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Arthroscopic supraglenoid origin-preserving biceps tenodesis: a reliable, simple, and cost-conscious technique

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Background: The purpose of this study was to assess the midterm clinical and ultrasonographic outcomes of a new all arthroscopic supraglenoid origin-preserving tenodesis technique of the long head of the biceps (LHB) brachii tendon in the setting of small to medium-sized rotator cuff repairs.

Materials and Methods: Thirty patients (33 shoulders) meeting inclusion criteria were identified who underwent LHB tenodesis with this technique in the setting of small to medium-sized rotator cuff repair at a mean age at surgery of 65.6 years between 2015 and 2017. Rotator cuff tears were repaired using the Southern California Orthopedic Institute (SCOI) row technique. The biceps tenodesis was incorporated into the anterior anchor of the rotator cuff repair after bony groove preparation, including débridement and bone vent placement. Frayed edges of the biceps tendon were gently débrided, but the intra-articular glenoid attachment was left intact. Patients were assessed at follow-up by clinical and ultrasonographic examination, as well as a satisfaction questionnaire, the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score and visual analog scale (VAS) score.

Results: Mean follow-up was 32.9 months for the 27 patients (30 shoulders), resulting in a 91% follow-up. Average ASES score was 94.4. Average patient-reported satisfaction with shoulder function was 9.4 of 10 and with biceps contour was 9.9 of 10. Average VAS score was 0.6 of 10, and 73% of patients reported a VAS score of 0. Ultrasonography demonstrated an intact biceps tendon in 27 of 28 shoulders and an intact supraspinatus tendon in all 28 shoulders. Mean range of motion was 170° in forward flexion, 169° in abduction, 49° in external rotation, and to thoracic vertebrae 12 in internal rotation. Mean muscle grading during Jobe test was 4.8 of 5. There were no intraoperative complications. No patients required revision surgery.

Conclusions: In situ arthroscopic biceps tenodesis with maintenance of the glenoid attachment incorporated into rotator cuff repair yields a high rate of healing and consistently excellent functional and cosmetic outcomes as well as patient satisfaction while saving surgical time and cost.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Biceps tendon long head; rotator cuff; arthroscopic; tenodesis; outcomes

Rotator cuff tears are commonly associated with degenerative pathologies of the long head of the biceps (LHB) brachii tendon. Concomitant degeneration, subluxation, or dislocation of the LHB tendon in the setting of full-thickness rotator cuff tearing has been reported to range from 16%-49% of cases.[15,26] Lesions of the biceps

This study was approved by the Western Institutional Review Board (no. 1182985).

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tendon associated with rotator cuff tears may vary in degree and severity, from minor tendinosis to a complete tear. Indications from the literature for treatment of biceps pathology include tears involving >50% of the tendon, medial biceps subluxation, superior labral tears, and biceps subluxation combined with a subscapularis tear.[13] In our experience, it is prudent to consider treating any significant biceps tendon fiber failure or instability knowing that once damaged, the tendon will never spontaneously heal.

Although it is generally agreed on that LHB pathology is a major pain generator in the shoulder and should be addressed at the time of rotator cuff surgery, the method of treatment is an ongoing debate among the orthopedic shoulder surgeon community.[3,5,8,17,18,20,27,28] There are several surgical treatment options, broadly divided into tenotomy or tenodesis. Tenotomy is technically simple and reliably provides pain relief with a rapid recovery without the need for immobilization.[26] However, tenotomy has been associated with cosmetic deformity and muscle spasm, especially in more active patients.[9-11,17,19,21,22,26] Mild decrease in elbow flexion and forearm supination strength has also been shown in some studies, though this loss of strength has been inconsistently demonstrated in the literature.[3,5] Advocates of biceps tenodesis argue that tenodesis preserves biceps length-tension relationship, prevents muscle cramping, minimizes Popeye deformity, and maximizes elbow flexion and supination power.[9-11,19,21,22,26] Many biceps tenodesis techniques have been described in the literature, but none leave the glenoid attachment of the biceps in place.

