Open Compared with Arthroscopic Biceps Tenodesis

A Systematic Review

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Abstract

Background: Biceps tenodesis can be performed via an open or arthroscopic approach, and there is currently no consensus over which method is superior. The purpose of this study was to systematically review the cohort studies available in the literature to ascertain if open or arthroscopic techniques for biceps tenodesis result in superior clinical outcomes.

Methods: A systematic search of articles in MEDLINE, Embase, and the Cochrane Library databases was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Cohort studies comparing the open and arthroscopic techniques for biceps tenodesis were included.

Results: Seven clinical trials were identified with 598 patients. The mean follow-up was 23.6 months. In all of the included studies, there was no significant difference ($p > 0.05$) in any of the functional outcome scoring systems used, including, most commonly, the American Shoulder and Elbow Surgeons (ASES) score and the Constant score. Similarly, no study found a significant difference ($p > 0.05$) in either patient satisfaction or return to sport. However, 2 studies found a slightly higher rate of complications with the arthroscopic technique due to an increased rate of fixation failure in 1 study and stiffness in the other study.

Conclusions: This study found that both open tenodesis and arthroscopic tenodesis result in excellent clinical outcomes, with no significant differences between either method.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Lesions of the long head of the biceps brachii tendon (LHBT) are a common pathology that can cause substantial pain in the shoulder, often accompanying rotator cuff disease[1-3]. LHBT lesions are primarily treated nonoperatively, but if conservative management fails, LHBT lesions can be treated surgically with a tenodesis or a tenotomy. Treatment algorithms generally recommend tenodesis for younger patients or those with cosmetic concerns[4]. Biceps tenodesis can be performed via an open or arthroscopic approach, and there is currently no consensus over which method is superior[5].

The open procedure has traditionally been the standard approach for biceps tenodesis, as it is a reliable and simple technique that has been shown to provide excellent outcomes[5]. Recently, there has been an increasing percentage of patients being treated with an arthroscopic tenodesis, which only

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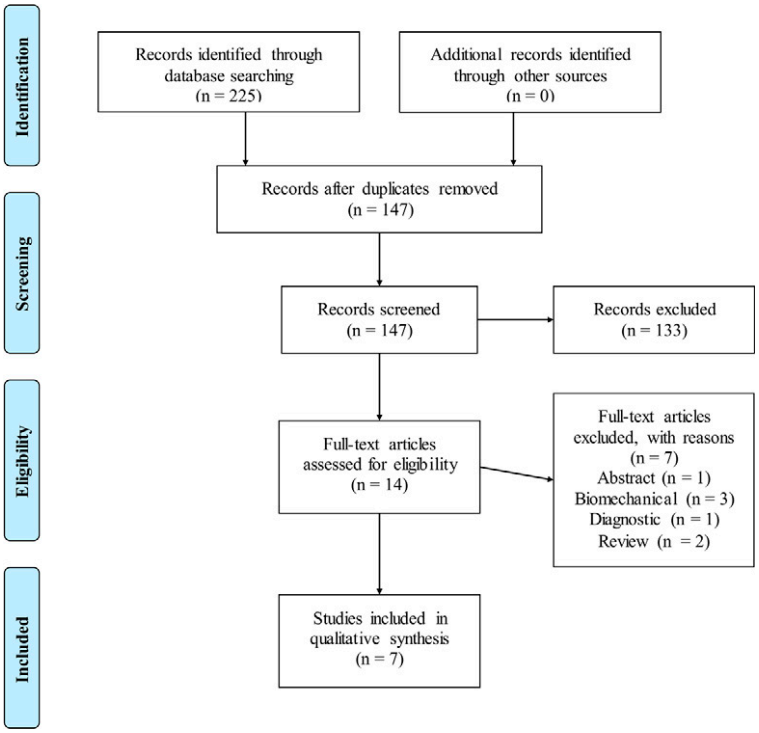

Fig. 1
PRISMA study selection flow diagram.

made up 0.15% of tenodeses in 2007 but 48.5% of tenodeses in 2011[6]. This recent shift is based on advancements in arthroscopic techniques and instrumentation, with authors advocating for arthroscopic techniques utilizing a minimally invasive approach, which potentially reduces the risk of complications[7].

