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ORIGINAL ARTICLE

The Proximity of the Axillary Nerve During Keyhole Tenodesis of the Long Head of the Biceps Tendon: A Cadaveric Study

Manu Jacob Abraham[2] · Rajkumar S. Amaravathi[1] · Keith Behram Tamboowalla[2] · Anoop Pilar[2] · Jean Kany[3] · Sunil Lakshmipura Krishnamurthy[1] · Padmanaban Sekaran[4] · Dan Isaac Luke[2]

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Abstract

Background Over time, surgical management for conditions involving the long head of the biceps tendon (LHBT) has evolved. Some techniques, such as keyhole tenodesis proposes bicortical drilling, however, carries an axillary nerve injury risk. The goal of our cadaveric study was to see if we could keep a safe zone between the point of exit of keyhole tenodesis of biceps and axillary nerve.

Methodology The study was performed on ten shoulders from five fresh frozen cadavers. Between the lower border of the transverse humeral ligament (THL) and the superior margin of the pectoralis major insertion at the lowest limit of the bicipital groove, a beath pin was driven through with the help of the modified tip aimer tibial jig procured from the anterior cruciate ligament reconstruction (ACL) set, which was fixed at an arc of 45°. The distance between the axillary nerve and beath pin at the exit point was measured.

Results The biceps tendon musculotendinous junction was followed all the way to the inferiorly and biceps tendon was found in the groove. The average distance from the axillary nerve to the exit point of the beath pin was 17.7 mm (range 14.4–20.9 mm, 95% CI).

Conclusion The axillary nerve is not injured during bicortical drilling when keyhole tenodesis of biceps is performed at the distal limit of the groove of biceps. The area in the biciptal groove between inferior margin of THL and superior border of pectoralis major insertion is safe area for biceps tenodesis.

Keywords Axillary nerve injury · Biceps tenodesis · Safe distance · Bicipital groove · Keyhole technique · Beath pin · ACL jig · Transverse humeral ligament · Bicortical drilling · Tenotomy

Introduction

Long head of biceps tendon (LHBT) has a very constrained path in bicipital groove, and it is surrounded by synovial sheath. Pathologies involving the LHBT have been identified as separate entities or as part of a rotator cuff injury. According to immunohistochemistry studies, the LHBT contains extensive sympathetic and sensory neural network. Hence any pathogenesis contributes to pain and dysfunction [1]. Treatment for biceps tendon pathologies has evolved along with its indication over the years. Operative intervention is often indicated when there is a partial tear [2, 3], subluxation of tendon, Superior Labral Anterior Posterior lesion involving the LHBT [4], hypertrophied intraarticular portion of the LHBT (hourglass biceps) [5, 6], and Habermeyer Type 4 Biceps lesion [6].

✉ Rajkumar S. Amaravathi
rajamarvathi@gmail.com

Sunil Lakshmipura Krishnamurthy
sunilmurthylk@gmail.com

1 Division of Sports Injury, Arthroscopy and Regenerative Medicine, Department of Orthopaedics, St. John's Medical College and Hospital, Bangalore, Karnataka, India

2 Department of Orthopaedics, St. John's Medical College and Hospital, Bangalore, Karnataka, India

3 Nouvelle Clinique de l'Union, Bd Ratalens, 31240 Saint-Jean-de-Luz, France

4 Padmanaban's Movementology Academy LLP, Koramangala Bangalore, Bangalore, KA 560095, India

Tenotomy of LHBT is typically indicated in patients over the age of 55–60, who do not engage in heavy manual labor, and who are obese. The benefits of biceps tenotomy include a faster return to activities and less post-operative stiffness. This procedure also had its share of complications, including excessive biceps tendon retraction, which resulted in deformity known as the "Popeye Sign," as well as biceps muscle fatigue. Although supination weakness is uncommon in younger patients, it is undesirable to operate in the dominant extremity [7, 8]. The aforementioned complications paved the way for the development of tenodesis of LHBT, which was recommended in young athletes or those who want to avoid deformity. Tenodesis involves attaching the tendon to the cortex with a suture anchor [9] or through a bone tunnel with an interference screw [10].

However, studies have shown that tenodesis of biceps by bicortical drilling is associated with risk of axillary nerve injury [11–15]. The arthroscopic keyhole biceps tenodesis technique was found to be safe, cost-effective, and implant-free [16, 17]. Supra pectoralis arthroscopic biceps tenodesis has the advantage over open procedures in that it avoids a separate axillary incision (which is required for subpectoral biceps tenodesis), allowing inspection of the entire bicipital groove and the LHBT up to the musculotendinous junction, as well as addressing other associated shoulder abnormalities such as tear in rotator cuff, labrum, impingement.