The purpose of this study was to assess the midterm clinical and ultrasonographic outcomes of a simple, new, all-arthroscopic supraglenoid origin-preserving tenodesis technique of the LHB tendon in the setting of small to medium-sized rotator cuff repairs.

Methods

After obtaining institutional review board approval, billing records were reviewed to identify patient charts that had Current Procedural Terminology (CPT) codes for arthroscopic rotator cuff repair (29827) and arthroscopic biceps tenodesis (29828) performed by the senior author (S.J.S.) between 2015 and 2017. Patients who underwent all-arthroscopic biceps tenodesis during arthroscopic rotator cuff repair with the intra-articular tendon left proximally intact were considered for enrollment in the study. Patients with grade III or IV chondromalacia, subscapularis tears requiring repair, and massive rotator cuff tears were excluded from this study. Each procedure was performed by a single surgeon (S.J.S.). Thirty eligible patients (33 shoulders) were identified who underwent LHB tenodesis with this technique in the setting of small to medium-sized rotator cuff repair at a mean age at surgery of 65.6 years (range 41-84) between the years of 2015 and 2017. All patients were contacted by telephone and e-mail to request a follow-up visit for purposes of the study, and consents were obtained.

Patients were assessed at follow-up by clinical and ultrasonographic examination (Fig. 1). Study subjects were examined for shoulder and elbow range of motion, pain, and strength. An ultrasonographic examination was conducted to evaluate the integrity of the tenodesis site and rotator cuff repair tendon footprint. Patients were asked to complete a questionnaire regarding their satisfaction with shoulder function and biceps contour, as well as the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score and visual analog scale.

Surgical technique

Glenohumeral arthroscopy

As with all of our shoulder arthroscopies, our technique begins with the Southern California Orthopedic Institute (SCOI) ''15-point system'' for performing a complete diagnostic arthroscopic evaluation of the glenohumeral joint.[22] The decision to perform the arthroscopic suture anchor biceps tenodesis is made when an active patient has a torn rotator cuff that is amenable to arthroscopic repair along with biceps pathology and who is not willing to risk the potential deformity and biceps weakness that may result from a biceps tenotomy. Arthroscopic débridement of the torn rotator cuff and biceps anchor is performed as needed. The biceps tendon can be damaged by friction on the rough surface of the intertubercular groove, especially as it turns medially at a right angle over the sharp bony edge of the inlet into the glenohumeral joint. It is therefore important to débride this bony edge of any irregularities, as well as any frayed fragments of the intra-articular portion of the biceps tendon.

Subacromial bursoscopy

Once glenohumeral work is completed, the arm is positioned in the bursal position (30° of abduction and 15° of forward flexion), the arthroscope is then placed in the subacromial space and a complete stepwise ''8-point diagnostic bursoscopy'' is performed.[22] Bursectomy is performed as needed for visualization and subacromial decompression is performed to address any impingement as well as to create room to perform repairs.

Biceps tenodesis

Our technique incorporates the biceps tendon fixation into the anterior rotator cuff repair anchor using a fortified ''Italian Loop'' stitch.[22] The intra-articular portion of the biceps tendon is left in situ at its insertion onto the superior labrum and biceps tubercle, even in the setting of significant tendon pathology, as long as there is enough tendon girth remaining at the articular margin to reliably hold suture.

