Preliminary Result of Arthroscopic Keyhole Biceps Tenodesis A Novel Technique

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Abstract: There is increased interest of the orthopedic surgeons in treating the pathology of long head of biceps. Although there is some clarity in the result of biceps tenotomy, it is not so clear concerning tenodesis. An open keyhole tenodesis of biceps is shrouded with concerns of primary stability, use of deltopectoral incision, operative pain, technical difficulty to access biceps tendon in case of intact or small cuff tear, and cosmesis. The purpose of the study is to describe an arthroscopic proximal biceps keyhole tenodesis and evaluate the outcome of the procedure.

Key Words: arthroscopy, keyhole, biceps tenodesis, technique

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The pathology affecting long head of biceps tendon (LHBT) can be because of trauma, microinstability, increased activity, or underlying inflammatory disease.¹ The LHBT's close relation with the rotator cuff leads to degeneration because of mechanical impingement and in turn a chronic inflammatory response results in hypertrophy of tendon.^{1,2} The LHBT has a rich sympathetic and sensory neural network because of which it is thought to be a pain generator in the shoulder.³ The surgical treatment for biceps pathology is tenotomy or tenodesis. But, there is no clear consensus with the most appropriate technique.⁴

A simple tenotomy is fraught with distal migration of the LHBT, popeye deformity, recurrent muscle spasm, fatigue, and discomfort with active elbow flexion and supination.⁵ Tenodesis techniques involve fixation of the tendon through a bone tunnel or by a suture anchor, staple or interference screw or suturing to rotator cuff, transverse humeral ligament, or conjoint tendon.^{6,7} There are, however, potential problems with tenodesis that should not be overlooked such as, longer surgical time, longer rehabilitation, anterior shoulder pain, recurrent muscle spasm, and symptomatic fixation or hardware.^{8,9}

We describe here an all arthroscopic technique of keyhole proximal biceps tenodesis and evaluate the results of the procedure. The hypothesis of the study was, can the arthroscopic keyhole biceps tenodesis be a safe, reproducible, and cost-effective technique.

MATERIALS AND METHODS

From May 2010 to October 2010, all the patients who had undergone arthroscopic keyhole tenodesis of the biceps tendon were analyzed in the preliminary study. The average age of the patient was 54 years (range, 43 to 70 y). There were 16 right arm injuries and 4 left arm injuries. Most of the patients were manual worker (n=17). All the patients who had anterior shoulder pain reproduced by tenderness in the intertubercular groove and frequently accompanied by active compression test indicating biceps tendon pathology, in addition to symptom and signs of cuff tear were included in the study. The local institution review board approved the study and all the patients gave written informed consent for the study.

The associated cuff tear was grouped as anterosuperior (subscapularis and supraspinatus) and posterosuperior (supraspinatus and infraspinatus), respectively. There were 12 anterosuperior cuff tears and 8 posterosuperior cuff tears. The biceps tendon pathology was grouped into 3 types as described by Eakin et al,¹⁰ biceps tendon instability (n=5), biceps tendon degeneration (n=14), and biceps tendon superior labrum anterior and posterior lesion (n=1). All the cases underwent arthroscopic keyhole proximal tenodesis of biceps tendon, in addition to cuff repair. The following were the cuff repairs, 2 transosseous cuff repairs, and 9 simple cuff repairs, respectively. All the cases were followed for a minimum period of 3 months to a maximum of 6 months (Table 1).

Surgical Technique

The patient is positioned in standard lateral posture with traction of approximately 10 pounds on the affected limb. A hypotensive anesthesia with a mean systolic pressure of 100 mm Hg is preferred. The portals used are posterior, lateral, and anterolateral for diagnostic and therapeutic purpose for the associated pathology of the rotator cuff and impingement. If subscapularis tear is encountered, it is repaired before other rotator cuff tendons to have better visualization. The treatment of biceps pathology is done last in treating the shoulder pathology. The intra-articular length of the biceps tendon is measured. A biceps tendomy is done at the level of the supraglenoid tubercle using radiofrequency device and the tendon is allowed to retract in the sulcus.

