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Case-control comparison of "in-the-groove" and lateral-row arthroscopic biceps tenodesis with concomitant rotator cuff repair

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Background: Lateral-row (LR) arthroscopic biceps tenodesis (BT) has been described as a technique using an LR rotator cuff repair (RCR) anchor for biceps fixation. This technique has not been compared with other BT techniques. The purpose of this study was to compare the clinical outcomes of patients undergoing a suprapectoral "in-the-groove" arthroscopic BT and patients treated with an LR tenodesis performed in conjunction with arthroscopic RCR.

Methods: Patients undergoing arthroscopic BT in the setting of an arthroscopic RCR were evaluated preoperatively and at a minimum of 12 months' follow-up. Patients who underwent an in-the-groove BT were matched 1:1 to patients who underwent an LR BT based on age at surgery and size of the rotator cuff tear using the Patte classification. Comparisons made included age, sex, body mass index, patient-reported outcome measures, range of motion, and patient satisfaction.

Results: There were 82 patients (41 in each group) who met the inclusion criteria, with an average follow-up period of 33 months and average age of 61 years. By use of the Patte classification, there were 20 matched pairs with stage 1 tears, 11 matched pairs with stage 2 tears, and 10 matched pairs with stage 3 tears. Comparisons of the 2 cohorts revealed no differences in preoperative or postoperative motion, patient-reported outcome measures, or patient satisfaction. Furthermore, no differences were found in overall improvements in motion or outcome measures, as well as overall satisfaction.

Conclusions: Patients undergoing simultaneous RCR and BT demonstrate similar patient-reported and objective outcomes for both LR tenodesis and in-the-groove tenodesis techniques.

Long head of the biceps (LHB) pathology frequently coexists with rotator cuff tears. There is a wide spectrum of pathology in a diseased biceps tendon,[2,9] including tearing and instability at the superior labrum origin, hypertrophy and thickening of the mid-substance, instability and attrition distal to the level of the bicipital groove, diffuse tearing, and tenosynovitis. Although the microscopic and macroscopic appearance of a diseased tendon has been well described,[5] it is still not fully understood exactly how these changes contribute to the generation of shoulder pain.

Although there is debate regarding the proper management of biceps pathology,[11] there is a common belief that the pathology of the biceps tendon is a major pain generator in the shoulder. Thus, recommendations have focused on releasing the biceps tendon from its insertion on the glenoid and either relocating the tendon or allowing the tendon to recede.[26,28] As a result, multiple surgical solutions have been attempted, with good results, ranging from simple tenotomy to open and arthroscopic biceps tenodesis (BT), with fixation anywhere along the bicipital groove[3] from the upper border of the pectoralis major tendon to the most superior aspect of the bicipital groove.

As various methods for BT have been proposed, one of the most commonly used surgical techniques remains securing the transferred biceps tendon proximally within the bicipital groove (ie, "in the groove") using arthroscopic techniques.[4] Our institution routinely uses a previously reported arthroscopic tenodesis technique that incorporates the BT into the lateral-row (LR) anchor

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during rotator cuff repair (RCR).[16] This technique is a simple, quick, reproducible, and cost-effective means of performing a simultaneous BT with a double-row RCR. However, it remains unclear if the results of this technique compare to other methods of BT.

The purpose of this study was to assess clinical outcomes and patient satisfaction when using an LR tenodesis in conjunction with RCR vs. an in-the-groove tenodesis using a case-control analysis. The hypothesis anticipated that patients undergoing LR BT would experience similar outcomes and satisfaction to patients undergoing in-the-groove BT during concomitant arthroscopic RCR.

