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Patient-determined outcomes after arthroscopic rotator cuff repair with and without biceps tenodesis utilizing the PITT technique

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Hypothesis and Background: The percutaneous intra-articular transtendon technique (PITT) is a simple, rapid, and low-cost method of performing a biceps tenodesis. Few studies exist that examine the patient-determined outcomes of this technique in general or in patients undergoing arthroscopic rotator cuff repair (RCR) with and without biceps tenodesis. We hypothesized that patients undergoing an isolated arthroscopic RCR would have equivalent outcomes to those undergoing RCRs with PITT biceps tenodesis.

Methods: We compared preoperative, patient-determined outcomes scores on patients undergoing primary arthroscopic RCR with and without a PITT biceps tenodesis with postoperative scores at a minimum of 2 years. These scores included the Western Ontario Rotator Cuff score (WORC), American Shoulder and Elbow Surgeons score (ASES), Single Assessment Numeric Evaluation (SANE), Simple Shoulder Test (SST), and Shoulder Activity Level (SAL). Indication for a concomitant biceps tenodesis was a partial long head biceps tendon tear or biceps instability/subluxation.

Results: A total of 153 patients underwent an isolated RCR and 131 patients underwent RCR with biceps tenodesis (RCRBT). Both groups had improvements in WORC, ASES, SANE, and SST ($P < .0001$) and deteriorations in the SAL ($P \leq .005$). There was no difference in the change in outcome scores between the groups (RCRBT vs. RCR, respectively) for WORC (46 vs. 47; $P = .85$), ASES (46 vs. 47; $P = .82$), SANE (53 vs. 51; $P = .35$), SST (5.8 vs. 5.8; $P = .93$), and SAL (-0.9 vs. -1.4; $P = .46$). There was no difference between the groups in complications that required revision surgery (1.5% vs. 1.3%; $P = .91$).

Conclusions: Arthroscopic PITT RCRBT is safe and effective with equivalent patient-determined outcomes compared with patients undergoing RCR without biceps tenodesis.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Biceps tenodesis; rotator cuff repair; patient-determined outcomes; PITT technique

The incidence of biceps tenodesis for the treatment of the long head of biceps tears or instability has increased recently.[44] Biceps tenodesis is often performed in combination with other shoulder procedures including rotator cuff repair (RCR).[44] There are many

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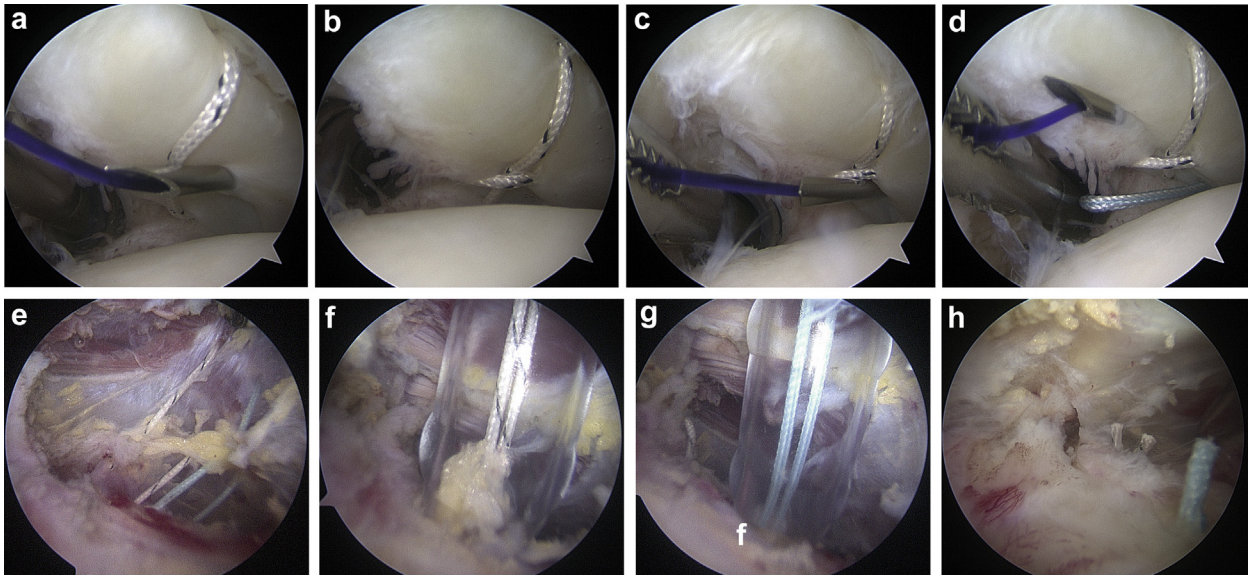