Separate portals are made for the proximal keyhole biceps tenodesis called the R, S, and A (Fig. 1). The "R" and "S" portals are along the course of the biceps tendon and "A" portal is at the level of the anterior edge of deltoid. The blunt trocar is used by the "S" portal to clear the soft tissue at the bicipital groove. Although viewing through the "A" portal, a shaver and radiofrequency device is used alternatively by "S" portal to clear soft tissue and identify the transverse humeral ligament, synovial sheath of biceps, and the superior edge of pectoralis major (Fig. 2A). A sharp incision is made on the sheath of the biceps tendon resulting in its automatic popping out. In some instances, if the tendon is flattened in the intraarticular region or if it is of hour-glass shape, the transverse humeral ligament is also incised to secure the tendon. With the grasper through the "S" portal, the tendon is exteriorized

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S.No	Age	Sex	Side	Job	MRI/CT/A'scopy	Treatment	FU months		
1	56	М	L	MW	CTR-PS,BTD	IRCT,TDB	3		
2	60	М	R	MW	CTR-PS,BTD	DBCR,TDB	6		
3	54	М	R	MW	CTR-AS,BTI(HG)	CR,TDB	6		
4	61	М	R	MW	CTR-AS,BTD	CR,TDB	6		
5	55	М	R	MW	CTR-AS,BTI	CR,TDB	6		
6	31	М	R	RUGBY	CTR-PS,BTD	DBCR,TDB	2		
7	46	М	L	MW	CTR-PS,BT-SLAP	TOCR,TDB	6		
8	60	М	L	MW	CTR-AS,BTI	CR,TDB	6		
9	43	М	R	MW	CTR-PS,BTD	DBCR,TDB	5		
10	57	М	R	MW	CTR-PS,BTD(HG)	DBCR,TDB	5		
11	46	М	R	MW	CTR-PS,BTD	DBCR,TDB	5		
12	51	М	R	MW	CTR-AS,BTD	CR,TDB	3		
13	53	М	L	GARDENER	CTR-AS,BTD	CR,TDB	3		
14	67	М	R	SKIER	CTR-PS,BTD(HG)	CR,TDB	3		
15	55	М	R	MW	CTR-AS,BTD	DBCR,TDB	2		
16	70	М	R	MW	CTR-AS,BTD(HG)	DBCR,TDB	3		
17	55	М	R	MW	CTR-AS,BTD	DBCR,TDB	3		
18	51	М	R	MW	CTR-AS,BTD,FAILED-SAD	CR,TDB	3		
19	64	М	R	MW	CTR-AS,BTI	TOCR,TDB	3		
20	58	М	R	MW	CTR-AS,BTI	CR,TDB	3		

TABLE 1. Patient Data

BTD(HG) indicates biceps tendon degenerated with hour glass biceps; BTD, biceps tendon degenerated; BTI, biceps tendon instability; CR, cuff repair; CTR-AS, cuff tear anterosuperior; CTR-PS, cuff tear posterosuperior; DBCR, double row cuff repair; FU, followup; IRCT, irrepairable cuff tear; MW-manual worker; SAD, subacromial decompression; TDB, tenodesis biceps; TOCR, transosseous cuff repair.

(Fig. 2B). The traction on the limb is released to get adequate length on the biceps tendon, after the intra-articular part of the tendon is excised.

An assorted set of instruments that are usually available in the operating room are now used for the procedure (Fig. 3). A No 2 polysorb is used as a traction suture and a No 2 vicryl is used to create a plug of the biceps tendon 2 to 2.5 cm from the musculotendinous junction (Fig 2C). Make sure the traction suture slides freely in the plug. Tendon sizers are used to note its size and that of the plug (Fig. 2D). An area of 1 cm proximal to pectoralis major tendon and distal to transverse ligament more medial than lateral on the bone, is prepared for drilling pilot hole using radiofrequency from portal "S." This site is preferred as the bone stock is good in quality and diameter.



FIGURE 1. Portals for arthroscopic keyhole biceps tenodesis.

The beath pin through a tissue protector is drilled from portal "R" making sure that, the pin as it exits the second cortex in anteroposterior direction is only tapped to avoid any neurovascular damage. The acorn reamer of desired size, usually size 6 or 7 is now used over the pin to create a pilot hole from the "R" portal, violating the proximal cortex only to a depth of 2.5 to 2.8 cm taking care that the pin is held secure at the exit point. This unicortical drilling helps in preventing a chance of fracture (Figs. 4A, B).

