

Patient Satisfaction After Biceps Tenotomy

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Background: Biceps tenotomy and tenodesis are frequently performed for proximal biceps lesions; however, there continues to be debate as to which method is superior. This study examined patient-reported outcomes after biceps tenotomy.

Hypothesis: Biceps tenotomy in the setting of concomitant shoulder pathology is a reasonable option with high satisfaction rates and a low incidence of pain and cramping in middle-aged to older individuals.

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

Methods: A total of 104 patients (mean age, 63.5 years; range, 40-81 years) were evaluated at the time of surgery and at a mean follow-up of 38.4 months (range, 22-57 months). Biceps tenotomy was performed as a component of more extensive shoulder surgery in all patients. Patient satisfaction, frequency of cramping and spasms, biceps pain, weakness, and cosmetic deformity were evaluated at over 1-year follow-up.

Results: Ninety-one percent of patients were satisfied or very satisfied with their surgical outcome, and 95% would have their surgery again. Three patients who reported being unsatisfied or very unsatisfied had either advanced glenohumeral arthritis or an irreparable rotator cuff tear. Cosmetic deformity occurred in 13% of patients. Twenty percent reported spasms and cramping in their biceps, and 19% reported some biceps pain; however, frequency of spasms and cramping was typically once weekly, and biceps pain was reported as severe or very severe in only 2 patients. Subjective biceps weakness was reported in 17% of patients. Age had no effect on outcome measures, and female sex was associated with less limitation and greater satisfaction after tenotomy compared with men.

Conclusion: Our results indicate that patient-reported downsides to biceps tenotomy were usually mild and/or infrequent and did not affect patient satisfaction. We conclude that biceps tenotomy is a viable option that can lead to a high rate of patient satisfaction and outcomes in middle-aged to older individuals undergoing shoulder surgery with biceps pathology.

Keywords: tenotomy; tenodesis; shoulder arthroscopy; biceps tendon

Pathology involving the long head of the biceps brachii tendon (LHBBT) is a common cause of shoulder pain.^{4,22,23,24,29}

Although isolated biceps tendinopathy, tearing, and tenosynovitis is reported, these conditions often coexist in the setting of other shoulder pathology such as rotator cuff disease.^{8,30} Partial, complete, and massive rotator cuff tears are often associated with lesions of the LHBBT, especially

in elderly patients.^{1,3,25} In a study of 122 patients with complete rotator cuff tears, Chen et al² found that 76% of them had associated LHBBT pathology. Thus, surgical treatment of the LHBBT is commonly performed during the repair of what is considered the primary shoulder pathology. Traditional operative procedures to address LHBBT lesions include debridement, biceps tenotomy, and tenodesis.

Currently, there is debate surrounding tenotomy versus tenodesis in the treatment of symptomatic LHBBT pathology. Both are potentially viable options with inherent risks and benefits. The major benefit of tenotomy is technical ease and expedited surgery, especially in the setting of concomitant procedures. Additionally, any risks associated with the specific tenodesis technique can be avoided. Also, unless there is a reason to protect concomitant procedures postoperatively, recovery can be fairly rapid. Downsides of tenotomy include the potential for the cosmetic deformity called a Popeye sign, pain as the result of cramping or spasm, and weakness.^{3,5,7,11,16,24} Advantages of tenodesis include closer approximation of the normal muscle-tendon length, which can minimize the Popeye sign (cosmesis) and cramping pain, as well as potentially improved ability to return to physical activity requiring biceps force.^{11,14,24,27,28}

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Ethical approval for this study was obtained from Eastern Virginia Medical School (IRB# 13-05-EX-0124).

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On the other hand, the downsides of tenodesis include longer healing times, implant costs, postoperative stiffness, persistent pain, and risks of subsequent failure, fracture, and neurovascular injury.^{12,19,20,21,28} Selection criteria for each procedure are often driven by a surgeon's personal algorithm and experience as well as the age, activity level, and desires of the patient.

