32 Subpectoral Biceps Tenodesis with an All-Suture Anchor

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32.1 Introduction

The long head of the biceps tendon (LHBT) is a common source of anterior shoulder pain and frequently occurs with concomitant shoulder pathology [1–4]. Numerous factors have been associated with proximal biceps tendon injury; however, the intimate anatomic relationship of the LHBT with the rotator cuff and superior glenoid labrum underlies most of the associated pathology [5–7]. Additionally, a hypovascular watershed region within the intra-articular segment of the tendon may lead to degenerative changes [8]. Pathology involving the LHBT is frequently symptomatic due to the extensive sympathetic and nociceptive innervation, which is more concentrated proximally [9, 10].

32.2 Diagnostic Evaluation

Evaluation of the patient with shoulder pain should always include a thorough assessment of the LHBT. Patients with shoulder pain secondary to LHBT pathology frequently complain of anterior shoulder pain, which may be exacerbated by overhead activities. Additionally, biceps pathology is rarely isolated and often occurs with concomitant shoulder conditions [11]. Various physical examination maneuvers exist for the detection of LHBT pathology; however, most are sensitive, but not specific [11–13]. Magnetic resonance imaging (MRI) is often helpful for detecting degenerative changes within the tendon, for fluid surrounding the tendon, and for instability or subluxation of the tendon often into the subscapularis.

Arthroscopic evaluation of the LHBT remains the gold standard for diagnosis; however, it is not without limitations. Intraoperatively, the LHBT can be further retracted into the glenohumeral joint to visualize some of the extra-articular segment of the tendon. Limited excursion of the proximal tendon and the propensity for more distal tear propagation make it challenging to reliably diagnose and recognize the full extent of biceps pathology [14–17]. Taylor et al. [14] reported that 47% of patients with chronic LHBT symptomatology had extra-articular pathology that was not evident from arthroscopic evaluation. Similarly, Gilmer et al. [16] reported that 33% of extra-articular biceps lesions were not evident during arthroscopic evaluation.

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32.3 Treatment Strategies for Biceps Pathology

Operative treatment of LHBT pathology usually consists of either tenotomy or tenodesis. This decision is usually influenced by the patient's body habitus, functional demands, age, desire for cosmesis, and surgeon preference. Biceps tenotomy is a fast and straightforward procedure, which has demonstrated predictable pain relief without necessitating prolonged rehabilitation [11, 18–25]. High rates of patient satisfaction have been reported following tenotomy, particularly in an older, low-demand population [22, 25–28]. Following tenotomy, the tension from the biceps at the biceps-labral complex no longer exists, which significantly decreases pain. In up to 80% of patients, the proximal tendon stump can remain in the bicipital groove [29]; however, it is unclear whether this remains a persistent pain generator [21, 30]. Concerns over cosmetic deformity [18, 20, 21, 25, 29, 31, 32] and muscle fatigue/cramping [18, 21, 27, 33] following tenotomy may cause some surgeons to favor biceps tenodesis. Biceps tenodesis may better restore the normal length-tension relationship of the LHBT, which may decrease both cosmetic concerns and muscle cramping symptoms following the procedure. Biceps tenodesis has also proven to be a very reliable procedure with excellent outcomes regarding function, pain relief, and cosmesis [22, 29, 30, 34–36].

32.4 Types of Biceps Tenodesis

Various techniques exist for tenodesis of the LHBT. Some of the more notable differences include open versus arthroscopic techniques, location of the tenodesis site, and fixation method. The rate at which tenodesis procedures are being performed appears to be increasing, with arthroscopic tenodesis procedures outnumbering open procedures [37]. Overall, biceps tenodesis is associated with a low complication rate [38]. The vast majority of studies which have compared arthroscopic suprapectoral tenodesis to open subpectoral tenodesis have demonstrated no significant differences regarding functional outcome scores, pain, or satisfaction [35, 36, 39]. Some authors have recently reported possible over tensioning and increased postoperative stiffness with arthroscopic suprapectoral tenodesis [36, 40]. However, a recent randomized prospective study comparing arthroscopic suprapectoral tenodesis with open subpectoral tenodesis demonstrated no significant differences regarding anterior shoulder pain, side-to-side biceps length, elbow strength, or biceps fatigue at various time points up to 1 year [41].

