis		Arthroscopic tenodesis		Open tenodesis		*P* value		
	No. of reoperations	%	No. of reoperations	%	No. of reoperations	%	Arthroscopic vs. no tenodesis	Open vs. no tenodesis	Arthroscopic vs. open
<30 d	546	1.1	75	1.1	29	0.8	.98	.17	.24
<90 d	1253	2.4	166	2.3	81	2.3	.63	.6	.88
<6 mo	1632	3.2	218	3.1	109	3.1	.66	.78	.97
<1 yr	2081	4.0	306	4.3	151	4.2	.28	.5	.92
Overall	2606	5.0	351	4.9	177	5.0	.68	.89	.89

Table IV
Comparison of unadjusted reoperation rates in patients broken down by each shoulder arthroscopy CPT code and whether they underwent concomitant arthroscopic or open biceps tenodesis

CPT code	No tenodesis		Arthroscopic tenodesis		Open tenodesis		*P* value		
	No. of reoperations	%	No. of reoperations	%	No. of reoperations	%	Arthroscopic vs. no tenodesis	Open vs. no tenodesis	Arthroscopic vs. open
29805	14	4.10	0	0.00	<11	—	—	—	—
29806	193	5.60	<11	—	<11	—	—	—	—
29807	265	6.10	26	5.40	17	6.30	.55	.93	.64
29819	29	4.30	<11	—	0	0.00	—	—	—
29820	29	6.50	0	0.00	<11	—	—	—	—
29821	19	4.50	<11	—	<11	—	—	—	—
29822	276	5.00	17	6.10	27	5.30	.39	.73	.64
29823	367	4.70	41	5.10	27	4.60	.59	.94	.67
29824	665	4.80	113	5.10	42	4.30	.62	.51	.39
29825	47	4.30	<11	—	<11	—	—	—	—
29826	1348	4.60	250	5.20	75	3.90	.05*	.17	.02*
29827	1261	5.10	267	5.20	81	5.00	.75	.86	.75
29828	24	†	142	2.00	<11	†	—	—	—
23430	24	†	28	†	90	2.50	—	—	—

CPT, Current Procedural Terminology.
Reoperation percentages were calculated using the total number of procedures for each CPT code as the denominator.
* Statistically significant ($P \leq .05$).
† No percentages are listed because these cohorts did not undergo these procedures initially.

articular débridement, subacromial decompression, and labral repair.[5,10,12,14,35,37,43,45] Because of this, we included any arthroscopic shoulder procedure in our patient population to encompass all potential patients undergoing biceps procedures. In our investigation, rotator cuff repair patients represented less than half of all patients included in the study. Thousands of patients who did not undergo rotator cuff repair but who underwent biceps tendon procedures would not have been captured if only rotator cuff repair patients were examined. We also only included patients for whom laterality information was available to be able to capture reoperations on the same index shoulder.

When adjusting for confounding factors, our study found an increased reoperation rate in patients undergoing biceps tenodesis. Although we statistically controlled for any potential age differences between the groups, it is possible that older patients were more likely to undergo no biceps treatment or undergo simple tenotomy, which would be classified within the non-tenodesis group. This is borne out in our baseline data as patients in the non-tenodesis group tended to be older, to be female patients, and to have a higher CCI, particularly vs. the open tenodesis group. Older patients may be less likely to undergo reoperation because of decreased activity levels—in so much as the demands placed on their shoulders are lower, and therefore, they have a higher chance of satisfaction with their current level of function. Furthermore, it is reasonable to conclude that some reoperations were for failed biceps tenodesis procedures. The non-tenodesis group would not be subject to this potential complication; therefore, this also could have contributed to the lower overall reoperation rate in this group. In addition, we found that CPT code 29826 was associated with a higher reoperation rate in the arthroscopic tenodesis group vs. both the non-tenodesis group and the open tenodesis group. A potential reason for this may include a steeper learning curve with the arthroscopic technique resulting in less anatomic and/or less stable fixation, leading to increased failure and reoperation rates.

In contrast to the reoperation rate, the biceps tenodesis groups had lower complication rates after adjustment for confounding factors within the regression model. In particular, the non-tenodesis group had a higher incidence of postoperative capsulitis, UTI, and dislocation. Older patients with increased medical complications, such as diabetes, may be more likely to experience capsulitis and UTI postoperatively. In addition, a significantly larger proportion of female patients were present in the non-tenodesis group vs. the other 2 groups. As we know that female patients are more likely to experience capsulitis-type pathology such as frozen shoulder,[33] this factor may have contributed to the overall increased complication rates seen in the non-tenodesis group. Only a randomized trial consisting of tenodesis vs. no-tenodesis patients who are evenly matched for age, sex, activity level, and concomitant procedures can truly parse out the differences in outcomes that were found in this investigation.