Currently, there is no consensus on whether open or arthroscopic techniques result in improved patient outcomes, and, to our knowledge, there has been no previous systematic review of cohort studies comparing the 2 approaches. The purpose of this study was to systematically review the cohort studies in the literature to ascertain if the open or arthroscopic approach for biceps tenodesis results in superior clinical outcomes. Our hypothesis was that both open and arthroscopic tendodeses would result in excellent outcomes, with no significant difference between them.

Materials and Methods

Study Selection

Two independent reviewers performed a literature search based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and reviewed the search results, with a senior author arbitrating in the event of a disagreement[8]. The title and abstract were reviewed for all search results, and potentially eligible studies received a full-text review. In addition, the reference lists of all included studies and all literature reviews found via the search were manually screened for additional articles that met the inclusion criteria.

Search Strategy

The search was conducted using MEDLINE, Embase, and the Cochrane Library, and databases were screened from their inception to November 5, 2017. The search algorithm was (biceps tenodesis) AND (open OR subpectoral) AND (arthroscopic OR suprapectoral or intracuff).

Eligibility Criteria

The inclusion criteria were clinical studies comparing open and arthroscopic biceps tenodesis, publication in a peer-reviewed journal, publication in English, and availability of the full manuscript of studies. The exclusion criteria were case series, no reported clinical outcomes, review studies, cadaver studies, biomechanical studies, or abstract only.

Data Extraction

All relevant information was collected by 2 independent reviewers using a predetermined data sheet. When required information was not available in the text, the authors were contacted via e-mail. The Level of Evidence (LOE) was assessed using the criteria from the Oxford Centre for Evidence-Based Medicine[9]. The methodological quality of the evidence (MQOE) was assessed using the Newcastle-Ottawa Scale, a 9-point scale in which studies with 7 to 9 points were identified as very good, 5 to 6 points were identified as good, 4 points were identified as satisfactory, and 0 to 3 points were identified as unsatisfactory[10].

Outcomes Analyzed and Statistics

The outcomes analyzed were functional outcomes (American Shoulder and Elbow Surgeons [ASES] score[11], Constant score[12], University of California at Los Angeles [UCLA] score[13], Disabilities of the Arm, Shoulder and Hand [DASH] score[14], and Simple Shoulder Test [SST][15]), patient satisfaction and

TABLE I Study Characteristics and Patient Demographic Characteristics*

Study	LOE	MQOE	Arthroscopic			Open			Follow-up (mo)
			No. of Patients	Age† (yr)	Male Sex	No. of Patients	Age† (yr)	Male Sex	
Duchman[16] (2016)	III	6	20	49.9 ± 11.8	75%	25	38.9 ± 11.0	88%	38.4
Gombera[17] (2015)	III	6	23	57.3 ± 6.8	NR	23	56.9 ± 6.7	NR	30.1
Green[18] (2017)	III	7	15	56.6 ± 10.7	67%	23	60.0 ± 10.2	91.3%	54.6
Jeong[19] (2016)	III	7	33	63.6 ± 5.8	64%	39	59.6 ± 10	51%	23.5
Werner[20] (2014)	III	8	106	51.5 ± 9.5	61%	143	53.5 ± 11.2	72%	9.7
Werner[21] (2014)	III	7	32	49.3 ± 7.2	67%	50	52.3 ± 7.7	63%	37.2
Yi[22] (2016)	III	7	34	55.8 ± 5	41%	32	54.4 ± 5.8	47%	26.8

*MQOE = methodological quality of evidence, and NR = not reported. †The values are given as the mean and the standard deviation.

return to sport, range of motion (forward, abduction, external rotation, and stiffness), and complications.

Statistics

Statistical analysis was performed using SPSS Statistics for Windows, version 22.0 (IBM). Qualitative analysis was performed for each study. Significance was set at $p < 0.05$.