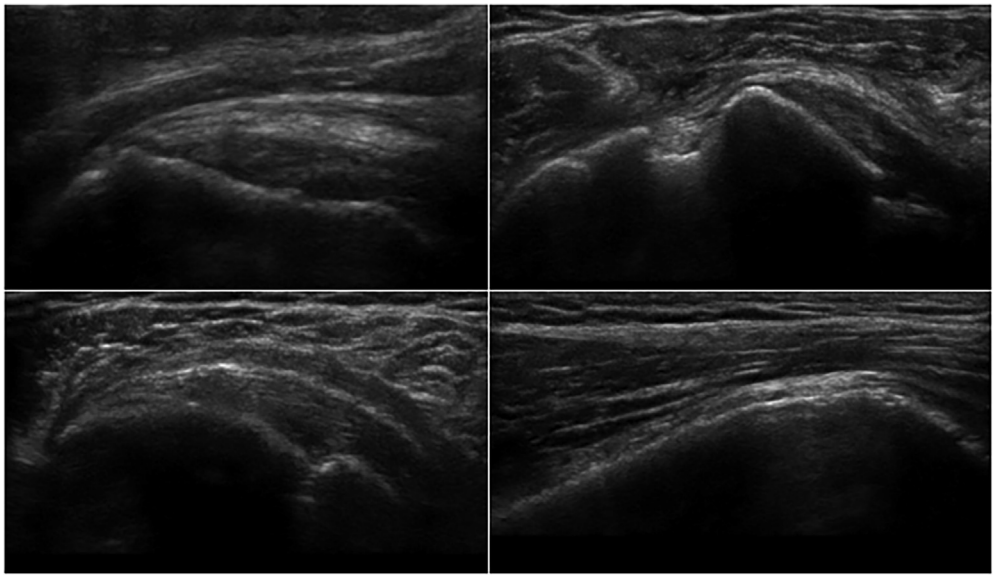

Figure 1 Ultrasonography (intact tenodesis and rotator cuff repair).

With the scope in the midlateral subacromial portal and operating cannulas in the anterior and posterior bursal portals, the steps to perform the tenodesis are as follows (Fig. 2) and (Video 1)[22]:

1. The biceps groove is débrided and lightly decorticated with the biceps tendon retracted anteriorly, taking care to maintain the tubercles. Often, a curette is helpful to completely prepare the biceps groove.
2. The rotator cuff and tuberosity is also débrided of any unhealthy tissue at this time to prepare for later repair.
3. A microfracture awl is used to puncture 2 or 3 bone marrow vents 6-9 mm deep in the bicipital groove as well as throughout the exposed tuberosity away from where the anchors will be placed. These bone vents create a Crimson Duvet as with the standard SCOI row technique, allowing bone marrow elements to egress and promote biceps and rotator cuff healing as well as rotator cuff footprint regeneration.[6,22,23]
4. A triple-loaded anchor with 3 strands of high-strength suture is inserted in the tuberosity just posterior to the biceps groove and at the edge of the articular cartilage.
5. The medial strand of the most anterior suture is passed through the rotator interval tissue if available and then through a healthy portion of the biceps tendon a few millimeters anterior to the anchor via standard shuttling technique with an appropriately curved suture hook placed through the anterior portal.
6. The same suture limb is retrieved and passed a second time through a healthy bite of the biceps tendon again at the level of the anchor from anterior to posterior through the anterior portal, completing the fortified Italian loop stitch.
7. The suture tails are retrieved and tied together with a Revo knot (nonsliding arthroscopic knot).
8. The portion of the biceps tendon proximal to the tenodesis site is left in situ attached at the glenoid, even in the setting of significant tendon pathology.
9. The remaining 2 sutures from the anchor are used to fix the anterior edge of the torn rotator cuff using SCOI Row technique as described below.[6,22,23]

Rotator cuff repair

Rotator cuff tears were repaired using the SCOI row technique, which uses a single row of triple-loaded anchors placed at the articular margin. One anchor is placed for every 12 mm of anterior to posterior rotator cuff tear, resulting in a spacing of 6 mm between each simple suture through the cuff.