The purpose of this study was to evaluate patient-reported results, complaints, and satisfaction after biceps tenotomy in middle-aged to older individuals with over 1-year follow-up. Our hypothesis was that biceps tenotomy in the setting of concomitant shoulder pathology is a reasonable option with high satisfaction rates and a low incidence of pain and cramping in middle-aged to older individuals. We also tested for the effects of age and sex on outcomes, working from the hypotheses that neither age nor sex would have any significant effect on any of the outcome variables.

METHODS

Institutional review board approval was obtained from Eastern Virginia Medical School prior to the start of the study. Over a 2-year period, the senior author (K.F.B.) performed a total of 126 arthroscopic biceps tenotomies, all with concomitant procedures. At over 1-year follow-up, 3 patients were deceased, and contact was attempted for the remaining 123 patients. Patients who were successfully contacted and consented to participate in the study answered a survey (Appendix) regarding the outcome and satisfaction of their surgery. The effect of age on level of satisfaction was tested using 1-way analysis of variance, and 2-sample *t* tests were used to test for differences in the age distributions of patients answering "yes" versus "no" to the remaining survey questions. A Wilcoxon-Mann-Whitney test was used to compare average satisfaction scores between men and women, and Fisher exact tests were used to test for differences in the sex distributions of patients answering "yes" versus "no" to the remaining survey questions. After testing the primary hypotheses on the effects of age and sex, we also conducted a post hoc analysis within the male patients, using a Wilcoxon-Mann-Whitney test to compare average satisfaction scores between patients answering "yes" versus "no" to the survey question on limitation.

RESULTS

Of the 123 patients who were eligible for study inclusion, 104 patients (85%) completed the follow-up evaluation. Seventeen patients were lost to follow-up, and 2 patients declined to participate in the study. The average patient age at the time of surgery was 63.5 ± 8.6 years, with a range of 40 to 81 years. Seven patients were aged 40 to 49 years, 20 patients were aged 50 to 59 years, 53 patients were aged 60 to 69 years, 21 patients were aged 70 to 79 years, and 3 patients were 80 years or older. Average follow-up was 38.4 months, with a range of 22 to 57 months. Varying degrees of

TABLE 1
Demographic Information

Patients, n	104
Age, y, mean (range)	63.5 (40-81)
Time since operation, mo, mean (range)	38.4 (22-57)
Surgical side, n (%)	
Left	33 (32)
Right	71 (68)
Sex, n (%)	
Male	48 (46)
Female	56 (54)

TABLE 2
Concomitant Procedures^a

Procedure Type Combined With Tenotomy	Patients, n (%)
Arthroscopic rotator cuff repair/SAD	64 (61)
Debridement of partial rotator cuff tear/SAD	30 (29)
AC joint resection	8 (8)
Debridement of an irreparable massive rotator cuff tear	2 (2)

^aAC, acromioclavicular; SAD, subacromial decompression.

glenohumeral arthritis were found in 27% of patients during arthroscopy by the senior author. Demographic information is reported in Table 1. Concomitant procedures included arthroscopic rotator cuff repair with subacromial decompression (61%), debridement of a partial rotator cuff tear with subacromial decompression (29%), acromioclavicular joint resection (8%), and debridement of an irreparable massive rotator cuff tear (2%) (Table 2).

Ninety-one percent of patients (95 of 104) were either satisfied or very satisfied with the outcome of their surgery (Figure 1A). This is compared with a total of 3% of patients (3 of 104) who were either unsatisfied or very unsatisfied with their surgery outcome. Two of the 3 patients who were unsatisfied or very unsatisfied had advanced glenohumeral arthritis, and the other patient had debridement of an irreparable massive rotator cuff tear as their concomitant procedure. Age had no effect on patient satisfaction ($P = .40$), but satisfaction scores were significantly lower in men than in women (4.4 ± 0.9 vs 4.8 ± 0.5 , respectively; $P < .01$).

Ninety-five percent of patients said they would have the surgery again (Figure 1B). Of the 5% (5 of 104) who would not elect to have the surgery again, 3 patients were those who were unsatisfied or very unsatisfied with their surgical outcome. Additionally, of the 2 remaining patients in this group, 1 had an irreparable massive rotator cuff repair.