Results

Literature Search

The initial literature search resulted in 225 total studies. Once duplicates were removed, 14 studies were assessed for eligibility and full texts were reviewed. Seven clinical trials with 598 patients were included in this review (Fig. 1).

Study Characteristics and Patient Demographic Characteristics

There were 7 studies included (all Level-III studies), with 263 patients treated with arthroscopic biceps tenodesis and 335 patients treated with open biceps tenodesis[16-22]. All of the included studies used an open subpectoral technique, 6 of the studies used an arthroscopic suprapectoral tenodesis, and 1 study[19] used an arthroscopic intracuff fixation technique. The mean age of patients treated ranged from 38.9 to 63.6 years. The mean follow-up time was 23.6 months (range, from 9.7 to 54.6 months). The study characteristics and patient demographic characteristics are reported in Table I.

Functional Outcomes

Six studies compared functional outcomes between patients treated with open tenodesis and those treated with arthroscopic biceps tenodesis[16-19,21,22] (Table II). Five studies compared the ASES scores between tenodesis techniques[16-18,21,22]. None of those 5 studies found a significant difference ($p > 0.05$). The mean ASES score ranged from 82.3 to 92.3 points for the open biceps tenodesis group and from 79.6 to 91.4 points for the arthroscopic biceps tenodesis group. Four studies used the Constant score for a comparison of techniques[16,19,21,22]. None of those 4 studies found a significant difference ($p > 0.05$). The mean Constant score ranged from 86.0 to 91.8 points for the open biceps tenodesis group and from 85.9 to 90.7 points for the arthroscopic biceps tenodesis group. Three other studies compared the UCLA, DASH, or SST scores between those 2 groups[16,19,21]. None of those 3 studies found a significant difference ($p > 0.05$) in any outcome measure.

Patient Satisfaction and Return to Sport

Three studies compared patient satisfaction and return to sport between patients treated with open tenodesis

TABLE II Functional Outcomes*

Study	ASES	Constant	UCLA	DASH	SST
Duchman[16] (2016)	82.3 vs. 79.6	88.0 vs. 86.7	NR	11.3 vs. 13.7	10.8 vs. 11.1
Gombera[17] (2015)	92.3 vs. 88.9	NR	NR	NR	NR
Green[18] (2017)	90.6 vs. 91.4	NR	NR	NR	NR
Jeong[19] (2016)	NR	86.5 vs. 85.9	30.5 vs. 31.5	NR	NR
Werner[21] (2014)	88.4 vs. 90.1	91.8 vs. 90.7	NR	NR	10.6 vs. 10.4
Yi[22] (2016)	86.0 vs. 84.7	86.0 vs. 86.4	NR	NR	NR

*The values are given as the reported means, in points, of patients who underwent open tenodesis compared with those who underwent arthroscopic tenodesis. NR = not reported.

TABLE III Patient Satisfaction and Return to Sport*

Study	Satisfaction	Return to Sport
Duchman[16] (2016)	96 vs. 100	NR
Gombera[17] (2015)	8.9 vs. 9.1	69.5 vs. 78.3
Green[18] (2017)	8.9 vs. 9.3	NR

*The values are given as the reported means, in points, of patients who underwent open tenodesis compared with those who underwent arthroscopic tenodesis. NR = not reported.

and those treated with arthroscopic biceps tenodesis[16-18] (Table III). All 3 studies found no significant difference in patient satisfaction ($p > 0.05$)[16-18]. One study showed that 96% of the patients were satisfied with the open biceps tenodesis and 100% of the patients were satisfied with the arthroscopic biceps tenodesis, and the other 2 studies showed no difference in the satisfaction subscale of the ASES score. One study compared return to sport and found no significant difference ($p > 0.05$), with 69.5% of patients returning to sport after the open biceps tenodesis and 78.3% of patients returning to sport after the arthroscopic biceps tenodesis[17].