Results

Raw data can be seen in Table I. Mean follow-up was 32.9 months (range 17-50 months) for the 27 patients (30 shoulders), resulting in a 91% follow-up. Two patients were interviewed by phone only because of geographical distance and inability to be examined locally. Three patients were unable to be reached despite multiple attempts at contact. Average ASES score was 94.4 (range 71.6-100). Average patient-reported satisfaction with shoulder function was 9.4 of 10 (range 7-10) and with biceps contour was 9.9 of 10 (range 7-10). Average visual analog scale score

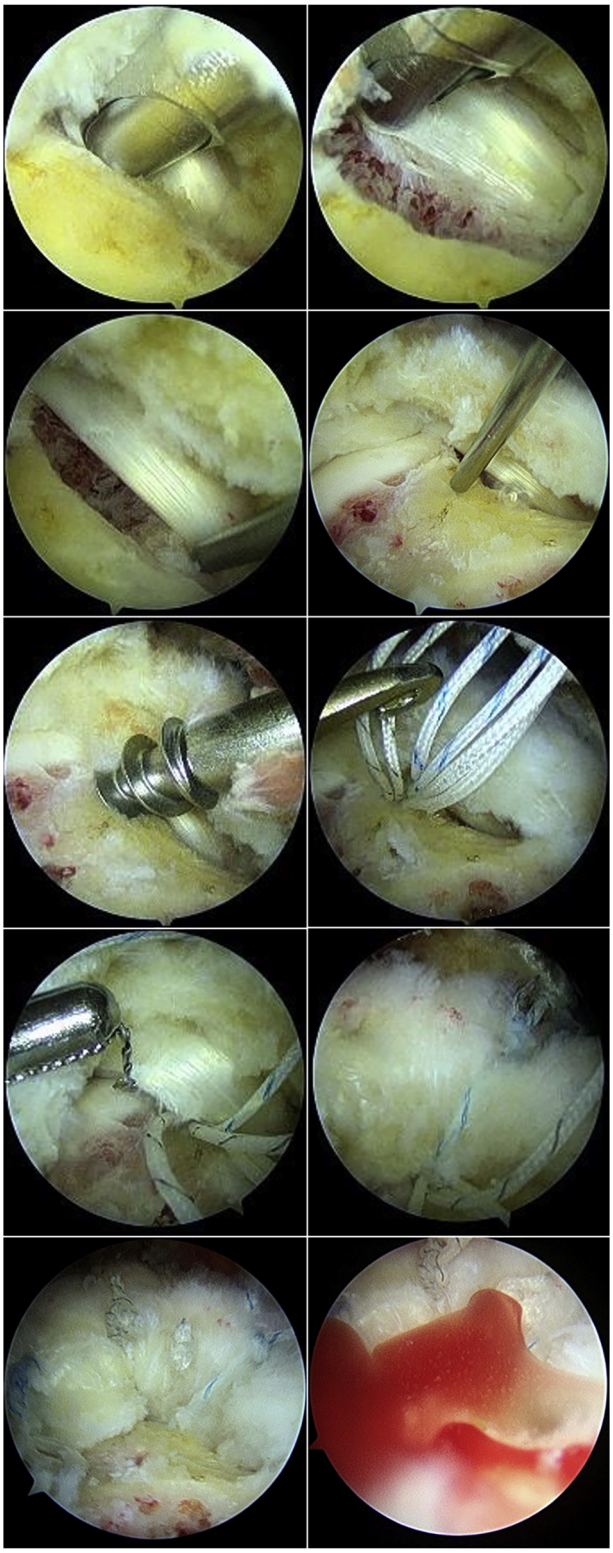

Figure 2 Surgical photos of repair steps.

was 0.6 of 10 (range 0-4), and 73% of patients reported a visual analog scale score of 0. The biceps tendon was intact in 27 of 28 shoulders. In one patient, the tendon was intact in the groove, but ruptured distal to the groove as apparent by ultrasonography as well as causing a resultant Popeye deformity. The supraspinatus tendon was intact on ultrasonography examination in all 28 shoulders. Mean range of motion was 170° in forward flexion, 169° in abduction, 49° in external rotation, and to thoracic vertebrae 12 in internal rotation. Mean muscle grading during Jobe's test was 4.8 (of 5). All patients stated that they were happy they underwent the surgery. There were no intraoperative complications. No patients required revision surgery.