32.5 Surgical Technique for Open Subpectoral Biceps Tenodesis with All-Suture Anchor

Following the induction of general anesthesia, the patient is placed into the beach chair position (the technique can be performed in the lateral decubitus position as well). Preoperative intravenous antibiotics are administered, followed by sterile preparation of the extremity with placement into a pneumatic arm holder (Spider 2, Smith & Nephew). The arm is abducted and externally rotated to identify the inferior border of the pectoralis major tendon. A 3 cm longitudinal skin incision is marked in an axillary skin crease over the inferior border of the pectoralis major tendon.

The senior author prefers to perform the first half of an in situ LHBT tenodesis prior to initiating shoulder arthroscopy. The advantage with this technique is that it may better restore the anatomic resting length and tension of the LHBT, since the tendon is not initially released from the superior labrum. In our experience, this results in a more cosmetic result with a lower likelihood of biceps cramping or fatigue. Additionally, the pilot hole can be made in an independent location not dependent on the position of the whipstitch, ultimately determining the position of the anchor placement. Finally, performing the initial in situ tenodesis offers a surgical approach with less soft tissue edema resulting from fluid extravasation and thus cleaner, more readily identifiable soft tissue planes.

With the arm abducted and externally rotated to expose the axillary crease, the positioning not only allows for adequate exposure, but it also helps decrease the distance from the eventual tenodesis site to the musculocutaneous nerve [42]. A No. 15 blade is used to incise the skin; care is taken not to penetrate deeper than the dermal layer. Curved Metzenbaum scissors are used to bluntly dissect the subcutaneous tissue, eventually exposing the interval between the inferior border of the pectoralis major tendon and the conjoined tendon. It is critical to identify this muscular interval to avoid iatrogenic neurovascular injury. A sharp Hohmann retractor is placed deep to the pectoralis major tendon and over the lateral humeral cortex exposing the LHBT (Fig. 32.1). A blunt Hohmann retractor can be placed anterior and lateral to the conjoined tendon to help isolate the LHBT; however, no retractive force is utilized due to the proximity of the musculocutaneous nerve. Once the LHBT is confirmed, the blunt Hohmann is repositioned to reflect the LHBT medially and expose the bicipital groove. A small Cobb elevator is used to roughen the periosteum of the bicipital groove at the planned tenodesis site.

After bony preparation, the drill guide is placed at the planned tenodesis site, and a unicortical pilot hole is made using a 2.8 mm drill (Fig. 32.2). It is critical to drill perpendicular to the bicipital groove to avoid eccentric hole placement, which has been demonstrated to reduce the torsional load to fracture the humerus by creating a stress riser [43]. We prefer to drill a small unicortical pilot hole, since larger 8 mm unicortical holes have been shown to reduce the torsional load to humeral fracture by 28% (Fig. 32.3) [44]. The 2.8 mm double-loaded all-suture anchor is then placed into the pilot hole and deployed. The blunt Hohmann retractor is used to assist with visualization of the LHBT. A right-angle clamp is used to secure the LHBT proximal to the

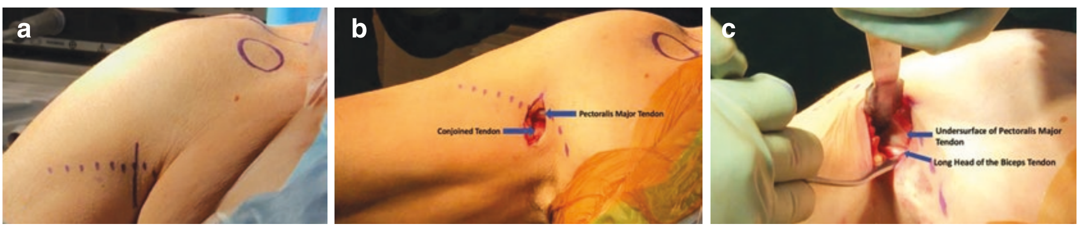

Fig. 32.1 3 cm incision in an axillary crease (**a**). Identification of the interval between the inferior border of the pectoralis major tendon and the conjoined tendon is critical (**b**). A retractor placed deep to the pectoralis major tendon and over the lateral humeral cortex exposes the LHBT (**c**)