Range of Motion

Six studies compared the range of motion between patients treated with open tenodesis and those treated with arthroscopic biceps tenodesis[16-18,20-22] (Table IV). Five studies compared the range of motion in forward flexion between the 2 groups, and 1 of those 5 studies found a significant difference in favor of open biceps tenodesis ($p < 0.05$)[16-18,21,22]. Five studies compared the range of motion in abduction between the 2 groups, and none of those studies found a significant difference ($p > 0.05$)[16-18,21,22]. Four studies compared the range of motion in external rotation between the 2 groups, and none of those studies found a significant difference ($p > 0.05$)[16,18,21,22]. Additionally, Werner et al. found an increased rate of stiffness following arthroscopic biceps tenodesis compared with the open approach[20].

Complications

All 7 studies compared the complication rates between patients treated with open tenodesis and those treated with arthroscopic biceps tenodesis[16-22] (Table V). One study showed a significantly higher overall complication rate ($p < 0.05$) with the arthroscopic technique due to an increased number with bicipital groove pain and the Popeye sign, a bulge in the biceps muscle due to failure of the fixation[19]. Werner et al. found a significantly higher rate of stiffness with the arthroscopic approach ($p < 0.05$)[20]. The Popeye sign was reported in 6 studies, with rates ranging from 0% to 5.1% for the patients who underwent the open approach and from 0% to 15.2% for the patients who underwent the arthroscopic approach[16-19,21,22]. Bicipital groove pain was reported in 4 studies, with rates ranging from 0% to 43.4% for the open approach and from 5.9% to 34.8% for the arthroscopic approach[16,17,19,22]. Brachial plexus palsy was reported in 2 cases with the open approach, 1 of which was transient, but no cases were reported using the arthroscopic approach[17,19]. Postoperative superficial wound infections were reported in 2 cases with the open approach, but no cases were reported using the arthroscopic approach[17,19].

Discussion

The most important findings from our study were that both open and arthroscopic tenodesis result in similarly excellent clinical outcomes. There were no significant differences between the functional outcome scores in any of the included studies. Therefore, based on the findings from our study, the decision to perform the biceps tenodesis either via an open approach or arthroscopically should be based on surgeon preference and consultation with the patient. In some cases, the approach utilized for tenodesis may be dictated by concomitant pathology, including rotator cuff or labral pathology, as the arthroscopic approach also allows for diagnostic assessment in the setting of uncertain pathology. However, further

TABLE IV Range of Motion*

Study	Forward Flexion	Shoulder Abduction	External Rotation	Stiffness
Duchman[16] (2016)	177.8° vs. 171.3°†	177.4° vs. 171.8°	0° vs. 5° deficit	NR
Green[18] (2017)	169.2° vs. 168.2°	161.7° vs. 158.9°	NR	NR
Jeong[19] (2016)	150.6° vs. 155.5°	155.9° vs. 154.5°	53.9° vs. 56.4°	NR
Werner[20] (2014)	NR	NR	NR	5.6% vs. 17.9%†
Werner[21] (2014)	98.1° vs. 95.9°	98.1° vs. 94.4°	99.4° vs. 94.6°	6% vs. 9.4%
Yi[22] (2016)	167.8° vs. 165.5°	169.5° vs. 170.3°	59.7° vs. 61.6°	NR

*The values are given as the reported means of the range of motion of patients who underwent open tenodesis compared with those who underwent arthroscopic tenodesis. NR = not reported. †Significant.

TABLE V Complications*

Study	Total Complications	Reoperations	Bicipital Groove Pain	Popeye Sign	Neurological Injury	Infection
Duchman[16] (2016)	20% vs. 15%	0% vs. 0%	20% vs. 10%	0% vs. 5%	0% vs. 0%	0% vs. 0%
Gombera[17] (2015)	5.2% vs. 3.5%	0% vs. 0%	43.4% vs. 34.8%	0% vs. 0%	4.3% vs. 0%	4.3% vs. 0%
Green[18] (2017)	8.7% vs. 0%	8.7% vs. 0%	NR	0% vs. 0%	0% vs. 0%	0% vs. 0%
Jeong[19] (2016)	12.8% vs. 33.3%†	0% vs. 0%	2.6% vs. 24.2%†	5.1% vs. 15.2%	2.6% vs. 0%	2.6% vs. 0%
Werner[20] (2014)	5.6% vs. 17.9%†	NR	NR	NR	NR	NR
Werner[21] (2014)	6.0% vs. 9.4%	0% vs. 0%	NR	0% vs. 0%	0% vs. 0%	0% vs. 0%
Yi[22] (2016)	9.7% vs. 8.8%	0% vs. 0%	0% vs. 5.9%	3.1% vs. 2.9%	0% vs. 0%	l0% vs. 0%

*The values are given as the incidence of complications in the open tenodesis group compared with the arthroscopic tenodesis group. NR = not reported. †Significant.

prospective randomized studies are needed to confirm these findings.