An offset guide of 5 mm is used from "S" portal to drill another beath pin in front of the pilot hole, make sure the tendon and the traction suture do not entangle during this time (Fig. 4C). A 4.5 mm cannulated drill bit is used over this pin to enlarge the proximal cortex only. The bony bridge between the 2 holes and also the sharp edges are removed with the Kerrison to create a "keyhole" (Fig. 4D, Fig. 5A). A monofilament No 2 is then pulled securely through the pilot hole from portal "R." The biceps plug is now pushed through the "S" portal with the grasper. Although viewing from "A" portal both limbs of the traction suture and the monofilament in the pilot hole are brought out by "S" portal. Care is taken not to take a loop of the deltoid or pectoralis major while doing so. The traction suture is now threaded through the monofilament to be shuttle relayed by the pilot hole (Fig. 5B). The traction is reapplied on the limb. A grasper now helps the biceps plug to be brought to the mouth of the pilot hole while maintaining traction on the suture at the exit point posteriorly. A sudden "snap" is to be felt to lock the tendon in the keyhole while sustained traction is maintained on the suture at the exit point (Fig. 5C). After checking for adequate fixation the traction suture is pulled out (Fig. 5D). Portals are cleaned, sutured, and dressed. The average time for the entire tenodesis is around 15 to 20 minutes. (View supplemental video, Supplemental Digital Content 1, http://links.lww.com/TSES/A2).



FIGURE 2. A, Transverse humeral ligament, long head of biceps tendon (LHBT), pectoralis major tendon. B, LHBT being grasped. C, Biceps tendon plug. D, Sizing of biceps plug and tendon.

Postoperative Protocol

To encourage better healing of the biceps tendon and avoid stiffness of the shoulder, patients wore a sling and early postoperative range of motion (ROM) is encouraged. In the first 4 weeks, active assisted flexion of elbow with arm at the side, with limitation in terminal 20 degrees of extension and passive external rotation are encouraged. At 6 weeks, sling is discontinued; active ROM in all planes is encouraged with stretching in internal rotation. At 12 weeks resistive strengthening exercises are initiated with isometric elastic bands and hand held cot. Rehabilitation for the rotator cuff, deltoid, and scapular stabilizers are started at this time. At 4 to 6 months, progressive strengthening exercises are allowed with unrestricted activity.

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Outcome Assessment

There is an overlap of rotator cuff and biceps tendon pathology, which makes it difficult to assess the result in isolation. We, however, used the shoulder subjective value (SSV), a patient's self-rated subjective assessment of his or her shoulder function compared with the normal limb. The SSV is known to correlate well with the constant score and is expressed as a percentage.¹¹ The visual analog scale (VAS) scores for the pain in the bicipital groove were used for assessment before and after surgery. The development of fatigue and discomfort in the arm and the popeye deformity was also evaluated along with the comparison in strength of the arm in flexion and supination in relation to normal limb.

RESULTS

All the cases were regularly followed at the institution with the average period of 4.2 months (range, 3 to 6 mo). All the cases were assessed for pain, fatigue, and discomfort in the arm and the popeye deformity along with the strength of the involved arm in flexion and supination. There were 2 cases with pain in the arm, 2 cases with capsulitis, and 1 case with minimal limitation of movement. The strength of the involved arm when compared with the uninvolved, tested manually did not show any significant difference in flexion and supination. The VAS was used to evaluate the pain in the shoulder. The preoperative VAS score of 6.45 (range, 5 to 8) improved to 0.35 (range, 0 to 1) postoperative value. We also assessed the SSV of the involved in comparison with normal limb. The preoperative SSV value of 62.75 (range, 50 to 70) improved to 97.75 (range, 90 to 100) postoperative value. In case of anterosuperior cuff tear, the VAS score, the preoperative value of 6.25 (range, 5 to 7) improved to 0.33 (range, 0 to 1) postoperative value and in posterosuperior cuff tear the VAS improved from a preoperative value of 6.75 (range, 6 to 8)



FIGURE 3. Assorted instruments used for the arthroscopic keyhole long head of biceps tendon tenodesis.



FIGURE 4. A, Acorn reamer used to drill pilot hole of adequate size. B, Pilot hole and secondary hole. C, Offset guide. D, Bony bridge between the 2 holes is being removed by Kerrison.

to 0.39 (range, 0 to 1) postoperative value. The SSV in anterosuperior cuff tear improved from 61.25 (range, 50 to 70) to 98.33 (range, 95 to 100) (Fig. 6) and in posterosuperior cuff tear SSV improved from 65 (range, 60 to 70) to 96.88 (range,

90 to 100). However, in none of the cases, fatigue or discomfort or popeye deformity was seen.