Methods

A retrospective review of our institution's shoulder and elbow surgery registry was conducted for all patients undergoing arthroscopic BT in the setting of an arthroscopic RCR from 2008 to 2015. On the basis of previous work that identified a plateau in clinical outcomes at 12 months after arthroscopic RCR,[14] all patients with complete preoperative data points and a minimum of 12 months' follow-up were included. Patients undergoing partial or revision RCR were excluded. All procedures were performed by the senior author using either the in-the-groove or LR BT technique. An in-the-groove BT was typically selected when the LR suture anchor was unable to accommodate additional sutures.

Overall, fewer in-the-groove BT procedures were performed; however, to minimize potential selection bias, a case-control analysis was performed by matching patients 1:1 based on age at surgery and size of the rotator cuff tear, which was classified intraoperatively by the senior author using the Patte classification[25] and documented in the operative record. The rotator cuff tear size was assessed with the patient's arm in the neutral position to best evaluate the actual degree of retraction. Two cohorts were created among patients undergoing arthroscopic RCR: in-the-groove BT and LR BT. Comparisons made between the 2 cohorts included age at surgery, sex, body mass index (BMI), patient-reported outcome measures (PROMs), range of motion (ROM), and patient satisfaction.

Per the standard institutional shoulder surgery repository protocol, data points for PROMs and ROM were routinely collected preoperatively and at 3, 6, and 12 months postoperatively, as well as annually thereafter. An automated e-mail message was generated for patients with missed follow-up appointments. The generated message included an encrypted link that allowed patients to complete PROM surveys using a Health Insurance Portability and Accountability Act–protected Web-based portal.[32] PROMs collected included the American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test score, Single Assessment Numeric Evaluation score, visual analog scale pain score, and Short Form 12 Mental Component Score and Physical Component Score. At each patient evaluation, best-effort active ROM was measured with a manual goniometer and recorded. Measured motion assessment included forward elevation, external rotation, and internal rotation. The internal rotation measurement was defined as the highest segment of the mid back that could be reached and was converted to a numerical value.[31] Patient satisfaction with the surgical procedure was defined and reported as "excellent," "good," "satisfied," or "unsatisfied." Comparisons were made between the 2 cohorts for preoperative variables, postoperative variables, and changes in outcome scores and measured motion from preoperatively to postoperatively.

Surgical technique

All surgical procedures were performed by a single shoulder and elbow fellowship–trained orthopedic surgeon (senior author, J.C.L.) at a single institution with the patient in the beach-chair position. The LHB tendon was inspected within the joint as well as within the bicipital groove by pulling the tendon into the joint. When sufficient biceps pathology of the LHB tendon was identified (significant tearing, subluxation, or hourglass stenosing tenosynovitis), an anterolateral accessory portal was established just inferior to the anterolateral acromion with the patient's arm in 30° of external rotation. Through this portal, a No. 11 blade was used to release the transverse humeral ligament, and a clamp was used first to mark the lateral-most aspect of the biceps tendon within the joint and then to secure the biceps tendon just distal to the origin. Next, a basket punch was used through the anterior portal, and the biceps was released from the origin at the biceps anchor. The shoulder and elbow were then flexed to remove tension from the biceps and allow ease of delivery of the tendon out of the anterolateral portal. With the clamp still fixated to the tendon, the tendon was pulled out through the anterolateral portal. A secondary clamp was used to assist in skin retraction and to achieve better tendon exposure. Next, a No. 2 FiberWire suture (Arthrex, Naples, FL, USA) was placed in a locking Krackow fashion through the tendon just inferior to the distinguishable clamp mark on the tendon. The proximal section of the tendon was then excised. With 2 suture limbs parked in the anterolateral portal, the tendon was allowed to retract back into the bicipital groove of the shoulder.

Next, attention was directed to the RCR. Mobilization of the rotator cuff was performed to prepare for a double-row transosseous-equivalent repair. A healing surface was created by light débridement of a portion of the greater tuberosity at the footprint. Anchors were placed medially along the articular margin with passage of sutures through the rotator cuff, followed by knot fixation.