Figure 1 The arthroscopic percutaneous intra-articular trans-tendon (PITT) bicep tenodesis technique. (**a**) A spinal needle is passed through the skin, subacromial space, rotator interval tissue, through the biceps tendon into the glenohumeral joint. Next a shuttle suture is passed through the spinal needle into the glenohumeral joint and retrieved with a grasper passed through the anterior cannula. (**b**) Both ends of a single high-strength suture are passed through the biceps tendon and retrieved out through the skin. (**c**, **d**) Next a spinal needle is used to shuttle both ends of a second high-strength suture through the biceps tendon in a similar fashion. A biceps tenotomy is completed. (**e**) The arthroscope is placed in the subacromial space and the sutures are identified. (**f**) The 2 limbs of 1 suture are retrieved through the cannula and secured using arthroscopic knot tying techniques. (**g**) This is repeated for the second pair of suture limbs, thus (**h**) completing the PITT technique for arthroscopic biceps tenodesis.

methods of performing biceps tenodesis each with their own purported advantages and disadvantages.[2,4-6,9,10,13,22,23,26,29,34,40,47,48] Currently, the optimal surgical treatment of biceps lesions remains controversial.[11] The percutaneous intra-articular tendon technique (PITT) has been developed as a simple, rapid, and low-cost method of performing a biceps tenodesis.[9,10,40] Opponents of this technique have expressed concerns with possible inferior biomechanical properties that may lead to postoperative rupture,[39,41] potential for intertubercular groove pain,[14,22,32,38] and the possibility for decreased elbow strength.[12,21] To date there are few studies that have examined the patient-determined outcomes of this technique.[21,39] In addition, to the best of the authors' knowledge, there are few studies that examined patient-determined outcomes in patients undergoing arthroscopic RCR with and without biceps tenodesis.[43] The purpose of this study was to examine the patient-determined outcomes in patients undergoing arthroscopic RCR with or without biceps tenodesis using the PITT technique. The authors hypothesized that patients who undergo arthroscopic RCR without a biceps tenodesis would have equivalent outcomes to those undergoing arthroscopic RCR with concomitant biceps tenodesis (RCRBT) using the PITT technique to treat partial biceps tears or biceps instability.

Materials and methods

We compared prospectively collected preoperative, patient-determined outcomes scores on patients undergoing RCR performed by a single surgeon (K.M.B.) to postoperative scores at a minimum of 2 years. These scores included the Western Ontario Rotator Cuff score (WORC), American Shoulder and Elbow Surgeons score (ASES),[37] Single Assessment Numeric Evaluation (SANE),[45] Simple Shoulder Test (SST),[33] and Shoulder Activity Level (SAL).[3] Patients who underwent primary arthroscopic RCR (supraspinatus and/or infraspinatus and/or subscapularis) between December 2008 and October 2013 and had completed preoperative patient outcome forms had the potential for inclusion in this study. Indication for a concomitant biceps tenodesis was a partial long head biceps tendon tear or biceps instability/subluxation.

The PITT biceps tenodesis was performed in a standardized fashion by passing a spinal needle from outside the shoulder through the rotator interval tissue and through the biceps tendon under arthroscopic visualization in the glenohumeral joint. A shuttle suture (0-PDS II; Ethicon, Somerville, NJ, USA) was passed through the spinal needle into the joint and retrieved with a grasper passed through a 5-mm cannula placed in the anterior portal. The spinal needle was then removed. The shuttle suture was tied around the end of a high-strength suture (Fiberwire; Arthrex, Naples, FL, USA), which was then shuttled into the anterior cannula, through the biceps, rotator interval, and subacromial space, respectively, and out through the skin. This was repeated to pass the second limb of the initial high-strength suture