Tenotomy is surgically easier to perform as there is no fixation required, but tenotomy results in a higher incidence of muscle cramping, Popeye sign, decreased elbow flexion, and decreased supination power compared with tenodesis[23-27]. As a result, tenotomy is typically indicated in older, non-active patients who are less concerned with the cosmetic result[4]. Although both result in excellent clinical outcomes, tenodesis is indicated in younger patients, athletes, and patients concerned with cosmetic appearance. It is a longer and more expensive procedure due to the use of additional implants, as well as requiring longer rehabilitation, but it allows for a better return to physical activity through the maintenance of the LHBT length-tension relationship[28].

Our study found that functional outcomes can be expected to be excellent with both open and arthroscopic approaches. No study showed a significant difference in the ASES score, which was the most commonly utilized functional outcome scoring system. Additionally, the Constant score was not significantly different between either approach. Similarly, the mean range of motion was similar in both procedures, although the forward range of motion was slightly higher with the arthroscopic procedure. Werner et al. found that the arthroscopic approach resulted in a higher incidence of postoperative stiffness and concluded this may be due to the position of the tenodesis, with a more superior position potentially being an influencing factor[20]. However, they also found that this result reduced over time and did not appear to have any long-term consequences. In the literature, there is limited evidence to suggest that LHBT location, specifically within the bicipital groove, may result in inferior outcomes compared with a more distal tenodesis location[5].

In 1 study, there were more complications observed with the open procedure compared with the arthroscopic approach[19]. A higher overall complication rate was not seen in the other included studies, but, in many of the studies, there was a slightly lower complication rate with the arthroscopic technique, although this did not reach significance. Additionally, in the study in which there was a higher complication rate with the open approach, the tenodesis was fixated intracuff, rather than suprapectorally, as in the other studies[19]. There is a concern that the open technique may lead to a higher risk of nerve injuries and may result in a higher risk of wound complications. However, further large-scale studies are necessary to evaluate this, as the reported incidence was very low across the included studies[17,19]. Mazzocca et al. performed a biomechanical assessment of 4 different tenodesis techniques in a cadaver model, including both arthroscopic and open fixation methods[3]. Their results showed no significant differences between the fixation approaches in the failure strength and concluded there are no biomechanical differences between the fixation methods. It does not appear that either approach results in a higher incidence of failure or a positive Popeye sign, as only a few instances were reported in the included studies[19,22]. As biceps tenodesis is often performed instead of tenotomy because of improved cosmetic appearance, the scar cosmesis could be a further deciding factor in consenting patients[4].

Further study is still required in this area, with randomized controlled trials needed to confirm our findings, as the literature currently consists of retrospective studies. Additionally, patient preference can be an important factor in determining surgical treatment alongside surgeon experience and preference, whereas patient perception of open tenodesis compared with arthroscopic tenodesis has not been studied.

There were limitations and inherent bias in our study. First, the limitations inherent in the included studies were present in this current study as this was a systematic review of their data. All of the included studies were retrospective and carried a risk of selection bias, as they were nonrandomized. Additionally, not all of the studies included a minimum follow-up of 2 years, so the patients may not have reached the point of maximal medical improvement. There were several

fixation methods used, which may also have affected the clinical outcome. Jeong et al. used an intracuff tenodesis, which resulted in the highest rate of complications and Popeye signs in the studies[19]. In half of the included studies, rotator cuff repairs were also performed and thus these patients did not have isolated biceps tenodesis. However, biceps tenodesis is often performed as an adjunct to a rotator cuff surgical procedure, and, thus, this represented a real-world treatment scenario. Lastly, 2 of the studies included overlapping patients, but we believed that inclusion of both was justified as they showed different results and we did not perform any pooling.