In cases of LR BT, the entire lateral wall of the transverse humeral ligament was released, allowing free mobility of the biceps tendon. One limb of each suture from the medial-row anchors was then combined with the bicep tendon suture limbs, placed into a 5.5-mm polyether ether ketone (PEEK) self-punching SwiveLock anchor (Arthrex), and advanced just posterior to the bicipital groove. When necessary, a second 5.5-mm PEEK self-punching SwiveLock LR anchor was used to secure the remaining medial-row rotator cuff sutures in a more posterior position.

When the anterior LR anchor was not able to accommodate additional sutures, an in-the-groove BT was performed. The rotator cuff sutures from the medial-row anchor(s) were advanced into 5.5-mm PEEK self-punching SwiveLock LR anchors. The bicipital groove was then cleared of soft tissue, and the biceps tendon sutures were placed into a separate 5.5-mm PEEK self-punching SwiveLock anchor and advanced into the bicipital groove.

Postoperative protocol

Postoperative rehabilitation was identical for all patients. The shoulder was maintained in a shoulder immobilizer for a minimum 6 weeks. Two rehabilitation groups were established, and patients were assigned 1 of these 2 groups based on the size of the rotator cuff tear. Those with Patte stage 1 tears[25] began a physical therapist–directed protocol within 1 week of surgery. The protocol focus allowed early active assisted and passive motion. Those with Patte stage 2 or 3 tears[25] were given a self-directed home program consisting of only pendulum exercises for the shoulder for the initial 6 weeks, followed by an active-assisted stretching program for the subsequent 6 weeks. Both protocols emphasized that resisted elbow flexion and supination should be avoided during the initial 6 weeks and strengthening exercises should be avoided for the first 3 months postoperatively.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics software (version 23; IBM, Armonk, NY, USA). Data were not normally distributed; thus, descriptive statistics including medians (with interquartile ranges [IQRs]) and frequencies were computed for all variables. The Wilcoxon signed rank test was used to compare continuous variables, and the McNemar test was used to compare categorical variables. All statistical tests were 2 tailed, and $P < .05$ was used to determine significance. The number of eligible patients limited the sample size; thus, post hoc power analysis was performed using G*Power software (version 3.1.9.3; Kiel University, Kiel, Germany).

Results

Among the 82 patients who met the inclusion criteria (41 patients in each group), the average age was 61 years (range, 38-82 years), with an average follow-up period of 33 months (range, 12-92 months) and an average BMI of 26 (range, 19-41). Patients in each cohort were matched based on age at surgery and size of the rotator cuff tear using the Patte classification.[25] There were 20 matched pairs (48.6%) with stage 1 rotator cuff tears, 11 matched pairs (26.8%) with stage 2 tears, and 10 matched pairs (24.4%) with stage 3 tears between the 2 cohorts.

The in-the-groove cohort consisted of 28 men (68.3%) and 13 women (31.7%) with a median follow-up period of 29 months (IQR, 13-92 months), median age of 61.2 years (IQR, 37.5-82.5 years), and median BMI of 27.3 (IQR, 25.1-30.5). The LR cohort consisted of 31 men (75.6%) and 10 women (24.4%) with a median follow-up period of 36 months (IQR, 12-85 months), median age of 61.3 years (IQR, 39.3-79.4 years), and median BMI of 25.7 (IQR, 23.6-27.5).

Comparisons of preoperative characteristics of the patients treated with in-the-groove vs. LR BT are shown in Table I. No significant differences were found between the 2 cohorts regarding sex, operative side, dominant-side surgery, PROMs, or measured ROM. However, BMI was statistically but not clinically significantly different between the in-the-groove (median, 27.3; IQR, 25.1-30.5) and LR (median, 25.7; IQR, 23.6-27.5) cohorts ($P = .015$).