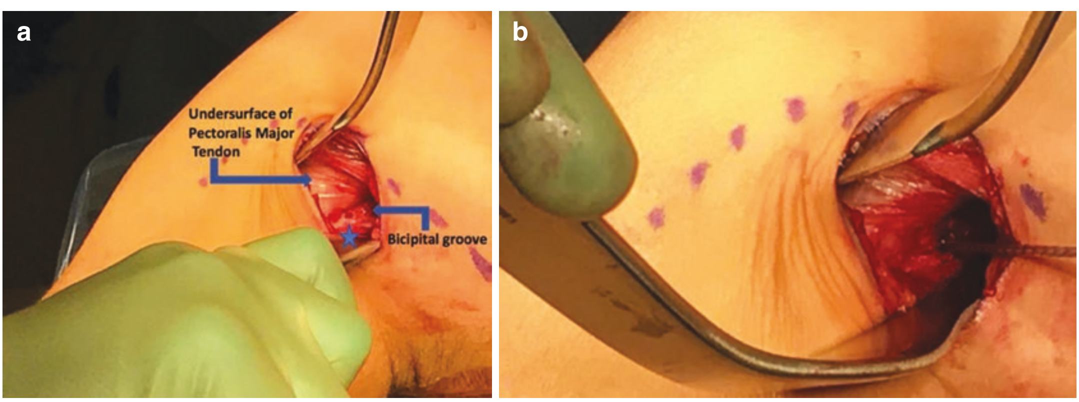

Fig. 32.2 After bony preparation a unicortical pilot hole (blue star) is made using a 2.8 mm drill (**a**). The double-loaded suture anchor can then be deployed through the pilot hole (**b**)

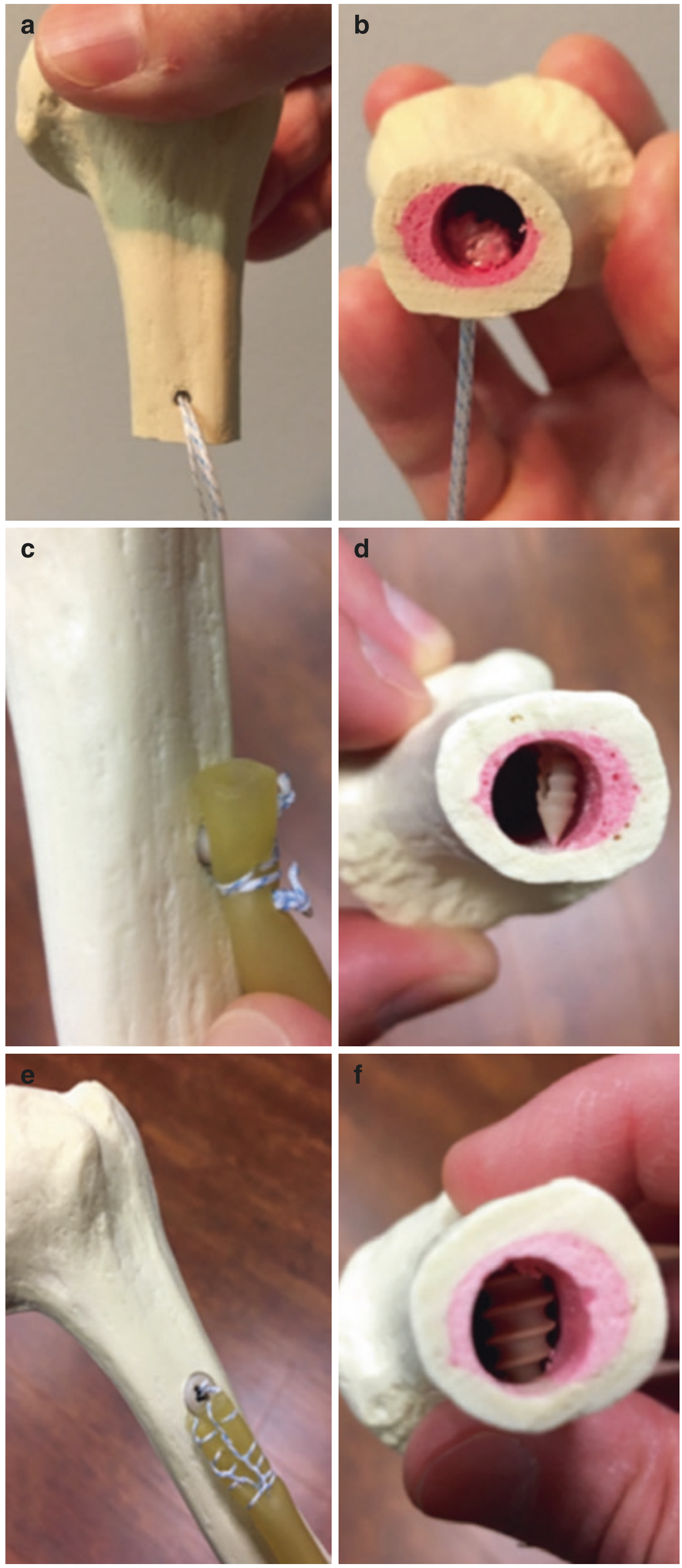

Fig. 32.3 Relative cortical and intramedullary appearance of various fixation devices for biceps tenodesis. 2.8 mm double-loaded all-suture anchor (**a** and **b**), compared to 2.9 mm double-loaded PEEK suture anchor (**c** and **d**) and 8 mm PEEK interference screw (**e** and **f**)