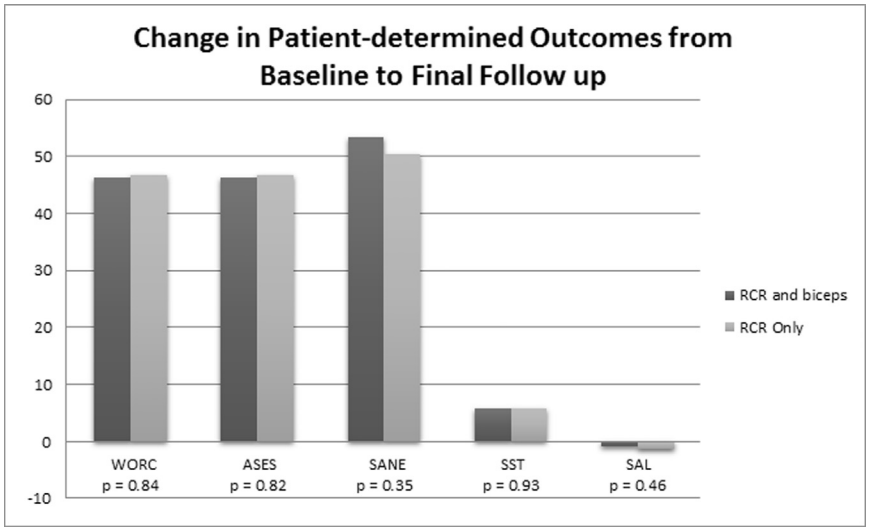

Figure 2 Change in patient-determined outcomes from baseline to final follow-up. *WORC*, Western Ontario rotator cuff Index; *ASES*, American Shoulder and Elbow Surgeons score; *SANE*, Single Assessment Numeric Evaluation; *SST*, Simple Shoulder Test; *SAL*, Shoulder Activity Level; *RCR*, rotator cuff repair.

in a similar fashion (Fig. 1, *a* and *b*). The same steps were repeated with a second high-strength suture (Fig. 1, *c* and *d*). Next, a biceps tenotomy was performed using a radiofrequency device. The arthroscope was then placed in the subacromial space and the sutures were identified (Fig. 1, *e*). The authors use different colored sutures to determine the corresponding limbs of the same suture. One set of sutures were retrieved out of a cannula and secured using arthroscopic knot tying techniques (Fig. 1, *f*). The second set of sutures were then retrieved and tied in the same fashion (Fig. 1, *g*) completing the arthroscopic PITT biceps tenodesis technique (Fig. 1, *h*).

Exclusion criteria were patients with less than 2 years of follow-up, patients who underwent revision RCR, patients who were deceased before postoperative outcome measures could be obtained, non–English speaking patients, and patients with concomitant cervical radiculopathy, adhesive capsulitis, proximal humerus fracture, or a diagnosis of inflammatory arthritis. After review of the database, 311 patients were eligible for inclusion in this study (166 patients with RCRs and 145 patients with RCRBTs).

We performed statistical analysis with Microsoft Excel 2010 (Seattle, WA, USA). We used a Student's *t*-test to examine differences between groups and χ^2testing to analyze continuous variables. We used analysis of variance when comparing multiple groups. The level of significance was set at .05.

Results

Of the 311 shoulders eligible for this study, 27 were lost to follow-up (8.7%). One hundred and fifty-three shoulders underwent arthroscopic RCR (follow-up rate = 90.3%) and 131 shoulders underwent arthroscopic RCRBT (follow-up rate = 92.2%). Both groups had similar ages at surgery 58.9 vs. 59.0 years ($P = .95$). There was a greater percentage of males in the RCRBT group (73.2%) compared with the RCR group (58.2%; $P = .008$). Mean follow-up was similar for both groups (3.8 vs. 3.6 years; $P = .06$). The RCR group required supraspinatus repair more frequently than the RCRBT group (96.1% vs. 86.2%; $P = .003$), but the RCRBT group required subscapularis repair more frequently than the RCR group (46.6% vs. 28.1%; $P = .001$). There was no difference between groups in frequency of infraspinatus repairs (14.5% RCRBT vs. 11.1% RCR; $P = .39$). There was no difference between groups in the mean number of suture anchors used to repair the subscapularis (1.8 vs. 1.8 anchors; $P = .77$). However, when repairing the supraspinatus and/or infraspinatus, the combined RCRBT group required more suture anchors than the isolated RCR group (4.6 anchors vs. 4.1 anchors; $P = .0006$).