The current study's goal was to measure the distance between the exit point of beath pin used for drilling keyhole tenodesis and axillary nerve. We hypothesized that with the help of a specific guide, a relatively safe distance could be maintained during keyhole tenodesis.

Materials and Methods

The cadaveric study was done in the department of anatomy at our institute. The specimen was acquired from the torso of three men and two female cadavers. These were fresh frozen cadavers which were stored at – 1 7°C and thawed 2 days prior to the experimental study. An equal distribution of side-specific dissection was maintained (Right-Sided vs. Left Sided). The age of the cadavers was not in record as these were unclaimed bodies.

The average height of an Indian male and female was 162–164 cm and 150–152 cm respectively [18, 19]. Studies have shown that distance between nerve and tunnel exit is closer in shorter individual. However, gender does not appear to affect the tendon length [20].

Surgical Dissection

The cadaver was put in a standard lateral position with the involved limb in neutral rotation by the side of the body, simulating the position used in an operating room. The deltopectoral approach was used for the anatomical dissection. The axillary nerve was found traversing at the inferior border of the subscapularis. The anterior deltoid was reflected out, leading to the isolation of the LHBT passing through the bicipital groove [21]. The THL was identified and divided. The LHBT was traced to the superior glenoid tubercle. The LHBT tenotomy was done and the groove was cleared of THL and soft tissues, exposing the "half pipe zone" of the bicipital groove. In the groove for drilling the beath pin, a point between the lower border of THL and the upper margin of pectoralis major was identified (Fig. 1). The keyhole biceps tenodesis technique described by Rajkumar et al. in their papers [16, 17, 21] was then used (Fig. 2). The trocar is placed in the groove at the designated point and parallel to the long axis of the humerus using the modified tip aimer tibial Jig (from the ACL set). The jig and trocar were used to locate the beathpin's entry point. The jig modification aids in

Fig. 1 A saw bone model indicating the surface landmark for entry of the beathpin

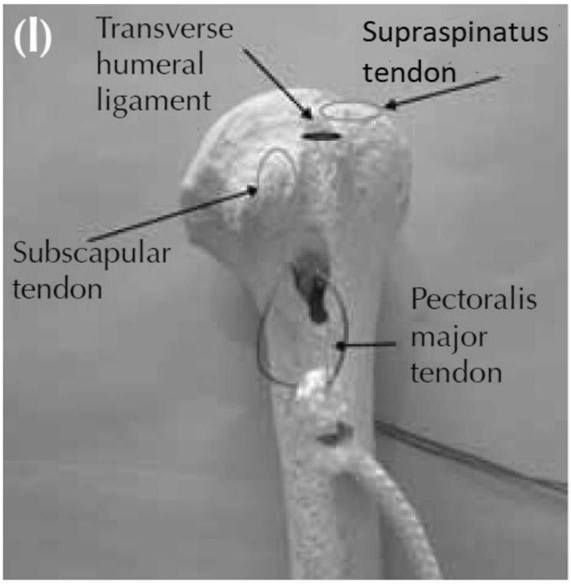


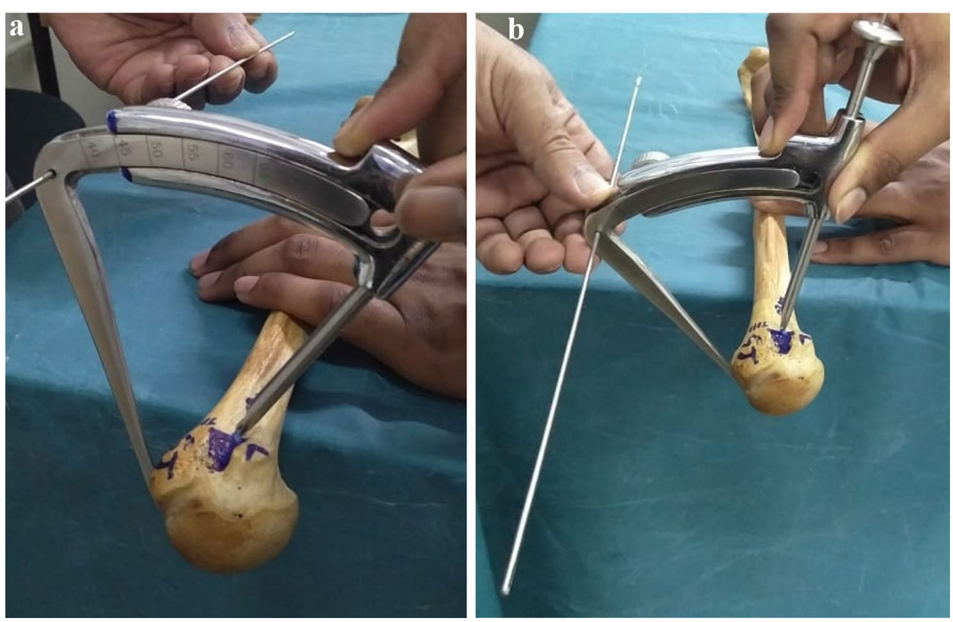
Fig. 2 A saw bone model simulating the keyhole proximal biceps tendon tenodesis[2]