planned tenodesis site. Using a small-diameter suture shuttle device, one of the suture limbs (initial post suture) is passed in situ through the LHBT at the same level as the anchor. Care must be taken during this step due to the proximity of the musculocutaneous nerve [45]. This suture will function as a post and has provided an anatomic in situ position for the tenodesis for theoretical appropriate tensioning and symmetry.

Following surgical exposure, suture anchor placement, and in situ passage of a post through the LHBT, shoulder arthroscopy is initiated. Standard diagnostic arthroscopy is used to identify any additional intra-articular pathology. Tenotomy of the LHBT near its insertion to the superior glenoid labrum is then performed using either an arthroscopic cutter or radiofrequency device. A stump of tissue on the superior labrum is left to ensure that the labrum is not violated during the tenotomy. This tissue is later debrided and the superior labrum recontoured with a motorized shaver.

After tenotomy of the LHBT is performed, attention is returned to the axilla to complete the tenodesis. The LHBT is pulled from the shoulder into the incision with a right-angle clamp. Using the opposite limb of the suture that was initially passed through the LHBT as the post, a circumferential double lasso-loop technique [46] is used to capture and secure the tendon allowing a complete 360° circumferential tenodesis. The step is then repeated (post and double lasso-loop) with the second suture set of the anchor (Fig. 32.4). Once both sutures have been passed, the two suture limbs which are posts are pulled tensioning and delivering the tendon into the incision and down to the suture anchor against the periosteum. Each suture set is then tied and cut. The biceps tendon is then cut a minimum of 1 cm above the tenodesis site to avoid loss of suture fixation.

The axillary wound is then copiously irrigated and a layered closure is performed. After the wound has been closed, we return to the shoulder to perform any additional procedures indicated. Once all arthroscopic shoulder procedures have concluded, skin glue followed by a sterile nonadherent dressing strip is placed over the axillary incision and then covered with a sterile dressing.

32.6 Rationale for Subpectoral Tenodesis

Open subpectoral biceps tenodesis is a safe, reliable, and efficient procedure for managing various pathologies of the LHBT. Subpectoral tenodesis offers a unique advantage by removing all potentially diseased tissue from the bicipital groove. This may reduce the incidence of persistent pain, which otherwise may be left unaddressed with more proximally based techniques [17, 36, 47]. Moon et al. [17] reported that 78% of proximal LHBT tears propagate distally, with 80% of patients having degenerative histological changes over 5.6 cm from the proximal origin, suggesting that subpectoral tenodesis may

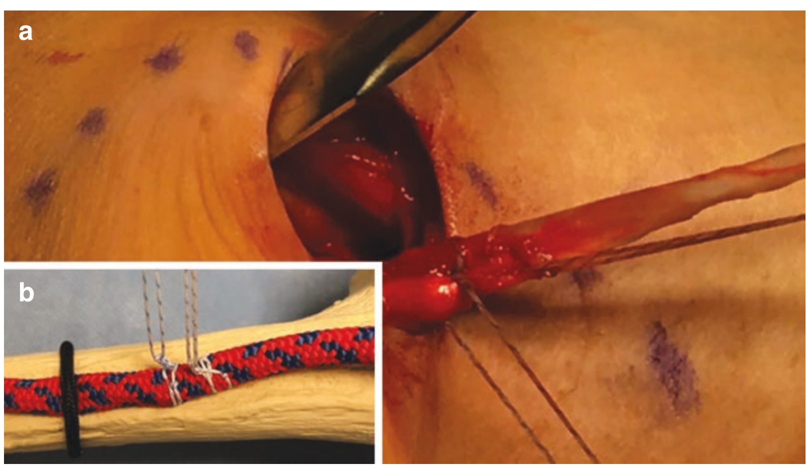

Fig. 32.4 Clinical image (**a**) and anatomic model (**b**) demonstrating a complete 360° double lasso-loupe circumferential biceps tenodesis

eliminate any potential for persistent degenerative tendon. Extra-articular LHBT pathology is exceedingly common and is often concealed from standard arthroscopy, leading to high rates of underestimating the extent of biceps pathology [14, 16]. Additionally, subpectoral biceps tenodesis may better restore the anatomic resting length and tension of the LHBT, thereby providing a more cosmetic result with a decreased likelihood of biceps cramping [40].