Discussion

Surgical treatment of the LHB globally can be broadly divided into tenotomy or tenodesis. Walch and colleagues[24] were one of the earlier groups to publish on the results of biceps tenotomy as a pain relief procedure in the setting of irreparable rotator cuff tears. Their patients experienced excellent pain relief and increase in functional range of motion, but no improvement in strength. Despite good pain relief with tenotomy, there remains a concern for cosmetic deformity, muscle cramps, and loss of strength.[3,5,8,17,19] These problems appear to be more significant in the young, athletic, and laborer population for whom repeated supination is important, although less apparent in the elderly population.[3,5,8,17,19,26] A 2018 review emphasized a major increase in biceps tenodesis procedures being performed, which can likely be attributed in part to interest in avoiding the potential downsides of tenotomy.[19] With the increasing frequency of tenodesis procedures, it is important to try to determine which techniques have the most reliable results.

LHB tenodesis can be further subdivided into arthroscopic and open tenodesis techniques. Abraham et al[1] reviewed 16 studies and 476 patients, which demonstrated no significant differences comparing arthroscopic and open biceps tenodesis. A large retrospective review of 15,257 patients across multiple institutions also found open and arthroscopic biceps tenodesis to result in comparable outcomes.[7] However, the debate regarding the optimal tenodesis location remains ongoing. Several studies emphasize the importance of occult lesions of the bicipital groove, found to be as common as 80% in Moon's study.[12,15,16,25] Surgeons who advocate for subpectoral tenodesis cite groove pathology, including osteophytes and stenosing tenosynovitis of the LHB, as reasons to perform a subpectoral tenodesis. Although this reasoning is sound, reports of excellent outcomes with articular margin tenodesis raises questions regarding the role groove disease plays in biceps tenodesis outcomes. Brady, Burkhart, and colleagues completed a 7-surgeon study with 1083 patients with a mean 136-week follow-up who underwent arthroscopic LHB tenodesis at the articular margin.[4] Only 4.1% of patients underwent revision surgery, and 0.4% underwent revision specifically for biceps issues. They argue that