maintaining a parallel alignment to the long axis of the arm throughout the procedure (Fig. 3b).

After that, a 2.4 mm beath pin is drilled bicortical through the bicipital groove at the designated landmark [21]. The drilling was done at a 10° cephalad angle to the long axis of the arm. The jig's positioning determines the drilling's medio-lateral direction. The deltoid's posterior fibers were reflected laterally, and the axillary nerve was traced deep to the inferior border of the teres minor and marked with a marker pin. The distance between the axillary nerve and the exit point was measured with a digital caliper (Mitotoyo series 700, Mitotoyo, Kawasaki, Japan) calibrated to 0.1 mm (accuracy 0.2 mm) (Fig. 4). The nature of the study entailed a single investigator to measure the above parameters [16].

The keyhole tenodesis performed as described [16]. The tendon of biceps is looped and sutured to form a plug 2–2.5 cm from musculotendinous junction with vicryl No 2. A No. 2 polysorb should be introduced into the loop prior to suturing, and the suture's two limbs are used as traction sutures. Graft sizers, which are commonly used in knee ligament reconstructions, are used to measure the tendon and plug size. Using acron reamer of appopriate diameter the pilot hole is created to depth of 25–30 mm. This unicortical drilling aids in fracture prevention. The beath pin remains in place. To drill a second hole, a 5 mm offset guide is placed distal to pilot hole and beath pin is passed. 4.5 mm cannulated drill bit is introduced over the second beath pin and near cortex is drilled. A Kerrison Rongeur is used to remove the bony bridge between the two holes, and a keyhole is created (Fig. 2). The initial beath pin (left in situ) is then used to pull a doubled monofilament No. 2 loop through the pilot hole, allowing the two limbs to exit posteriorly. The traction suture's two limbs are then threaded through the monofilament loop and shuttled to the posterior aspect of the proximal arm via the pilot hole. The limb is given new traction. Two limbs of traction sutures are pulled and simultaneously the tendon is negotiated through the keyhole with the help of suture manipulator. A sudden 'snap' is felt as the tendon plug gets locked into the keyhole. After the tendon plug has been locked, the traction suture is removed.

Fig. 3 **a** A modified tibial jig fixed at an arc of 45°. **b** The pin parallel to the arm



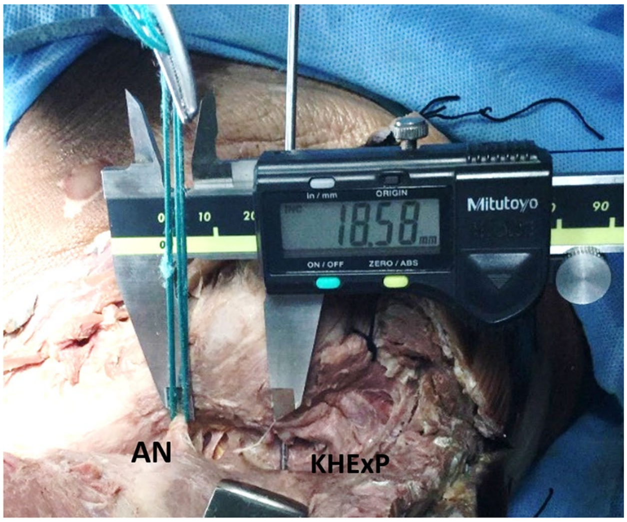


Fig. 4 Distance between the axillary nerve (AN) and keyhole exit point (KHExP) was measured with a digital caliper

Statistics

All measurements were calculated with a 95% confidence interval and provided as mean with standard deviation (Table 1).