Postoperative characteristic comparisons between the 2 cohorts are shown in Table II. Again, no significant differences were found between the 2 cohorts regarding patient satisfaction, PROMs, ROM, and manual strength testing. Although not significantly different, patient satisfaction with surgery was rated excellent by 30 patients (73.2%) who underwent in-the-groove surgery compared with 35 patients (85.4%) treated with an LR BT.

Treatment efficacy comparisons between the 2 cohorts are shown in Table III. No significant differences were found when comparing preoperative-to-postoperative changes in all variables assessed (PROMs, ROM, and manual strength testing).

Post hoc power analysis using the Wilcoxon signed rank test with 41 matched pairs, a 2-tailed α of .05, and a power of 0.8 showed that the minimum detectable effect size (dz) was 0.43. The sample size was thus sufficiently powered to detect a medium effect size in the examined variables between the 2 cohorts.

Table I
Comparison of preoperative characteristics of patients treated with in-the-groove vs. lateral-row bicep tenodesis (N = 82)

Variable	Preoperative value, median (IQR) or n (%)		*P* value
	Groove (n = 41)*	Lateral row (n = 41)*	
BMI	27.3 (25.1-30.5)	25.7 (23.6-27.5)	.015
Sex			.461
Male	28 (68.3)	31 (75.6)	
Female	13 (31.7)	10 (24.4)	
Operative side			.169
Right	23 (56.1)	29 (70.7)	
Left	18 (43.9)	12 (29.3)	
Surgery on dominant side	24 (58.5)	28 (68.3)	.359
SST score	5 (4-5)	6 (4-9)	.431
SF-12			
PCS	39 (34.6-48.5)	40.2 (31.9-47.1)	.794
MCS	54.7 (50.1-60.4)	57.4 (52.9-64.2)	.210
SANE score	4 (3-6)	5 (4-6)	.334
ASES score	47.4 (30-61.7)	40.9 (30.4-54.6)	.506
ASES score for function	23.1 (13.3-30)	20 (11.7-26.7)	.816
VAS pain score	5 (2-7)	6 (4-7)	.367
Active external rotation, °	50 (30-60)	60 (40-60)	.298
Active elevation, °	145 (130-170)	155 (60-170)	.928
Active internal rotation†	8 (7.5-10)	8 (8-10)	.214

IQR, interquartile range; *BMI*, body mass index; *SST*, Simple Shoulder Test; *SF-12*, Short Form 12; *PCS*, Physical Component Score; *MCS*, Mental Component Score; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale.

* Patients were matched by age and rotator cuff retraction grade.

† Active internal rotation was evaluated on a 10-point scale: 2 points, buttock or greater trochanter; 4 points, sacrum to L4; 6 points, L3 to L1; 8 points, T12 to T8; and 10 points, T7 to T1.

Discussion

A variety of surgical techniques to address a pathologic LHB tendon have been described in the literature. A diseased tendon is commonly encountered during RCR, as described in a recent meta-analysis by Chen et al[7] that noted that 76% of patients treated with BT underwent simultaneous RCR. With numerous techniques available for BT, selection of a surgical technique that has minimal additional morbidity, lower costs, and equivalent outcomes is preferred. The findings of our study suggest that equivalent outcomes can be achieved with a BT using an additional anchor placed within the bicipital groove (ie, in-the-groove technique) and with a technique incorporating the BT directly into the RCR. This finding highlights the appeal of an LR BT that uses no additional anchors and incorporates the biceps tendon into the LR anchor for double-row RCR.