Both groups showed statistically significant improvements in WORC, ASES, SST, and SANE ($P < .0001$). Both groups showed statistically significant deteriorations of the SAL at the $P < .0001$ level for the RCR group and $P = .005$ for the RCR group (Fig. 2).

There was no difference in the mean outcome scores between groups (RCRBT vs. RCR, respectively) for (1) preoperative WORC (41 vs. 43; $P = .23$), ASES (41 vs. 42; $P = .47$), SANE (35 vs. 40; $P = .06$), SST (4.4 vs. 4.6; $P = .42$), and SAL (11.7 vs. 11.6; $P = .81$); (2) postoperative WORC (87 vs. 90; $P = .07$), ASES (87 vs. 89; $P = .41$), SANE (88 vs. 90; $P = .21$), SST (10.1 vs. 10.2; $P = .60$), and SAL (10.6 vs. 10.1; $P = .35$); or (3) change in scores from baseline to final follow-up WORC (46 vs. 47; $P = .85$), ASES (46 vs. 47; $P = .82$), SANE (53 vs. 51; $P = .35$), SST (5.8 vs. 5.8; $P = .93$), and SAL (−0.9 vs. −1.4; $P = .46$) (Fig. 2).

There was no difference between groups when examining complications that required revision surgery ($P =$

.91). Two patients (1.5%) in the RCRBT group underwent conversion to an open subpectoral biceps tenodesis with one of these patients also undergoing a concomitant lysis of adhesions. Two patients (1.3%) in the RCR group had a revision surgery with 1 patient undergoing a revision RCR and 1 patient undergoing a lysis of adhesions.

Forty of the shoulders in the isolated RCR group (26.1%) had a rupture of the long head of the biceps that was confirmed at the time of surgery and was left untreated. Subgroup analysis did not identify any clinical or statistical differences for any preoperative outcome score (WORC $P = .48$; ASES $P = .72$; SST $P = .59$; SANE $P = .15$; SAL $P = .38$) or change in outcome score (WORC $P = 0.77$; ASES $P = 0.97$; SST $P = 0.79$; SANE $P = 0.63$; SAL $P = 0.68$) between the RCRBT group or patients in the RCR group with or without a biceps tendon rupture. Overall, there were 171 shoulders (60.2%) with biceps pathology (RCRBT group or RCR group with a biceps rupture) in this cohort of patients. Within this cohort, patients with biceps pathology were more likely to be male (121 shoulders; 75.4%; $P < .0001$).

Discussion

Although multiple studies demonstrate that the outcomes of biceps tenotomy are equivalent to those of biceps tenodesis,[1,5,15,19,24-27,35,36,48] some surgeons prefer biceps tenodesis over tenotomy to prevent postoperative cosmetic deformity, fatigue discomfort and cramping, and potential strength loss.[15,16,19,24,26,28] Currently, there is no consensus as to which is (1) the best fixation technique or (2) optimal location for biceps tenodesis.

There are many fixation methods available for biceps tenodesis. These include interference screw fixation in a bone tunnel,[2,5,23,34,47] isolated suture anchor,[48] incorporation in the suture anchor for RCR,[6,13,23,26,29] suture fixation through the rotator cuff,[4,22] or suture fixation through the rotator interval and/or transverse humeral ligament (PITT technique).[9,10,40] There are also different locations where the tenodesis may be performed: proximal in the bicipital groove (with or without bicipital sheath release[38]), distal in the bicipital groove, and subpectoral. Currently, there is no consensus as to the optimal location of tenodesis. Although many advocate for a more distal tenodesis,[12,14,15,22,32] a systematic review by Leroux et al[27] found that the potential for residual bicipital groove pain was low and surgeons should not be deterred from performing a proximal tenodesis.