The mean pain scores measured by VAS and mean shoulder function scores measured by SSV of the patients who underwent



FIGURE 5. A, Keyhole. B, Shuttle relay and traction suture into pilot hole. C, Saw bone model simulating keyhole biceps tendon tenodesis. D, Final seating of the long head of biceps tendon into the keyhole.



FIGURE 6. Postoperative radiograph of a double row anterosuperior cuff repair with keyhole biceps tenodesis.

the surgical procedure are given in Table 2. Although the scores were distributed normally, a nonparametric test was chosen to test the statistical significance in the preoperative and postoperative scores, as the patients were not assigned randomly to the operative procedure. The Wilcoxon signed-rank test was used to test the significance of difference in the mean preintervention and postintervention scores. With a significance level set at 0.05, a P value of 0.001 obtained with the test indicates rejection of the null hypothesis; that there is evidence to doubt the assumption of no effect of the surgical procedure on the patient's outcomes of shoulder pain and function measured by VAS and SSV, respectively. The mean pain score has decreased by 6.09 units and the mean SSV scores has increased by 35.5 units after the surgical procedure. On the basis of these results, there is evidence to suggest that the LHBT surgical procedure has positive outcome on the patient's status.

DISCUSSION

With the renewed interest in the treatment of the pathology of biceps tendon, it is important to know the incidence, diagnostic characteristics, indications and treatment methodology, and also their results with the limitations. The incidence of biceps tendinitis is 54%, when associated with rotator cuff tear it is 60%,¹² and with anterosuperior cuff tear it is 30% to 60%.¹³ Sometimes the LHB may have a benign intra-articular course and only 49% of cases may show the pathology on arthroscopy.¹⁴

The pathologic changes in the LHB commonly include chronic inflammation (63%) and fibrosis, which result from

mechanical impingement.¹⁵ It is also categorized into (1) biceps tendon degeneration (tendonitis), (2) origin disorders (superior labrum anterior and posterior), and (3) tendon instability.¹⁰ There is mixed opinion concerning the function of LHBT. The electromyography studies have shown that the LHBT is not active in isolated shoulder motion when forearm and elbow are controlled.^{2,16} According to Walch et al¹⁷ there is minimal if any superior migration of humeral head after isolated rupture of LHBT. In contrast, it is also observed that the superior migration of humeral head specially in rotator cuff tears of all sizes is prevented by LHBT and its removal may lead to reduced acromiohumeral distance and concomitant shoulder dysfunction.^{18,19}

The indications for surgery in the pathology of LHBT are chronic tendinitis, partial tear of LHBT involving more than 25% to 50% of its width and instability of the LHBT in the bicipital groove.²⁰ Tenodesis of LHBT can also be done if the pain is present for more than 5 months, tender in bicipital groove and limitation of ROM.²¹

Tenotomy of LHBT is a simple technique giving good pain relief but with it also come the risk of "popeye" deformity due to distal migration of tendon (40% to 70% of time), fatigue and discomfort (30%), and loss of strength and glenohumeral stability^{5,6,22} Hence, this technique is preferred to be done in women, older individuals with sedentary lifestyle. The tenodesis of LHBT is done to maintain the muscle length and tension relation and avoid complication such as muscle atrophy, pain and discomfort, and popeye deformity.²² It is usually done in young, active individuals concerned with cosmesis and strength. Although most studies have reported satisfactory pain relief, some have shown their failure rates to be 6% to 40%.^{17,23}

Paulos et al²⁴ compared a wedge tenodesis with traditional keyhole tenodesis and tenotomy. The bicipital groove postoperatively was still tender in 23% of the cases in wedge tenodesis and 6% of keyhole tenodesis. However, the outcome of both the procedures were identical. Drakos et al⁷ in their study of transfer of LHBT to the conjoint tendon reported good pain relief. There were no side-to-side difference in the strength but 12.5% of the cases had discomfort and some had (3 cases) rupture of tendon.