Several different methods and locations for anchoring the LHB tendon have been described, including securing the tendon to the repaired rotator cuff, performing a transfer to the conjoint tendon, or securing the tendon proximal to, within, or distal to the bicipital groove in an arthroscopic or open manner.[1,27] Few studies have examined the results of concomitant RCR and proximal arthroscopic BT. Nho et al[22] reported on a series of 17 patients who underwent successful RCR with subpectoral distal BT, all experiencing significant improvements in the Simple Shoulder Test score, the ASES score, and shoulder function outcomes. Other studies have specifically examined proximal arthroscopic BT in RCR, either using a separate biceps suture anchor or using a soft tissue tenodesis,[6,10,13] in which the biceps tendon is simply sutured directly to the torn rotator cuff tendon. Clinical outcomes, cosmesis, and structural integrity appear to be greater with bony suture anchor fixation.[29] Park et al[24] recently described a technique of combined bony and soft tissue tenodesis by suturing the tendon to the rotator interval in addition to placing a separate suprapectoral suture anchor in the bicipital groove. Lee et al[15] reported decreased pain and increased ASES and Constant scores in 84 patients undergoing suture anchor tenodesis in the bicipital groove in the setting of RCR. Although they described evidence of distal migration of the tenodesis in 15 patients (25%), this was deemed clinically insignificant. Our study is the first to compare 2 unique proximal

Table II
Comparison of postoperative characteristics of patients treated with in-the-groove vs. lateral-row bicep tenodesis (N = 82)

Variable	Postoperative value, median (IQR) or n (%)		*P* value
	Groove (n = 41)*	Lateral row (n = 41)*	
Patient satisfaction with surgery			.421
Excellent	30 (73.2)	35 (85.4)	
Good	8 (19.5)	3 (7.3)	
Satisfied	2 (4.9)	2 (4.9)	
Unsatisfied	1 (2.4)	1 (2.4)	
SST score	11 (8-12)	11 (9.5-12)	.396
SF-12			
PCS	52.3 (44-55.9)	49.5 (40.2-55.3)	.312
MCS	56.2 (52.7-59.8)	56.9 (54-60.6)	.494
SANE score	9 (8-10)	9 (8-10)	.919
ASES score	91.7 (78.3-96.7)	91.7 (75-98.3)	.719
ASES score for function	45 (38.3-50)	46.7 (40-50)	.319
VAS pain score	0 (0-1.5)	0 (0-3)	.579
Active external rotation, °	52.5 (40-60)	60 (40-60)	.862
Active elevation, °	170 (145-170)	160 (150-170)	.948
Active internal rotation†	8 (8-9.5)	8 (8-10)	.144

IQR, interquartile range; *SST*, Simple Shoulder Test; *SF-12*, Short Form 12; *PCS*, Physical Component Score; *MCS*, Mental Component Score; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale.

* Patients were matched by age and rotator cuff retraction grade.

† Active internal rotation was evaluated on a 10-point scale: 2 points, buttock or greater trochanter; 4 points, sacrum to L4; 6 points, L3 to L1; 8 points, T12 to T8; and 10 points, T7 to T1.

tenodesis techniques in the setting of RCR, demonstrating that the addition of a separate biceps suture anchor is not needed to achieve good clinical outcomes.

Authors who advocate a more distal BT location focus on the benefits of excising diseased tenosynovial tissue along the path of the bicipital groove.[17,21] Proponents of distal fixation techniques report additional benefits including direct visualization of anatomic landmarks, ease of reproducibility, and a theoretically faster learning curve, in addition to removal of a greater portion of the diseased intra-articular portion of the tendon.[9] It is thought that entirely removing the diseased tendon from the bicipital groove and its original intra-articular location can decrease the "pain generator" effect, although this has not been well substantiated in the literature.[17,19] Sanders et al[28] analyzed 127 biceps surgical procedures with an average follow-up period of 22 months and demonstrated a higher revision rate after a technique that did not release the biceps sheath (20.6%, 14 of 68 patients) compared with a technique that released the biceps sheath (6.8%, 4 of 59 patients). Although the LR BT technique used in our study may have similar benefits to more distal tenodesis methods owing to the release of the entire lateral border of the transverse humeral ligament, no differences in clinical outcomes were observed compared with the in-the-groove technique. Future comparison of LR BT with distal tenodesis techniques would be helpful in further identifying the benefits of transverse humeral ligament release as a means of eliminating pain pathology from within the bicipital groove.