Twenty percent of patients (21 of 104) reported some spasms or cramping in their biceps muscle. Of these patients, 12 reported spasms or cramping occurring approximately once per week. Nine patients reported cramping 5 or more times per week (Figure 2A). There were no differences in the distributions of age ($P = .28$) or sex ($P = .22$) in patients with and without biceps spasms or cramping.

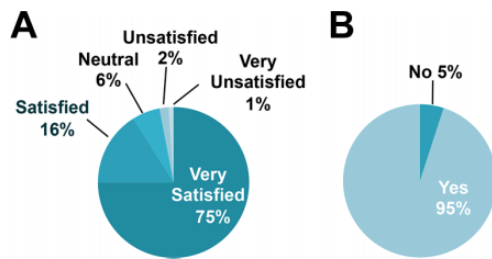


Figure 1. Patient-reported satisfaction after biceps tenotomy and concomitant procedure. (A) Percentage of patients reporting satisfaction. (B) Percentage of patients reporting they would have the same surgery again.

Nineteen percent of patients (20 of 104) reported pain in their biceps muscle. Only 2 of these patients reported the pain as being either severe or very severe (Figure 2B). Both these patients also had the presence of advanced glenohumeral arthritis. There were no differences in the distributions of age ($P = .67$) or sex ($P = .32$) in patients with and without biceps pain.

Thirty-six percent of patients (37 of 104) reported that they did have at least some pain in their shoulder postoperatively. Ten percent (10 of 104) reported very minimal pain, 5% (5 of 104) had minimal pain, and 13% (14 of 104) had moderate pain, while 8% (8 of 104) reported severe to very severe shoulder pain (Figure 2C). Eighty-four percent of patients reporting shoulder pain (31 of 37) were satisfied or very satisfied with the outcome of their surgery, and 5% (2 of 37) were unsatisfied or very unsatisfied. Eighty-nine percent of patients reporting shoulder pain (33 of 37) would have their surgery again. Rotator cuff repairs were performed in 65% of patients with shoulder pain (24 of 37), and glenohumeral arthritis was noted in 38% (14 of 37). In patients with severe to very severe shoulder pain, glenohumeral arthritis was seen in 4 of 8 patients, with severity ranging from mild (1 patient) to moderate (1 patient) and advanced (2 patients). There were no differences in the distributions of age ($P = .75$) or sex ($P = .41$) in patients with versus without shoulder pain.

Seventeen percent of patients (18 of 104) reported weakness with specific activities. One had debridement of an irreparable massive rotator cuff tear, and 12 had rotator cuff repairs. We did not assess the integrity of the repair within this study. Eight patients had glenohumeral arthritis ranging from mild to advanced. The most common activities these patients reported having trouble with were using a screwdriver (10 patients) and opening a can (10 patients). Only 2 patients reported weakness with elbow flexion (Figure 2D). Eleven percent of the patients (11 of 104) reported their daily activity was limited by their biceps tenotomy; 4 of these patients had advanced glenohumeral arthritis. Additionally, only 1 patient reported the limitation as being severe (Figure 2E). Patient age did not influence weakness ($P = .93$) or limitations ($P = .87$), and patient sex had no influence on weakness ($P = .99$). There was, however, a significant effect of sex on limitations ($P = .04$): A greater proportion of patients answering “yes” were men (72%) compared with those answering “no” (49%).

Thirteen percent of all patients (14 of 104) reported a Popeye sign, with 2 of the 14 patients saying that it bothered them cosmetically (Figure 2F). There were no differences in the distributions of age ($P = .10$) or sex ($P = .28$) in patients with versus without the cosmetic burden of the deformity.

Of the patients in the 40- to 49-year age group, 100% (7 out of 7) were satisfied or very satisfied and 100% would have their surgery again. Only 1 patient in this group had a Popeye sign and was not bothered by it.

Because men reported significantly lower satisfaction scores and were also more likely to report limitations, we explored whether there was a link between limitation and satisfaction within the male patients. Comparing average satisfaction scores, we found that the 9 men who reported limitations also tended to report significantly lower satisfaction than the remaining male patients reporting no limitations (3.0 ± 1.1 vs 4.7 ± 0.5 ; $P < .01$).

