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

Michelle Xiao, BS a, Geoffrey D. Abrams, MD a,b,*

a Department of Orthopedic Surgery, Stanford University School of Medicine, Stanford, CA, USA
b Veterans Administration, Palo Alto, CA, USA

ARTICLE INFO

Keywords:
Biceps
tenodesis
tenotomy
shoulder
arthroscopy
complication

Level of evidence: Level III; Retrospective Cohort Design Using Large Database; Treatment Study

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.

© 2019 The Authors. Published by Elsevier Inc. on behalf of American Shoulder and Elbow Surgeons. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
with concomitant arthroscopic or open tenodesis compared with rotator cuff repairs performed with no tenodesis. Because LHB tendon pathology can occur in non—rotator cuff shoulder disorders, the purpose of this study was to determine 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 1) 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 1, 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.

Statistical analysis

We used χ² 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

| CPT code | Procedure | No tenodesis (n = 51,773) | Arthroscopic tenodesis (n = 7134) | Open tenodesis (n = 3554) |
|----------|-----------|--------------------------|-------------------------------|--------------------------|
| 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 debridement | 5543 10.7 | 277 3.9 | 507 14.3 |
| 29823    | Arthroscopic shoulder surgery with extensive debridement | 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 coracocromial 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.
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).

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

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

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 |
|-------|--------------|------------------------|----------------|---------|
| <30 d | 546          | 1.1 75                 | 0.8 29         | .98     |
| <90 d | 1253         | 2.4 166                | 2.3 81         | .63     |
| <6 mo | 1632         | 3.2 218                | 3.1 109        | .66     |
| <1 yr | 2081         | 4.0 306                | 4.3 151        | .48     |
| Overall | 2606       | 5.0 351                | 4.9 177        | .68     |

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 ≤ .05).
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 tenotomy. 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-tenotomy group. This is borne out in our baseline data as patients in the non-tenotomy group tended to be older, to be female patients, and to have a higher CCI, particularly vs. the open tenotomy 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 tenotomy procedures. The non-tenotomy 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-tenotomy group and the open tenotomy 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-tenotomy 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-tenotomy group vs. the other 2 groups. As we know that female patients are more likely to experience capsulitis-type pathology such as frozen shoulder, this factor may have contributed to the overall increased complication rates seen in the non-tenotomy group. Only a randomized trial consisting of tenodesis vs. no-tenotomy 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.17,24,37,43 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.26 However, the option of tenodesis has been advocated in younger and more active

| 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 tenotomy | Arthroscopic tenodesis | Open tenotomy | P value |
| --- | --- | --- | --- | --- |
| | No. of reoperations | % | No. of reoperations | % | No. of reoperations | % | Arthroscopic vs. no tenotomy | Open vs. no tenotomy | 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 | .30 | .30 | .30 |
| 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 | 1 | 142 | 2.00 | <11 | — | — | — | — |
| 23430 | 24 | 1 | 28 | 90 | 2.50 | — | — | — | — |

---

| 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 | 0.82 (0.79-0.86) | <.001* | 0.51 (0.49-0.53) | <.001* |
| Total reoperation | 1.3 (1.2-1.5) | <.001* | 0.96 (0.88-1.03) | .558 |

CCI, Charlson Comorbidity Index; OR, odds ratio.

* No tenotomy was used as a reference.

† Male sex was used as a reference.

‡ Statistically significant (P ≤ .05).
patients and in patients who wish to avoid a cosmetic deformity.2,23,36 The open subpectoral approach and the arthroscopic supraperichoral approach are the 2 most common techniques to reattach the biceps tendon distal to the bicipital groove.23,28 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 al1 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 al23 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.12,32 In addition, Werner et al34 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.12,25 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

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2019.08.002.

References

1. Abraham VT, Tan BH, Kumar VP. Systematic review of biceps tenodesis: arthroscopic versus open. Arthroscopy 2016;32:365–71. https://doi.org/10.1016/j.arthro.2015.07.028.
2. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. Am J Sports Med 2013;41:2333–9. https://doi.org/10.1177/0363546513495641.
3. Ahmad CS, ElAttrache NS. Arthroscopic biceps tenodesis. Orthop Clin North Am 2003;34:499–506.
4. Ahrens PM, Boileau P. The long head of biceps and associated tendinopathy. J Bone Joint Surg Br 2007;89:1001–9. https://doi.org/10.1302/0301-620X.89B8.
5. Anthony SG, McCormick F, Gross DJ, Golijanin P, Provencher MT. Biceps tenodesis for long head of the biceps after auto-rupture or failed surgical tenotomy: results in an active population. J Shoulder Elbow Surg 2015;24:406–10. https://doi.org/10.1016/j.jse.2014.06.031.
6. Bergemund H, Lundgarde F, Nilsson P, Petersson CJ. Shoulder pain in middle age. A study of prevalence and relation to occupational work load and psychosocial factors. Clin Orthop Relat Res 1988:234–8.