The PITT technique for biceps tenodesis used in this study is an all-arthroscopic proximal tenodesis that uses sutures instead of implants. It is an easy and efficient method that avoids hardware complication and cost.[31,42] Clinical comparative research varies in performance of this technique compared with others. Elkousy et al[10] demonstrated that biceps tenodesis success was not improved by using implantable hardware compared with the more cost-effective PITT technique. However, other studies showed that elbow strength and biceps fixation success were superior when using interference screws or anchors compared with soft tissue fixation, but ASES scores and Constant scores were similar between the types of fixation methods.[21,39]

Comparative biomechanical studies have also varied in their recommendations of the optimal fixation technique. The PITT technique was demonstrated to have similar ultimate loads to failure compared with suture anchor techniques.[31] One study demonstrated superior load to failure properties of the PITT technique compared with the interference screw technique,[20] whereas another study had the opposite results.[41] When examining strain characteristics, Levin et al[28] demonstrated that soft tissue tenodeses better maintained the native strain environment when compared with the bony tenodesis using an interference screw and suggested that a soft tissue procedure may be more preferable clinically.

The hypothesis of our study was validated because we demonstrated equivalent patient-determined outcome scores in patients undergoing arthroscopic RCR with a concomitant arthroscopic proximal tenodesis using the PITT technique compared with those patients undergoing RCR without biceps tenodesis. In addition, we found that patients undergoing arthroscopic RCR with a prior proximal long head biceps tendon rupture left untreated had similar outcomes compared with (1) the isolated RCR group and (2) the concomitant biceps tenodesis and RCR group. Shoulders undergoing biceps tenodesis were more likely to have a subscapularis tear compared with the isolated RCR group. This finding is intuitive because biceps subluxation/dislocation was an indication for biceps tenodesis, and the subscapularis is typically torn at least superiorly when the biceps is subluxated/dislocated. We also identified that patients with rotator cuff tears and biceps pathology were more likely to be male.

The findings of our study agreed with those of Kukkonen et al[25] that stated that biceps procedures did not impair the final outcomes of patients treated with RCRs. A recently published study found that patients who underwent biceps tenodesis or biceps tenotomy had lower baseline ASES scores and significantly greater improvement in ASES, VAS, and WORC scores at 1 year of follow-up compared with patients who had isolated RCRs.[43] Our study differed from this study because our baseline scores and improvement in scores were similar between groups. Our study also differed from that of Erickson et al[11] that found that significantly more patients who had a concomitant biceps tenodesis required a reoperation at 6 months and 1 year compared with patients undergoing isolated RCR. In our study, the reoperation rate

in the RCRBT group was 1.5% compared with 1.3% in the RCR group ($P = .91$). This rate was lower than the biceps tenodesis revision rate published by Friedman et al[14] for both proximal tenodesis techniques (12%) and distal tenodesis techniques (2.7%).

Although this study was a comparative study with a control group (RCR without biceps tenodesis), it was potentially limited by the lack of comparison with another type of biceps tenodesis. Therefore, it does not prove superiority or inferiority to other tenodesis types. Rather, it reveals that patients who have a concurrent biceps tenodesis using the PITT technique can expect to have equivalent patient-determined outcomes compared with patients undergoing RCR without a concurrent tenodesis. Another limitation of our study was that it was not designed to compare the results of biceps tenodesis with no tenodesis because, although we had a comparative group, we did not include a group where biceps pathology was identified but left untreated. To the best of our knowledge, there are no prospective, randomized controlled trials that have addressed the question of whether to treat the long head of the biceps pathology in addition to RCR.[46] However, we do know that lesions of the long head of the biceps tendon have long been considered a significant cause of anterior shoulder pain and disability.[7] In addition, many of our patients had concomitant subscapularis repairs, and it has been shown that concomitant treatment of the biceps along with subscapularis repair has been shown to positively influence both subjective and objective patient outcomes.[8] Another limitation was that the size of the rotator cuff tear determined arthroscopically was not recorded. However, we did report on the number of sutures anchors that were required for the repair. A previous study by Le et al[30] demonstrated that the number of suture anchors used highly correlated with rotator cuff tear size. Therefore, it may be reasonable to use the number of suture anchors as a proxy for tear size. Other limitations include its retrospective, nonrandomized nature, the lack of (1) a physical examination, (2) determination of biceps contour and fixation status, (3) presence of tenderness at the bicipital groove, or (4) determination of subjective cramping biceps pain at the final follow-up. Lastly, ultrasound or other diagnostic tools were not used postoperatively to assess the status of the biceps tenodesis or the RCR. Although determination of these outcomes would have made this article more comprehensive, it did not limit the examination of the hypothesis of this study. The strengths of this study include the novelty of the hypothesis because there are very few studies that examine the outcomes of the PITT technique. In addition, it uses a comparative group to provide the reader with a frame of reference for outcome interpretation. The sample size included in this study is large with a high follow-up rate at an intermediate follow-up time point that supersedes that of many studies that examine biceps tenodeses.[9,10,15,17,18,26,32]