DISCUSSION

Potential procedures for repair of the LHBBT pathology are biceps tenotomy and tenodesis. The allure of tenotomy is that it is quick, is simple to perform, is inexpensive, and requires minimal rehabilitation.²⁹ Surgeons must weigh a variety of factors when deciding between operative procedures for proximal biceps lesions. Patient-reported outcomes and satisfaction are important considerations when deciding between biceps tenotomy and tenodesis. The present study demonstrates a high level of patient-reported satisfaction with few downsides after biceps tenotomy in middle-aged to older individuals. In line with these results, many individuals in this demographic group do extremely well with non-operative treatment after proximal biceps ruptures.^{18,25,26}

The findings of our study reveal a 91% patient satisfaction rate, which is in agreement with other patient satisfaction tenotomy studies. Duff and Campbell⁵ looked at 117 patients and found 95% were satisfied or very satisfied with biceps tenotomy in a similarly aged patient population (mean age, 64 years). In a study of 307 shoulders with biceps tenotomies, Walch et al²⁶ found that 86% of patients rated their result as excellent or good. Additionally, Leroux et al¹⁵ found no significant differences in patient satisfaction in the setting of rotator cuff repair when comparing tenotomy versus tenodesis.

A systematic review by Slenker et al²⁴ found that of 699 patients who had undergone a biceps tenotomy, 77% had an excellent/good outcome. Moreover, 430 of those patients had a biceps tenotomy with concurrent rotator cuff disease, with 74% reporting an excellent/good outcome. In the setting of concomitant shoulder pathology, we found that biceps tenotomy results in a high rate of patient satisfaction, with the majority of patients (95%) saying they would have the procedure again.

Interestingly, only 3 patients were unsatisfied or very unsatisfied with their surgery. Two of these patients had advanced glenohumeral arthritis and the third had an irreparable rotator cuff tear, which may have contributed to their dissatisfaction. Although only observational,