32.7 Rationale for All-Suture Anchor

Various fixation techniques and implants are available when performing a subpectoral biceps tenodesis [48–53]. Interference screw fixation has traditionally served as the baseline comparator in biomechanical studies for tenodesis methods given the superior ultimate loads to failure [54–58]. However, given the concern for a humeral stress riser with larger holes to accommodate the tenodesis screw [43, 44], other techniques have evolved to mitigate this risk while taking advantage of the benefits imparted by the subpectoral approach [17, 36, 47].

Recent basic science research suggests that tendon-to-bone healing in an animal tenodesis model by fixation within a bone tunnel or to the cortical surface results in similar biomechanical and histological outcomes. Tan et al. [59] compared these two methods of tenodesis fixation in a rabbit model. Biomechanical testing of the two constructs demonstrated similar load to failure and stiffness. Additionally, micro-CT was used to quantify new bone formation on the humeral surface, which demonstrated no difference between the groups. The authors reported minimal new bone formation within the bone tunnel, questioning the purported benefit of intra-tunnel healing. Lastly, histological analysis evaluating tendon-to-bone healing on the humeral surface of both groups was similar; however, minimal intra-tunnel healing was observed in the bone tunnel group. The results of this study suggest that while similar biomechanical and histological properties may be obtained with either technique, the risk profile of humeral bone tunnel fixation may outweigh previously perceived benefits [59].

The recent development of all-suture anchors has yielded promising biomechanical results for biceps tenodesis. In a recent cadaveric biomechanical study for suprapectoral tenodesis, Hong et al. [60] compared the properties of transtendinous all-suture anchor tenodesis to interference screw tenodesis. During cyclic loading and maximum load to failure testing, the authors noted similar ultimate load to failure with the all-suture anchor group and interference screw group. However, cyclic and failure displacement were greater with the all-suture anchor group. In a similar biomechanical study for subpectoral tenodesis, Chiang et al. [61] compared all-suture anchor tenodesis to interference screw tenodesis. The authors evaluated ultimate load to failure, displacement with cyclic and failure loads, and mode of failure. Similar to Hong et al. [60], the authors note similar ultimate load to failure between the two techniques, however higher displacement with cyclic and failure loading with the all-suture anchors [61].

A recent study by Bernardoni and colleagues [62] provides the most comprehensive comparative biomechanical evaluation of the all-suture anchor to date. The authors performed a cadaveric study to evaluate the biomechanical properties of all-suture anchors in comparison to both interference screws and conventional suture anchors during subpectoral biceps tenodesis. Each treatment group had seven fresh frozen cadavers (mean age of 55 ± 6.1 years), which were randomly allocated. The authors then evaluated the three subpectoral biceps tenodesis constructs in cyclic displacement, maximum load to failure, and failure mode. Moreover, the authors also evaluated the unique properties of each specific suture anchor construct when the humerus was subjected to torsional forces. During cyclic loading evaluation, there were no failures with either the all-suture anchor or the conventional suture anchors; however, the interference screw group had tendon tear failures in 42% of specimens. The authors also reported no significant differences in peak load to failure among the treatment groups.

Unique to this study was the evaluation of torsional forces on the humerus with each specific tenodesis construct. Spiral fractures through the anchor or screw hole occurred in two of seven specimens with all-suture anchors compared to four of seven specimens with conventional suture anchors and in all seven specimens with interference screws. There were no significant differences in maximum torsional load between the groups. Therefore, while the all-suture anchor demonstrated similar biomechanical properties regarding fixation strength, it may have the added benefit of lowering the risk of humeral fracture secondary to a smaller pilot hole.

32.8 Conclusion

Subpectoral biceps tenodesis offers reliable pain relief, high patient satisfaction rates, and low rates of complications. An all-suture anchor utilizes a smaller osseous pilot hole and has the benefit of unicortical intramedullary fixation. Performing an in situ tenodesis may better restore the anatomic resting length and tension of the LHBT resulting in a more predictable symmetric contour of the biceps and lower incidence of biceps cramping and fatigue. Biomechanical studies of the all-suture anchor are promising and demonstrate similar biomechanical properties compared to other techniques with a potentially lower risk of humeral fracture. Clinical outcome data is necessary to more fully ascertain the potential benefits and complication profile of this technique.

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