In conclusion, this current study found that both open tenodesis and arthroscopic tenodesis result in excellent clinical outcomes, with no significant differences between either method. Surgeons should base their decision to perform the tenodesis via an open or arthroscopic approach on their own surgical preference and technical experience.

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References

1. Castricini R, Familiari F, De Gori M, Riccelli DA, De Benedetto M, Orlando N, Galasso O, Gasparini G. Tenodesis is not superior to tenotomy in the treatment of the long head of biceps tendon lesions. Knee Surg Sports Traumatol Arthrosc. 2018 Jan;26(1):169-75. Epub 2017 Jun 16.

2. Checchia SL, Doneux PS, Miyazaki AN, Silva LA, Fregoneze M, Ossada A, Tsutida CY, Masiole C. Biceps tenodesis associated with arthroscopic repair of rotator cuff tears. J Shoulder Elbow Surg. 2005 Mar-Apr;14(2): 138-44.

3. Mazzocca AD, Bicos J, Santangelo S, Romeo AA, Arciero RA. The biomechanical evaluation of four fixation techniques for proximal biceps tenodesis. Arthroscopy. 2005 Nov;21(11): 1296-306.

4. Galdi B, Southren DL, Brabston EW, Popkin CA, Jobin CM, Levine WN, Ahmad CS. Patients have strong preferences and perceptions for biceps tenotomy versus tenodesis. Arthroscopy. 2016 Dec;32(12):2444-50. Epub 2016 Jun 16.

5. Abraham VT, Tan BH, Kumar VP. Systematic review of biceps tenodesis: arthroscopic versus open. Arthroscopy. 2016 Feb;32(2):365-71. Epub 2015 Sep 28.

6. Vellios EE, Nazemi AK, Yeranosian MG, Cohen JR, Wang JC, McAllister DR, Petrigliano FA. Demographic trends in arthroscopic and open biceps tenodesis across the United States. J Shoulder Elbow Surg. 2015 Oct;24(10):e279-85. Epub 2015 Jul 2.

7. Harris JD. Editorial commentary: open versus arthroscopic biceps tenodesis—you choose. Arthroscopy. 2016 Feb;32(2):372-3.

8. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009 Jul 21;6(7):e1000100. Epub 2009 Jul 21.

9. Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, Moschetti I, Phillips B, Thornton H. The Oxford 2011 levels of evidence. 2011. http://www.cebm.net/index.aspx?o=5653. Accessed 2018 Nov 27.

10. Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2013. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed 2018 Nov 27.

11. Kocher MS, Horan MP, Briggs KK, Richardson TR, O'Holleran J, Hawkins RJ. Reliability, validity, and responsiveness of the American Shoulder and Elbow Surgeons subjective shoulder scale in patients with shoulder instability, rotator cuff disease, and glenohumeral arthritis. J Bone Joint Surg Am. 2005 Sep;87(9):2006-11.

12. Conboy VB, Morris RW, Kiss J, Carr AJ. An evaluation of the Constant-Murley shoulder assessment. J Bone Joint Surg Br. 1996 Mar; 78(2):229-32.

13. Roddey TS, Olson SL, Cook KF, Gartsman GM, Hanten W. Comparison of the University of California-Los Angeles Shoulder Scale and the Simple Shoulder Test with the shoulder pain and disability index: single-administration reliability and validity. Phys Ther. 2000 Aug;80(8): 759-68.

14. Gummesson C, Atroshi I, Ekdahl C. The Disabilities of the Arm, Shoulder and Hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskelet Disord. 2003 Jun 16;4:11. Epub 2003 Jun 16.

15. Godfrey J, Hamman R, Lowenstein S, Briggs K, Kocher M. Reliability, validity, and responsiveness of the Simple Shoulder Test: psychometric properties by age and injury type. J Shoulder Elbow Surg. 2007 May-Jun;16(3): 260-7. Epub 2006 Dec 22.