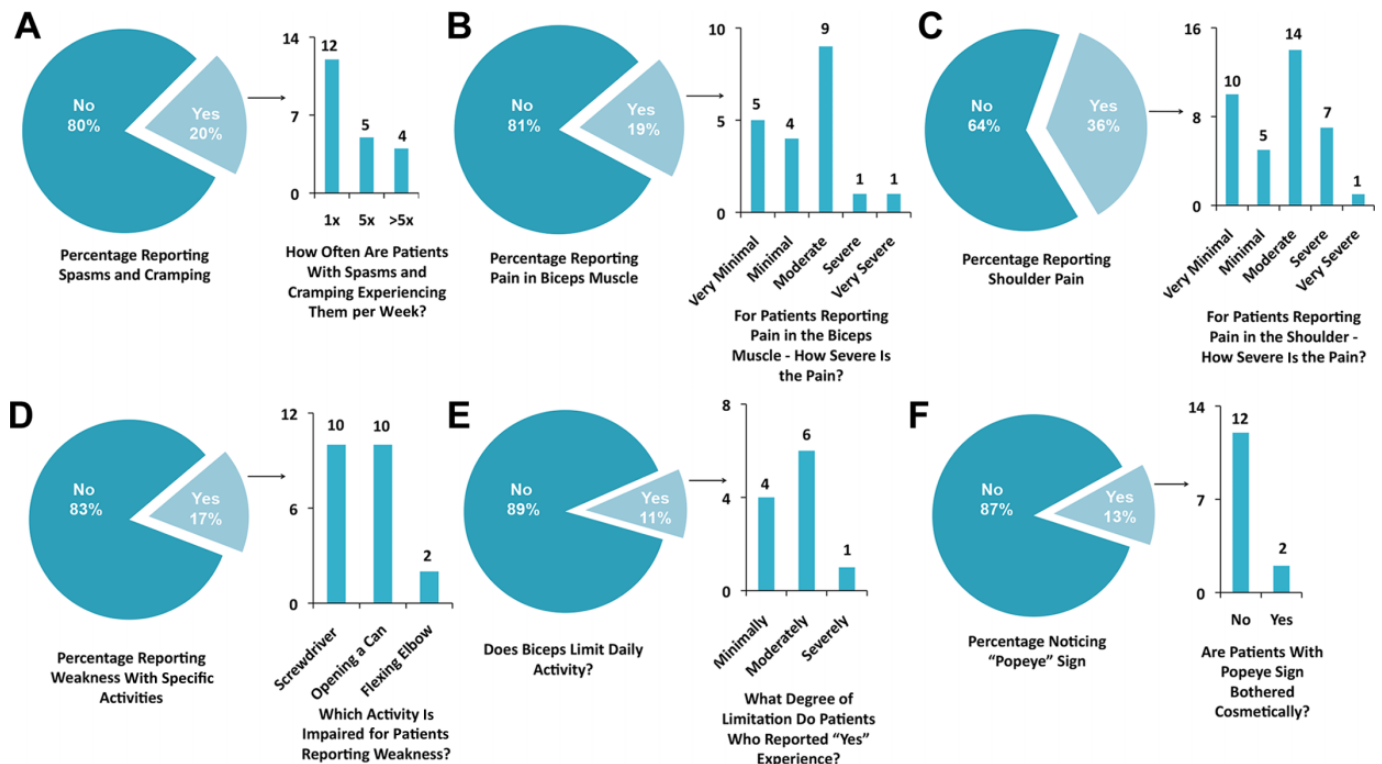


Figure 2. Patient-reported outcomes after biceps tenotomy and concomitant procedure. (A) Pie graph depicts percentage of patients reporting biceps spasms and cramping. Bar graph displays frequency for patients with biceps spasms and cramping. (B) Pie graph depicts percentage of patients reporting pain in the biceps muscle. Bar graph displays severity for those patients with biceps pain. (C) Pie graph depicts percentage of patients reporting shoulder pain. Bar graph displays severity for those patients with shoulder pain. (D) Pie graph depicts percentage of patients reporting weakness with specific activities. Bar graph displays which activity is impaired for patients reporting weakness. (E) Pie graph depicts percentage of patients who felt their biceps limited their daily activities. Bar graph displays severity for those that felt limited in daily activities. (F) Pie graph depicts percentage of patients noticing a Popeye sign. Bar graph displays whether patients were cosmetically bothered by a Popeye sign.

existing glenohumeral arthritis or having a concomitant irreparable rotator cuff tear may have negatively affected the results in some of our patients.

Female sex was associated with greater satisfaction in our cohort, and men who reported limitations from their biceps were more likely to be unsatisfied. This finding may be a result of societally influenced sex biases in the occupations or levels of physical activity of the patients rather than being due to a direct, physiological effect of biological sex on these postoperative outcomes. This possible explanation cannot, however, be resolved with the information from our questionnaire. To our knowledge, no other studies have reported sex-specific differences in patient-reported satisfaction. Thus, patient sex may be an important consideration when considering tenotomy for lesions of the LHBBT and overall satisfaction after surgery.

Biceps pain as a result of spasms and cramping is a potential downside of tenotomy. Cramping and cramp-like arm pain have been reported in anywhere from 8% to 40% of patients undergoing biceps tenotomy.^{5,16,18,29} However, studies have shown similar rates of cramping when comparing tenotomy versus tenodesis.^{5,6,14,15,18} Thus, performing the alternative technique of tenodesis may not obviate

this drawback. Additionally, biceps that are tenodesed via a variety of techniques may fail postoperatively despite our best efforts to optimize fixation.¹⁰

Biceps spasms and cramping were experienced by 20% of our patients, which is similar to another study reporting a rate of 19%.⁵ Biceps pain was experienced by 19% of our patients, with 2 patients (2%) reporting severe and very severe biceps pain. Very minimal or minimal biceps pain was experienced by 8.5% of patients, and 8.5% experienced moderate biceps pain.