Conclusions

This study suggests that arthroscopic biceps tenodesis using the PITT technique concurrently with arthroscopic RCR is a safe and effective procedure with equivalent patient-determined outcomes compared with patients undergoing RCR without biceps tenodesis and is associated with a low revision rate. In addition, this study revealed a high prevalence of biceps pathology found in patients undergoing RCR. Lastly, it appears that male gender may be a risk factor for biceps pathology found during RCR.

Disclaimer

Keith M. Baumgarten reports that he receives speaking fees from Arthrex and Wright Medical and consulting fees from Wright Medical.

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References

1. Biz C, Vinanti GB, Rossato A, Arnaldi E, Aldegheri R. Prospective study of three surgical procedures for long head biceps tendinopathy associated with rotator cuff tears. Muscles Ligaments Tendons J 2012; 2:133-6.
2. Boileau P, Krishnan SG, Coste JS, Walch G. Arthroscopic biceps tenodesis: a new technique using bioabsorbable interference screw fixation. Arthroscopy 2002;18:1002-12.
3. Brophy RH, Beauvais RL, Jones EC, Cordasco FA, Marx RG. Measurement of shoulder activity level. Clin Orthop Relat Res 2005;439: 101-8. https://doi.org/10.1097/01.blo.0000173255.85016.1f
4. Castagna A, Conti M, Mouhsine E, Bungaro P, Garofalo R. Arthroscopic biceps tendon tenodesis: the anchorage technical note. Knee Surg Sports Traumatol Arthrosc 2006;14:581-5. https://doi.org/10.1007/s00167-005-0026-1
5. Castricini R, Familiari F, De Gori M, Riccelli DA, De Benedetto M, Orlando N, et al. Tenodesis is not superior to tenotomy in the treatment of the long head of biceps tendon lesions. Knee Surg Sports Traumatol Arthrosc 2018;26:169-75. https://doi.org/10.1007/s00167-017-4609-4
6. Checchia SL, Doneux PS, Miyazaki AN, Silva LA, Fregoneze M, Ossada A, et al. Biceps tenodesis associated with arthroscopic repair of rotator cuff tears. J Shoulder Elbow Surg 2005;14:138-44. https://doi.org/10.1016/j.jse.2004.07.013