Table III
Comparison of treatment efficacy (preoperative-to-postoperative change) in patients treated with in-the-groove vs. lateral-row bicep tenodesis (N = 82)

Variable	Preoperative-to-postoperative change, median (IQR) or n (%)		*P* value
	Groove (n = 41)*	Lateral row (n = 41)*	
SST score	4 (2-7)	5 (3-7)	.429
SF-12			
PCS	10.8 (0-18.4)	7.5 (3-14.9)	.814
MCS	0 (−5.9 to 3.9)	−1.9 (−4.4 to 3.2)	.686
SANE score	3.5 (2-6)	4 (2-5)	.621
ASES score	36.7 (21.3-51.3)	41.7 (23.3-54.9)	.304
ASES score for function	16.7 (7.7-25)	23.4 (11.7-35)	.111
VAS pain score	−4 (−6 to −1)	−3.5 (−6 to −2)	.660
Active external rotation, °	0 (−5 to 15)	0 (−5 to 5)	.213
Active elevation, °	0 (0-30)	0 (−5 to 40)	.905
Active internal rotation†	0 (0-2)	0 (0-2)	.795

IQR, interquartile range; *SST*, Simple Shoulder Test; *SF-12*, Short Form 12; *PCS*, Physical Component Score; *MCS*, Mental Component Score; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale.

* Patients were matched by age and rotator cuff retraction grade.

† Active internal rotation was evaluated on a 10-point scale: 2 points, buttock or greater trochanter; 4 points, sacrum to L4; 6 points, L3 to L1; 8 points, T12 to T8; and 10 points, T7 to T1.

With similar outcomes between the 2 studied techniques, the advantages of the LR BT relate to the simplicity of the technique, the ability to secure the tendon using no additional anchors, and the potential financial savings in operating room time and anchor costs. Furthermore, as a proximal BT technique, it avoids the rare but serious risks of neurovascular injury and proximal humeral fracture previously described with certain distal tenodesis techniques.[23] In addition, with the modern health care focus on value, the cost savings achieved with the LR BT technique likely improve value based on equivalent outcomes with lower total costs. Further investigation into the value impacts of this surgical technique is warranted, as a financial analysis of total cost was not accessible for this study.

Both techniques in this study used suture anchor fixation for BT. Several studies have examined the different methods of fixation, including soft tissue tenodesis, interference screws, suture anchors, cortical buttons, and keyhole and bone tunnel techniques.[4,12,19,20,33] For arthroscopic BT, multiple studies have supported the use of either suture anchors or interference screws as viable fixation options.[30] Mazzocca et al[18] showed near equivalence among several techniques including open subpectoral bone tunnel, arthroscopic suture anchor, open subpectoral interference screw, and arthroscopic interference screw fixation. It is our observation that a strong and successful repair can be obtained by incorporating both the RCR and BT within the same suture anchor, with no difference in clinical outcome.

The strengths of this study include matching and comparing patients according to rotator cuff tear size, which helped minimize the inherent bias of comorbid shoulder pathology when assessing outcomes that included RCR. The use of an identical rehabilitation protocol in both cohorts further helped limit variability in recovery pathways. Limitations of the study relate to evaluation of only two

of the multitude of described BT techniques, without comparison to distal tenodesis techniques, as well as the lack of confirmatory imaging to characterize tendon healing. Furthermore, patient comorbidities and average operating room times were not assessed in our comparative analysis. Although no differences were observed between the 2 cohorts, the post hoc power analysis suggested that the sample size was sufficiently powered to detect a medium effect size, or visible difference, in the examined outcome variables between the 2 cohorts but was underpowered to detect a small effect size, which may have limited clinical significance.[8]

Conclusion

Patient-reported and objective outcomes after LR tenodesis were comparable to those after in-the-groove tenodesis when performed together with arthroscopic RCR.

Disclaimer

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