Mazzocca et al^{25,26} evaluated the results of the 4 fixation techniques in human cadavers. They looked at precyclic ultimate failure strength in keyhole, subpectoral tenodesis, and subpectoral interference screw and anchor fixation. All had favorable load to failure characteristics, interferential screw (IFS) being comparatively better. Since then the author has given up doing proximal biceps tenodesis because of the technical difficulty, hardware problems, pain, and tenosynovitis, and hence switched over to distal open subpectoral tenodesis. Jayamoorthy et al²⁷ studied failure strength of keyhole technique and 2 different usages of IFS, and concluded that there was no difference in load to failure between IFS and keyhole tenodesis. This study also concluded that failure with IFS occurred at bone-screw interface due to

TABLE 2. Outcome Assessment									
Pre-op	Post-op	Difference - 6.09 (0.8)	Z(-ve ranks)	P 0.001					
6.5 (0.7)	0.35 (0.36)		- 3.93						
62.8 (6.7)	97.8 (3.2)	35.5 (6.8)	- 3.96	0.001					
	Pre-op 6.5 (0.7) 62.8 (6.7)	Pre-op Post-op 6.5 (0.7) 0.35 (0.36) 62.8 (6.7) 97.8 (3.2)	Pre-op Post-op Difference 6.5 (0.7) 0.35 (0.36) - 6.09 (0.8) 62.8 (6.7) 97.8 (3.2) 35.5 (6.8)	Pre-op Post-op Difference Z(-ve ranks) 6.5 (0.7) 0.35 (0.36) - 6.09 (0.8) - 3.93 62.8 (6.7) 97.8 (3.2) 35.5 (6.8) - 3.96					

SSV indicates shoulder subjective value; VAS, visual analogue scale.

splitting or slippage of tendon and by pullout in keyhole technique. However, they did not use cyclic loading before testing the ultimate failure strength, which closely resembles the stress in vivo at the reconstruction site.

Ozalay et al²⁸ in their study assessed mechanical strength of 4 different biceps tenodesis techniques, the tunnel, the IFS, the anchor, and the keyhole technique. The strongest construct was with the IFS, followed by tunnel, anchor and keyhole technique. The tests were carried out on sheep model, which usually fail to match the in vivo situations in human being.

The tendon can fail at the bone and tendon interface or because of pullout of the IFS or because of failure of anchors by pullout or suture breakage at the eyelet.²⁰ An all arthroscopic technique by Lo and Burkhart²⁹ describe the proximal biceps tenodesis with its own limitations. Biceps tenodesis is done before a cuff repair and in case the cuff is intact it will be difficult to do tenodesis. The site of tenodesis, the greater tuberosity, in a weak bone can be problem with fixation using IFS. A special instrumentation for using the IFS is also needed. Kusma et al³⁰ described 5 different proximal tenodesis techniques in a porcine model. They compared suture anchor, bone tunnel, keyhole, interference screw, and ligament washer fixation after 200 cyles. The IFS was shown to be better in ultimate load to failure and gap formation. The criticism of this study were that, the tests were done in porcine bone substrate, bone mineral density was not known, only 200 cycles of loading was used and there was increased gap formation with the IFS group when compared with other studies in literature.31

The keyhole technique was first described by Froimson and Oh^{32} in 1974 by open method. This method gives better visualization of entire biceps tendon and its sheath, provides inherent stability with early ROM of shoulder and elbow and no hardware is necessary. However, because of the low primary stability, the need of deltopectoral incision, postoperative pain, and cosmetic issues have precluded the usage of the procedure.

A recent study on concerns with the strength of biceps tendon after tenodesis or tenotomy in supination and flexion of elbow showed no significant difference, with regard to age, sex, height, and weight-matched control groups. There was also no difference in the results of the involved side and uninvolved side of normal and dominant sides concerning movement with the control group.³³ There is also no difference in cybex testing of elbow flexion and manual testing of supination strength in comparison of 2 groups of patients with potential biceps rupture when treated operatively and nonoperatively.³⁴

With paucity of meaningful studies, conclusions are difficult to be drawn between tenotomy and tenodesis. With regard to tenodesis with IFS, the need for special instrumentation, use of hardware, cost, and the inherent technical difficulty are a matter of concern. An ideal fixation method should provide early and active full ROM and return to activity.¹⁰ In a clinical setting, it is possible that the pain relief offered by either biceps tenodesis or tenotomy in patients with associated cuff tear overrides the biomechanical effects and offers an improved pain score and gain in functional ROM.³⁵

Our technique is safe, easy to reproduce, takes less time, cost-effective, especially in third world countries and there is no need of any special instrumentation. This technique also allows the examination of biceps sheath and distal biceps tendon, which can be of concern with regard to unidentified tears, synovitis of tendon, and fibrosis.

A long-term follow-up of adequately randomized patients can help to evaluate this technique in a better way.

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