There are many ways to approach management of LHB tendon pathology. Two well-established surgical options are biceps tenotomy and tenodesis.[16–20,24] Many studies have shown no difference in clinical outcomes between tenotomy and tenodesis, with both procedures providing improved patient outcomes.[17,24,27,30] Tenotomy is a straightforward procedure that provides pain relief and requires minimal postoperative rehabilitation.[17,31] However, tenotomy has been shown to have higher incidences of brachial biceps muscle cramping, decreased elbow flexion and supination strength, and biceps tendon retraction, which can result in a cosmetic deformity.[18,21,31] As a result, tenotomy is usually preferred in older and less active individuals.[1,31]

Biceps tenodesis is another surgical technique that provides LHB tendon pain relief with maintenance of length-tension relationships and results in a lower incidence of cosmetic deformity.[1,26] Tenodesis is more technically demanding, is a longer procedure, and requires a greater recovery time than tenotomy.[22] However, the option of tenodesis has been advocated in younger and more active

Table V
Adjusted ORs for total complication and reoperation rates after multivariate regression analysis controlling for age, sex, and CCI

	Tenodesis multivariate analysis		Male vs. female multivariate analysis	
	OR (95% CI)	*P* value*	OR (95% CI)	*P* value†
30-d complication rate	0.82 (0.79-0.86)	<.001‡	0.51 (0.49-0.53)	<.001‡
Total reoperation rate	1.3 (1.2-1.5)	<.001‡	0.96 (0.88-1.03)	.558

CCI, Charlson Comorbidity Index; *OR*, odds ratio.
* No tenodesis was used as a reference.
† Male sex was used as a reference.
‡ Statistically significant ($P \leq .05$).

Table VI
Comparison of unadjusted complication rates in patients who underwent shoulder arthroscopy with and without concomitant arthroscopic or open biceps tenodesis

Complication	No tenodesis		Arthroscopic tenodesis		Open tenodesis		*P* value		
	n	%	n	%	n	%	Arthroscopic vs. no tenodesis	Open vs. no tenodesis	Arthroscopic vs. open
Total	5356	10.35	588	8.24	297	8.36	<.001*	<.001*	.84
Capsulitis	4060	7.84	489	6.85	230	6.47	.003*	.003*	.46
UTI	589	1.14	54	0.76	28	0.79	.003*	.05*	.86
Dislocation	483	0.93	28	0.39	21	0.59	<.001*	.04*	.15
AKI	183	0.35	15	0.21	14	0.39	.05*	.7	.09
Surgical-site infection	130	0.25	<11	<0.15	<11	<0.31	—	—	—
Hematoma	43	0.08	<11	<0.15	<11	<0.31	—	—	—
DVT or PE	34	0.07	<11	<0.15	0	0.00	—	—	—
Cardiac arrest	21	0.04	<11	<0.15	<11	<0.31	—	—	—
Wound dehiscence	18	0.03	0	0.00	<11	<0.31	—	—	—
Nerve injury	11	0.02	<11	<0.15	0	0.00	—	—	—

UTI, urinary tract infection; *AKI*, acute kidney injury; *DVT*, deep vein thrombosis; *PE*, pulmonary embolism.
* Statistically significant ($P \leq .05$).

patients and in patients who wish to avoid a cosmetic deformity.[4,23,36] The open subpectoral approach and the arthroscopic suprapectoral approach are the 2 most common techniques to reattach the biceps tendon distal to the bicipital groove.[23,26] Biceps tenodesis procedures have increased in incidence over the years, with arthroscopic tenodesis outpacing the frequency of open tenodesis.[43]

A systematic review by Abraham et al[1] comparing arthroscopic vs. open tenodesis revealed that 98% of patients in both groups reported good or excellent results. In addition, a 2% complication rate was found in both tenodesis groups. Abraham et al concluded that both methods of tenodesis could be recommended to patients with LHB tendon disorders. Gombera et al[23] reached a similar conclusion when comparing arthroscopic and open tenodesis in the short term but advocated further studies using longer follow-up to aid in differentiation of potential long-term differences between the 2 procedures.

There are limitations to both tenodesis procedures. Arthroscopic tenodesis places the biceps tendon closer to the bicipital groove compared with an open subpectoral approach.[26] Persistent pain after arthroscopic tenodesis may result if part of the tendon remains in the bicipital groove.[32,38] In addition, Werner et al[44] found an increased incidence of postoperative stiffness after arthroscopic tenodesis compared with open tenodesis but noted that the stiffness typically improved with time. The open approach to biceps tenodesis requires a larger incision, leading to an increased risk of complications including nerve injury and infection.[13,25] There have also been reports of proximal humeral fractures after subpectoral tenodesis.[26]

Limitations

The national database used in our study is a well-known database and has been used in many other investigations.[2,8,43,46] It includes a large number of patients with shoulder arthroscopy and/or biceps tenodesis procedures but also has several limitations. As with all studies using insurance claims data, the quality of results depends on the accuracy of diagnosis and procedure reporting. Data before 2007 were not available. In addition, the database does not include the entire population of the United States, and exclusion of Medicare patients also limited our available claims population. However, the Medicare patient population is older and less representative of the general patient population undergoing shoulder arthroscopy. Furthermore, individual patient-level data are not available, and comparisons between groups with fewer than 11 patients cannot be made because the database does not report the exact number of patients in these cases owing to patient privacy. Therefore, we could not compare complications related to surgical-site infection or nerve injury because of the low patient counts. In addition, there is no CPT code for tenotomy, so the patient population in our study that did not undergo tenodesis (group 1) also included patients who underwent tenotomy, and we were unable to compare the results of tenotomy vs. tenodesis. Finally, we were unable to determine specific patient symptoms and clinical outcomes before and after the procedures.

Conclusion

Reoperation rates were significantly higher in patients undergoing shoulder arthroscopy with biceps tenodesis than in patients undergoing shoulder arthroscopy without biceps tenodesis. Both the arthroscopic and open tenodesis groups had significantly lower complication rates compared with no tenodesis.

Disclaimer

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Supplementary data

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