Overall, we found that 36% of patients in our group had some degree of shoulder pain at latest follow-up. Despite this, there was a high rate of patient satisfaction and percentage of patients who, if given the choice, would choose to have the surgery performed again. Most of our patients who had shoulder pain described it as minimal to moderate, with only 8 patients (8%) reporting severe to very severe shoulder pain. It is likely this reported pain is multifactorial given concomitant shoulder procedures and a spectrum of shoulder pathology severity. In fact, 65% of those reporting shoulder pain (24 of 37) had rotator cuff repairs and 38% (14 of 37) had existing glenohumeral arthritis.

In a study of 80 patients having biceps tenotomies in the setting of a more extensive shoulder procedure, Osbahr et al¹⁸ found approximately 62% of patients had anterior shoulder pain. However, these results were not statistically significant when compared with patients with anterior shoulder pain in the biceps tenodesis group.¹⁸ Eliminating shoulder pain is probably unrealistic for many patients in the setting of concomitant pathology and procedures, whether it be with tenodesis or tenotomy. Interestingly, the presence of shoulder pain did not appear to have much influence on patient satisfaction according to our results.

Weakness after biceps tenotomy is a concern for surgeons and patients. It has been reported that 20% of forearm supination strength and 8% to 20% of elbow flexion strength are lost after spontaneous rupture of the LHBBT, and thus weakness might be expected after tenotomy.¹⁷ The current literature is consistent with this expectation, with Kelly et al¹³ reporting a significant percentage of patients having fatigue and discomfort in their biceps muscle after resisted elbow flexion with tenotomy. Likewise, Lim et al¹⁶ found decreased elbow flexion strength compared with the contralateral side after tenotomy in 45% of patients. Although we did not objectively evaluate biceps strength in our study, we attempted to make the survey questions specific to biceps weakness. In our study, we found that 17% of patients reported weakness, which was lower than the rate of 31% found by Duff and Campbell⁵ in a similar study. Additionally, when asking patients about weakness with specific activities, 10 out of 18 reported weakness only when using a screwdriver or opening a can, and only 2 reported weakness with elbow flexion. However, tenodesis does not appear to ensure biceps strength preservation either, as some comparison studies have not found differences in weakness after tenotomy versus tenodesis.^{6,30} Additionally, high-level throwing athletes have anecdotally been reported to return to the professional level after tenotomy or spontaneous ruptures. Therefore, some weakness after tenotomy may be an acceptable downside in middle-aged to older individuals based on our patient-reported data and others.

Cosmetic deformity, or Popeye sign, has been reported in the literature as a drawback to biceps tenotomy. Percentage of deformity after biceps tenotomy has varied widely, with studies reporting rates between 3% and 70% and a majority reporting rates over 25%.^{4,5,9,13,14,16,18,29} Gill et al⁹ and De Carli et al³ found rates of Popeye sign at 3% and 17%, respectively; however, both studies only looked at 30 patients with tenotomy. Another study looked at a series of 77 tenotomy patients and found that 9.1% had a Popeye sign.³⁰ A recent review of 16 studies looked at 699 patients with tenotomy and found 43% of patients had a Popeye sign.²⁴ In the current study, 13% of the 104 patients had a Popeye sign. These results fall within the reported range; however, they are toward the lower end of what many would expect. As reported by other authors, possible explanations for low reported rates of Popeye sign include surgeon technique, longer periods of immobilization after surgery resulting in an autotenodesis phenomenon, and the higher average age of patients and consequent loss of muscle tone and definition.^{14,18,24,26,29,30} In our study, we

simply tenotomized the tendon at the insertion into the superior labrum, but we did not perform a technique specifically designed to avoid distal displacement of the tendon down the groove. Therefore, we do not feel our technique contributed to a relatively low rate of Popeye sign.