Table 1 Raw data for each patient involved in the study

Identifier	Months of follow-up	No. of anchors	Biceps intact	Cuff intact	ASES	Satisfied function	Satisfied contour	VAS	Sex	Age at OR	BMI	Diabetic	Smoker	Pertinent PMH	Workers Compensation	Hand Dominance	FF	Abduction	ER	IR	SSP strength	BG TTP	Speeds	Other positive tests	Surgical side	Supra pain
1	48	2	Y	Y	100	10	10	0	M	41	31	N	N	N	N	R	180	180	60	T12	5	N	N	N	R	
2	50	3			98.3	10	10	0	F	69	33	N	N	N	N	R									L	
3	43	3	Y	Y	100	10	10	0	M	71	25	N	N	N	N	R	170	170	30	T12	5	1+	N	AL bursa 1+	L	
4	44.5	2	Y	Y	100	10	9	0	M	56	27	Y	N	N	N	R	170	170	45	L2	5	N	N	N	R	
5	45	3			100	10	10	0	M	58	26	N	N	N	N	R									R	
6	42	2	Y	Y	95	10	10	1	F	77	25	N	N	N	N	R	17	170	45	T10	4	N	N	N	R	
7	31	3	Y	Y	90	10	10	2	F	55	21	N	N	N	N	R	17	170	45	L3	5	N	N	N	R	
8	42	2	In groove, not distal	Y	100	9	8	0	F	58	23	N	N	N	N	R	17	170	80	T12	4	N	N	N	R	
9	39.5	3	Y	Y	100	10	10	0		82	22	N	N	N	N	R	150	140	35	L1	4	N	N	N	R	
10	39.5	2	Y	Y	95	9	10	1	M	62	25	N	N	N	N	R	170	170	50	T12	5	N	N	N	R	1+
11	42	2	Y	Y	83.3	9	10	1	F	65	23	N	N	N	N	L	160	160	40	L1	5	1+	N	N	R	
12	29	3	Y	Y	93	8	10	0	M	65	28	Y	N	N	N	R	170	170	45	L1	5	N	N	N	R	
13	35.5	2	Y	Y	100	10	10	0	M	77	27	Y	Former	N	N	L	180	180	60	T10	5	N	N	N	R	
14	35	3	Y	Y	100	9	10	0	F	66	25	N	N	RA, Fibro	N	R	180	180	60	T10	5	N	N	N	R	
15	32	2	Y	Y	95	10	10	0	F	63	18	N	N	N	N	R	160	160	45	L1	4	N	N	N	R	
16	34	3	Y	Y	86.6	9	10	2	M	71	30	N	N	N	N	L	170	170	45	T12	5	N	N	N	R	
17	30	2	Y	Y	100	10	7 due to elbow	0	M	82	33	N	Y	N	Y	R	170	160	50	L1	5	N	N	N	L	
18	33	2	Y	Y	100	10	10	0	M	58	27	N	N	N	N	R	160	160	40	L3	5	N	N	N	R	
19	30	2	Y	Y	100	10	10	0	M	59	31	N	N	N	N	R	170	170	50	L1	5	1+	N	N	R	
20	29	3	Y	Y	85	10	10	0	M	66	28	N	Y	N	N	R	170	170	45	L1	5	N	N	N	L	
21	29	3	Y	Y	71.6	7	10	4	M	57	26	N	N	N	N	R	180	180	35	T12	4	N	N	N	R	1+
22	28.5	2	Y	Y	100	10	10	0	M	67	25	N	N	N	N	R	170	160	60	L1	5	N	N	N	R	
23	24.5	2	Y	Y	100	10	10	0	M	78	23	N	N	sp Chemo +rad	N	L	170	170	45	L1	5	N	N	N	R	
24	24	2	Y	Y	100	10	10	0	M	63	28	N	N	N	N	L	180	180	45	T10	5	N	N	N	L	
25	24	2	Y	Y	100	9	10	0	M	53	24	N	N	N	N	R	180	180	50	T8	5	N	N	N	L	
26	24	2	Y	Y	74.9	7	10	3	F	64	27	N	N	N	N	R	165	165	60	T10	5	1+	N	N	L	
27	23	3	Y	Y	100	10	10	0	M	76	24	Y	N	N	N	R	170	170	65	T10	5	N	N	N	R	
28	20.5	2	Y	Y	100	10	10	0	M	59	31	N	N	N	N	R	170	170	40	T12	5	N	N	N	L	
29	19	2	Y	Y	93.3	8	10	1	M	84	33	N	Y	N	Y	R	170	160	50	T12	5	N	N	N	R	
30	17	2	Y	Y	71.6	7	10	2	F	67	23	N	N	N	N	L	160	165	45	L1	5	N	1+	N	L	

Y, yes; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *VAS*, visual analog scale; *M*, male; *F*, female; *OR*, operation; *BMI*, body mass index; *N*, no; *PMH*, past medical history; *RA, Fibro*, rheumatoid arthritis, fibromyalgia; *sp Chemo+rad*, status post chemo and radiation; *R*, right; *L*, left; *FF*, forward flexion; *ER*, external rotation; *IR*, internal rotation; *SSP*, supraspinatus; *BGTTP*, biceps groove tenderness to palpation; *AL*, anterolateral; *Supra*, supraspinatus.

good results are attainable with this type of tenodesis despite other groups noting a revision rate up to 45.5% when the LHB tenodesis is performed high in the groove without decompressing the bicipital sheath.[20] The Burkhart team suggests that this discrepancy in outcomes potentially may be attributed to missed pathology involving the subscapularis or subcoracoid impingement.[4]