16. Duchman KR, DeMik DE, Uribe B, Wolf BR, Bollier M. Open versus arthroscopic biceps tenodesis: a comparison of functional outcomes. Iowa Orthop J. 2016;36:79-87.

17. Gombera MM, Kahlenberg CA, Nair R, Saltzman MD, Terry MA. All-arthroscopic suprapectoral versus open subpectoral tenodesis of the long head of the biceps brachii. Am J Sports Med. 2015 May;43(5):1077-83. Epub 2015 Mar 29.

18. Green JM, Getelman MH, Snyder SJ, Burns JP. All-arthroscopic suprapectoral versus open subpectoral tenodesis of the long head of the biceps brachii without the use of interference screws. Arthroscopy. 2017 Jan;33(1):19-25. Epub 2016 Sep 19.

19. Jeong HY, Kim JY, Cho NS, Rhee YG. Biceps lesion associated with rotator cuff tears: open subpectoral and arthroscopic intracuff tenodesis. Orthop J Sports Med. 2016 May 9; 4(5):2325967116645311.

20. Werner BC, Pehlivan HC, Hart JM, Carson EW, Diduch DR, Miller MD, Brockmeier SF. Increased incidence of postoperative stiffness after arthroscopic compared with open biceps tenodesis. Arthroscopy. 2014 Sep;30(9): 1075-84. Epub 2014 May 22.

21. Werner BC, Evans CL, Holzgrefe RE, Tuman JM, Hart JM, Carson EW, Diduch DR, Miller MD, Brockmeier SF. Arthroscopic suprapectoral and open subpectoral biceps tenodesis: a comparison of minimum 2-year clinical outcomes. Am J Sports Med. 2014 Nov;42(11):2583-90. Epub 2014 Sep 8.

22. Yi Y, Lee JM, Kwon SH, Kim JW. Arthroscopic proximal versus open subpectoral biceps tenodesis with arthroscopic repair of small- or medium-sized rotator cuff tears. Knee Surg Sports Traumatol Arthrosc. 2016 Dec;24(12): 3772-8. Epub 2015 Jun 4.

23. Koh KH, Ahn JH, Kim SM, Yoo JC. Treatment of biceps tendon lesions in the setting of rotator cuff tears: prospective cohort study of tenotomy versus tenodesis. Am J Sports Med. 2010 Aug;38(8):1584-90. Epub 2010 Jun 15.

24. Oh JH, Lee YH, Kim SH, Park JS, Seo HJ, Kim W, Park HB. Comparison of treatments for superior labrum–biceps complex lesions with concomitant rotator cuff repair: a prospective, randomized, comparative analysis of debridement, biceps tenotomy, and biceps tenodesis. Arthroscopy. 2016 Jun;32(6):958-67. Epub 2016 Feb 23.

25. Osbahr DC, Diamond AB, Speer KP. The cosmetic appearance of the biceps muscle after long-head tenotomy versus tenodesis. Arthroscopy. 2002 May-Jun; 18(5):483-7.

26. Shank JR, Singleton SB, Braun S, Kissenberth MJ, Ramappa A, Ellis H, Decker MJ, Hawkins RJ, Torry MR. A comparison of forearm supination and elbow flexion strength in patients with long head of the biceps tenotomy or tenodesis. Arthroscopy. 2011 Jan;27(1):9-16. Epub 2010 Oct 29.

27. Wittstein JR, Queen R, Abbey A, Toth A, Moorman CT 3rd. Isokinetic strength, endurance, and subjective outcomes after biceps tenotomy versus tenodesis: a postoperative study. Am J Sports Med. 2011 Apr;39(4):857-65. Epub 2010 Dec 28.

28. Werner BC, Lyons ML, Evans CL, Griffin JW, Hart JM, Miller MD, Brockmeier SF. Arthroscopic suprapectoral and open subpectoral biceps tenodesis: a comparison of restoration of length-tension and mechanical strength between techniques. Arthroscopy. 2015 Apr; 31(4):620-7. Epub 2014 Dec 10.