7. Dines D, Warren RF, Inglis AE. Surgical treatment of lesions of the long head of the biceps. Clin Orthop Relat Res 1982;164:165-71.
8. Edwards TB, Walch G, Sirveaux F, Mole D, Nove-Josserand L, Boulahia A, et al. Repair of tears of the subscapularis. J Bone Joint Surg Am 2005;87:725-30.
9. Elkousy HA, Fluhme DJ, O'Connor DP, Rodosky MW. Arthroscopic biceps tenodesis using the percutaneous, intra-articular trans-tendon technique: preliminary results. Orthopedics 2005;28:1316-9.
10. Elkousy H, Romero JA, Edwards TB, Gartsman GM, O'Connor DP. Ultrasound and clinical evaluation of soft-tissue versus hardware biceps tenodesis: is hardware tenodesis worth the cost? Am J Orthop (Belle Mead NJ) 2014;43:62-5.
11. Erickson BJ, Basques BA, Griffin JW, Taylor SA, O'Brien SJ, Verma NN, et al. The effect of concomitant biceps tenodesis on reoperation rates after rotator cuff repair: a review of a large private-payer database from 2007 to 2014. Arthroscopy 2017;33:1301-7.e1. https://doi.org/10.1016/j.arthro.2017.01.030
12. Feldman MD. Editorial commentary: to screw or to sew—which is better for arthroscopic biceps tenodesis? Arthroscopy 2016;32:568. https://doi.org/10.1016/j.arthro.2016.01.023
13. Franceschi F, Longo UG, Ruzzini L, Rizzello G, Maffulli N, Denaro V. Soft tissue tenodesis of the long head of the biceps tendon associated to the Roman Bridge repair. BMC Musculoskelet Disord 2008;9:78. https://doi.org/10.1186/1471-2474-9-78
14. Friedman DJ, Dunn JC, Higgins LD, Warner JJ. Proximal biceps tendon: injuries and management. Sports Med Arthrosc 2008;16:162-9. https://doi.org/10.1097/JSA.0b013e318184f549
15. Friedman JL, FitzPatrick JL, Rylander LS, Bennett C, Vidal AF, McCarty EC. Biceps tenotomy versus tenodesis in active patients younger than 55 years: is there a difference in strength and outcomes? Orthop J Sports Med 2015;3. https://doi.org/10.1177/2325967115570848
16. Ge H, Zhang Q, Sun Y, Li J, Sun L, Cheng B. Tenotomy or tenodesis for the long head of biceps lesions in shoulders: a systematic review and meta-analysis. PLoS One 2015;10:e0121286. https://doi.org/10.1371/journal.pone.0121286
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;43:1077-83. https://doi.org/10.1177/0363546515570024
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;33:19-25. https://doi.org/10.1016/j.arthro.2016.07.007
19. Gurnani N, van Deurzen DF, Janmaat VT, van den Bekerom MP. Tenotomy or tenodesis for pathology of the long head of the biceps brachii: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc 2016;24:3765-71. https://doi.org/10.1007/s00167-015-3640-6
20. Hartigan DE, Beran MC, Fleischli JE, D'Alessandro DF, Zheng NN. Biomechanical evaluation of two arthroscopic biceps tenodesis techniques: proximal interference screw and modified percutaneous intra-articular transtendon. Am J Orthop (Belle Mead NJ) 2016;45:E261-7.
21. Hwang JT, Yang CJ, Noh KC, Yoo YS, Hyun YS, Lee YB, et al. Which is better for arthroscopic tenodesis of the long head of the biceps: soft tissue or bony interference fixation? Arthroscopy 2016;32:560-7. https://doi.org/10.1016/j.arthro.2015.10.024
22. 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;4. https://doi.org/10.1177/2325967116645311
23. Klepps S, Hazrati Y, Flatow E. Arthroscopic biceps tenodesis. Arthroscopy 2002;18:1040-5.
24. 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;38:1584-90. https://doi.org/10.1177/0363546510364053
25. Kukkonen J, Rantakokko J, Virolainen P, Aarimaa V. The effect of biceps procedure on the outcome of rotator cuff reconstruction. ISRN Orthop 2013;2013:840965. https://doi.org/10.1155/2013/840965
26. Lee HJ, Jeong JY, Kim CK, Kim YS. Surgical treatment of lesions of the long head of the biceps brachii tendon with rotator cuff tear: a prospective randomized clinical trial comparing the clinical results of tenotomy and tenodesis. J Shoulder Elbow Surg 2016;25:1107-14. https://doi.org/10.1016/j.jse.2016.02.006
27. Leroux T, Chahal J, Wasserstein D, Verma NN, Romeo AA. A systematic review and meta-analysis comparing clinical outcomes after concurrent rotator cuff repair and long head biceps tenodesis or tenotomy. Sports Health 2015;7:303-7. https://doi.org/10.1177/1941738114539627
28. Levin SD, Wellman DS, Liu C, Li Y, Ren Y, Shah NA, et al. Biomechanical strain characteristics of soft tissue biceps tenodesis and bony tenodesis. J Orthop Sci 2013;18:699-704. https://doi.org/10.1007/s00776-013-0429-7
29. Levy JC. Simultaneous rotator cuff repair and arthroscopic biceps tenodesis using lateral row anchor. Arthrosc Tech 2012;1:e1-4. https://doi.org/10.1016/j.eats.2011.12.003
30. Le BT, Wu XL, Lam PH, Murrell GA. Factors predicting rotator cuff retears: an analysis of 1000 consecutive rotator cuff repairs. Am J Sports Med 2014;42:1134-42. https://doi.org/10.1177/0363546514525336
31. Lopez-Vidriero E, Costic RS, Fu FH, Rodosky MW. Biomechanical evaluation of 2 arthroscopic biceps tenodeses: double-anchor versus percutaneous intra-articular transtendon (PITT) techniques. Am J Sports Med 2010;38:146-52. https://doi.org/10.1177/0363546509343803
32. Lutton DM, Gruson KI, Harrison AK, Gladstone JN, Flatow EL. Where to tenodese the biceps: proximal or distal? Clin Orthop Relat Res 2011;469:1050-5. https://doi.org/10.1007/s11999-010-1691-z
33. Matsen FA III, Ziegler DW, DeBartolo SE. Patient self-assessment of health status and function in glenohumeral degenerative joint disease. J Shoulder Elbow Surg 1995;4:345-51.
34. Mazzocca AD, Rios CG, Romeo AA, Arciero RA. Subpectoral biceps tenodesis with interference screw fixation. Arthroscopy 2005;21:896. https://doi.org/10.1016/j.arthro.2005.04.002
35. Meeks BD, Meeks NM, Froehle AW, Wareing E, Bonner KF. Patient satisfaction after biceps tenotomy. Orthop J Sports Med 2017;5. https://doi.org/10.1177/2325967117707737. 2325967117707737.
36. Oh JH, Lee YH, Kim SH, Park JS, Seo HJ, Kim W, et al. 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;32:958-67. https://doi.org/10.1016/j.arthro.2015.11.036
37. Richards RR, An KN, LU Bigliani, Friedman RJ, Gartsman GM, Gristina AG, et al. A standardized method for the assessment of shoulder function. J Shoulder Elbow Surg 1994;3:347-52.
38. Sanders B, Lavery KP, Pennington S, Warner JJ. Clinical success of biceps tenodesis with and without release of the transverse humeral ligament. J Shoulder Elbow Surg 2012;21:66-71. https://doi.org/10.1016/j.jse.2011.01.037
39. Scheibel M, Schroder RJ, Chen J, Bartsch M. Arthroscopic soft tissue tenodesis versus bony fixation anchor tenodesis of the long head of the biceps tendon. Am J Sports Med 2011;39:1046-52. https://doi.org/10.1177/0363546510390777
40. Sekiya JK, Elkousy HA, Rodosky MW. Arthroscopic biceps tenodesis using the percutaneous intra-articular transtendon technique. Arthroscopy 2003;19:1137-41. https://doi.org/10.1016/j.arthro.2003.10.022
41. Su WR, Budoff JE, Chiang CH, Lee CJ, Lin CL. Biomechanical study comparing biceps wedge tenodesis with other proximal long head of