Our results in this study are akin to those of the Burkhart team, with excellent patient satisfaction and functional outcomes and zero revisions required. The idea behind this technique initially stemmed from early experience with rotator cuff reconstruction using human dermal allograft. In many of these cases, there was minimal anterior cuff tissue remaining to which the graft could be attached. Thus, when the biceps tendon was present, we would tenodese the tendon at the articular margin, leave the glenoid attachment in place, and sew the graft anteriorly to the stabilized LHB tendon.[22] We found that these patients generally did not have LHB symptoms at follow-up, which prompted the decision to perform this type of tenodesis in standard rotator cuff repairs as well.

Discrepancies in the outcomes of articular margin tenodesis in the literature suggest the specific technique used may play a significant role. We emphasize several critical points to consider when performing our technique to ensure good results. First, the arm must be maintained in the bursal position during tenodesis to ensure the tendon is fixed with appropriate length and tension to avoid loss of motion. Second, a strong stitch, such as the Italian Loop must be used to reliably secure the biceps tendon. Finally, it is critical to prepare the bicipital groove by débridement and placement of bone vents to stimulate healing. Without bone preparation, the tendon, although fixed, may not heal to the bone and result in persistent pain.

With several authors reporting excellent outcomes with articular margin tenodesis, there remains a looming question of how reliably good results can be attained in the setting of a high incidence of occult groove disease. An interesting study by Alpantaki et al[2] investigated the sympathetic and sensory innervation of the LHB and demonstrated that the tendon origin and proximal third was the most densely innervated. Nuelle and colleagues[18] also demonstrated that section of the biceps tendon from its origin at the glenoid to the bicipital tunnel tends to have the most tendinopathy changes.[14] These 2 studies suggest that the proximal portion of the tendon is likely the greatest pain generator. Although these studies lend support to the success of articular margin tenodesis reported by some authors, they do not explain the successful outcomes with our technique, because it preserves the pathologic proximal tendon and its glenoid attachment. Our results support the notion that excising the disease may not be the only solution to pain relief. We theorize that perhaps residual tendon and groove pathology becomes irrelevant when tendon motion within the groove is eliminated with tenodesis.

Our study suggests that biceps tenosynovitis, groove pain, and pain generated by biceps anchor pathology may be alleviated by fixing the tendon at the articular margin with its native tension. This form of tenodesis is technically simple to perform and avoids any guesswork with tensioning the biceps. The benefit of preserving the biceps glenoid anchor attachment includes augmentation of the cuff repair with the proximal stump, which supports the anterior superior portion of the cuff hood. Maintaining the proximal stump also adds strength to the biceps tenodesis by sharing tension with the sutures in the Italian loop. This technique is both cost conserving by negating the need for an additional anchor for the biceps tendon, and potentially timesaving given the time needed to prepare the groove and fix the LHB is generally less than 5 minutes. An additional open incision as well as the time needed to close that incision is also avoided.

Limitations of this study include its retrospective nature as well as a lack of preoperative patient-reported outcomes scores. Also, the patient population studied is reflective of a typical surgical center with patients who are generally healthy, with few patients who have a history of smoking, workers compensation, diabetes, or significant comorbidities. It must also be noted that although the youngest patient in the study was 41 years old, the average patient age was 65.6, so these results should not be extrapolated to young patients or high-level athletes. For these patients, a tenodesis should always be performed in the setting of significant biceps pathology, but the surgeon should use appropriate clinical judgment in deciding which tenodesis technique is most reliable for that patient population in his or her hands.

Conclusions

With meticulous technique, in situ arthroscopic biceps tenodesis with maintenance of the glenoid attachment incorporated into rotator cuff repair yields a high rate of healing and consistently excellent functional and cosmetic outcomes as well as patient satisfaction while saving cost and, potentially, surgical time.

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.2020.03.013.

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