Some authors advocate tenotomy for patients older than 55 to 60 years, while tenodesis is preferred in patients younger than 50 years.^{7,11,14,24,27,30} One reason for this school of thought is that younger patients may be more concerned with the cosmesis of a Popeye sign, should it develop. In the current study, 7 tenotomies were performed on the “cosmetically concerned” demographic, age 40 to 49 years. Of note, all 7 were also offered tenodesis, which is typically the preferred treatment in this age group by the senior author, but for various reasons tenotomy was chosen. We found 100% of these patients were satisfied or very satisfied and 100% would have their surgery again. Only 1 patient in this group had a Popeye sign; however, the patient reported no cosmetic concern because of it. Another reason tenodesis is preferred in younger, more active patients is for strength preservation; yet, Friedman et al⁶ reported no differences in strength or outcomes in tenotomy versus tenodesis in active patients younger than 55 years. In the current study, 1 out of the 7 patients in the 40- to 49-year age group reported cramping, weakness with specific activities, and biceps muscle pain. It is difficult to draw conclusions from this group, as there were only 7 patients, but it seems that biceps tenotomy is reasonable in this age group based on our results, despite other authors' opinions. Likewise, when deciding between tenotomy versus tenodesis and considering the possibility of a Popeye sign, it is important to remember that many studies have found that patient complaints of deformity between tenodesis and tenotomy are similar.^{6,15,18,30}

Limitations

Proximal biceps lesions are usually seen in combination with more extensive shoulder pathology, which limits drawing specific conclusions about biceps tenotomy procedures.^{5,8,9,30} This is the case in our study, in which the concomitant pathology potentially influenced the perceived results that we wished to report. For instance, the presence of patient-reported shoulder pain may likely be due to the more extensive coexistent shoulder pathology, versus attributable to the tenotomy component. Therefore our results must be interpreted with caution, as the additional concomitant procedures may have influenced biceps tenotomy outcomes.

Many studies have evaluated outcomes after tenotomy via the use of a shoulder scoring system instead of a survey questionnaire.^{1,3,4,9,26} We attempted to create a more biceps-specific questionnaire to evaluate outcomes, although this has not been validated like other scoring systems and may represent an additional limitation to our study.

Finally, the decision to proceed with a tenotomy or tenodesis was based on the senior author's experience and personal algorithm, as well as patient wishes after discussion of surgical options. In addition to biceps tenotomy, the

senior author also performed a high volume of tenodesis procedures during this study period. Therefore, the patient cohort included in this study may not be representative of all patients in this age group.

CONCLUSION

We conclude that biceps tenotomy is a viable option in middle-aged to older individuals undergoing shoulder surgery with biceps pathology. The patients in this study had a high satisfaction rate of 91%, with 95% stating they would have their surgery again. Although the majority of patients did not have adverse outcomes, the most significant drawbacks in this cohort of patients included Popeye sign (13%), biceps muscle spasms and cramping, weakness, and pain in the biceps. However, when complications did occur, they seemed to be mild and/or infrequent and did not affect patient satisfaction.

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APPENDIX
Biceps Tenotomy Questionnaire

-
- Name:
Date of Birth:
Date of Shoulder Surgery:
Side: Right or Left
1. How would you rate your overall satisfaction with the surgery you had performed on your shoulder?
On a scale of 1-5:
1-Very unsatisfied, 2-Unsatisfied, 3-Neutral, 4-Satisfied, 5-Very satisfied
 2. Do you experience painful spasms or cramping in your biceps muscle?
Yes or No
If so how often per week?
1-More than five times per week, 2-Five times per week, 3-Once per week
 3. Do you have any pain in the biceps muscle area?
Yes or No
If yes,
On a scale of 1-5:
1-Very severe pain, 2-Severe pain, 3-Moderate pain, 4-Minimal pain, 5-Very minimal pain
 4. Do you have any shoulder pain?
Yes or No
If yes,
On a scale of 1-5:
1-Very severe pain, 2-Severe pain, 3-Moderate pain, 4-Minimal pain, 5-Very minimal pain
 5. Do you have any weakness flexing your elbow, opening a can, or using a screwdriver?
Yes or No
If yes,
Which one?
 6. Does your biceps limit any of your daily activities?
Yes or No
If yes, how limited are you?
1-Severely limited, 2-Moderately limited, 3-Minimally limited
 7. Do you notice a biceps muscle bulge ("Popeye sign")?
Yes or No
If yes, do you mind it from a cosmetic standpoint?
Yes or No
 8. If you could go back in time, would you have the surgery done again?
Yes or No
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