the biceps tenodesis techniques. Arthroscopy 2013;29:1498-505. https://doi.org/10.1016/j.arthro.2013.06.013
42. Tashjian RZ, Belisle J, Baran S, Granger EK, Nelson RE, Burks RT, et al. Factors influencing direct clinical costs of outpatient arthroscopic rotator cuff repair surgery. J Shoulder Elbow Surg 2018;27:237-41. https://doi.org/10.1016/j.jse.2017.07.011
43. Watson ST, Robbins CB, Bedi A, Carpenter JE, Gagnier JJ, Miller BS. Comparison of outcomes 1 year after rotator cuff repair with and without concomitant biceps surgery. Arthroscopy 2017;33:1928-36. https://doi.org/10.1016/j.arthro.2017.05.009
44. Werner BC, Brockmeier SF, Gwathmey FW. Trends in long head biceps tenodesis. Am J Sports Med 2015;43:570-8. https://doi.org/10.1177/0363546514560155
45. Williams GN, Gangel TJ, Arciero RA, Uhorchak JM, Taylor DC. Comparison of the Single Assessment Numeric Evaluation method and two shoulder rating scales. Outcomes measures after shoulder surgery. Am J Sports Med 1999;27:214-21.
46. Wu PT, Jou IM, Yang CC, Lin CJ, Yang CY, Su FC, et al. The severity of the long head biceps tendinopathy in patients with chronic rotator cuff tears: macroscopic versus microscopic results. J Shoulder Elbow Surg 2014;23:1099-106. https://doi.org/10.1016/j.jse.2013.11.013
47. 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;24:3772-8. https://doi.org/10.1007/s00167-015-3641-5
48. Zhang Q, Zhou J, Ge H, Cheng B. Tenotomy or tenodesis for long head biceps lesions in shoulders with reparable rotator cuff tears: a prospective randomised trial. Knee Surg Sports Traumatol Arthrosc 2015;23:464-9. https://doi.org/10.1007/s00167-013-2587-8