Results

Using descriptive statistics and conventional statistical procedures, the mean, standard deviation, and 95% confidence intervals of data measured in mm were determined (Table 1). The average distance from the drill hole to the axillary nerve was 17.7 mm (95% confidence interval, 15.3–19.98). In our study, no axillary nerve injuries occurred in any of the cadavers when drilling was done through this landmark. The biceps tendon's musculotendinous junction was followed all the way to the lower margin of pectoralis major insertion. As a result, at this distance, we report a risk estimate of zero for axillary nerve injury.

Discussion

The drill was inserted at the lower limit of the groove for biceps in our keyhole technique of tenodesis of biceps. The average distance between the nerve and the exit point is 17.7 mm, indicating that there is no risk of nerve injury. This landmark for drilling has the advantage of drilling in an area where the bone quality is good regardless of the patient's gender or age. Furthermore, most of the pain generators along the bicipital groove and behind the THL are debrided. During the keyhole biceps tenodesis, any anomaly in the bicep tendon can be inspected and treated, and the working length of the tendon is kept in reasonable tension.

Study done by Lancaster et al. showed a mean distance from the axillary nerve of 10.7 mm, 18.2 mm, and 36.2 mm when the drill entry was at the Superior limit of the pectoralis major insertion, the inferior limit of the groove, and the superior limit of the bicipital groove, respectively [13]. Ding et al. measured 25.1 mm between the nerve and the drill exit point in their series [12]. In their study, Saithna et al. measured the axillary nerve's position susceptibility (laterally and posteriorly) with respect to the drill exit point taken through the bicipital groove about 1 cm above the lower border of pectoralis major [14].

Knudsen et al. investigated the axillary nerve risk by placing a low anterolateral portal over the lower aspect of the

Table 1 Distance between the axillary nerve and the keyhole exit point with statistical analysis

Cadaver	Side	Gender	Distance between axillary nerve and the keyhole exit point
1	Right	Male	15.1
2	Left	Male	14.4
3	Left	Male	15.2
4	Right	Female	18.5
5	Left	Female	19.1
6	Right	Male	20.9
7	Right	Male	19.6
8	Left	Male	19.3
9	Left	Female	19.2
10	Right	Female	20.1

	N	Mean	SD	95% CI
Distance (mm)	10	17.7	3.2	15.38–19.98

groove, followed by an open dissection to investigate the potential damage sustained. Eleven of the 23 shoulders dissected had the cannula in contact with the nerve [22]. Sethi et al. discovered that the risk of axillary nerve injury was higher in supra pectoral biceps tenodesis than in subpectoral biceps tenodesis. However, it was noted that the entry point was superior pectoralis major margin, which differed from the one used in our study [15].

Arora et al. discovered axillary nerve contact during bicortical drilling in subpectoral biceps tenodesis in some cases [11]. Suprapectoral and subpectoral biceps tenodesis proponents argue that removing the tendon of biceps from the groove improves outcomes [23]. Lutton et al. showed the tenodesis of the tendon of biceps in the proximal part of the groove had persistent shoulder pain in about 40% of patients [24].

An interference screw is used to perform a suprapectoral BT 15 mm distal to the upper edge of the groove. The safe drilling position was discovered to be 00 vertical or 150 lateral inclinations, as opposed to 200 caudal drilling, which injures the axillary nerve or cartilage of the head of the humerus [25]. Bradbury et al. described 'T' shaped tenotomy of biceps at tendon and labrum junction, which allowed the biceps tendon to self-lock at the THL [26]. Kany et al. examined the outcome of keyhole biceps tenodesis at the same entry point as this study. In their follow-up, no axillary nerve injury was discovered [21].

In another study comparing interference screw and keyhole biceps tenodesis, there was high incidence of deformity & popeye sign in the interference screw group than in the keyhole group, as evidenced by radiological marker migration. The procedure has the advantage of being less expensive, implant-free, and with the ability to be revised if the keyhole fails [21]. In addition, unlike open subpectoralis biceps tenodesis, keyhole biceps tenodesis can be done arthroscopically [11, 21].

Limitations

The age of the cadavers at death could not be ascertained but its influence on the study was negligible as most biceps tenodesis procedures are done in younger individuals. Only a single position of drilling was assessed during bicortical drilling. However optimum assessment of the bicep tendon and use of a modified tip aimer ACL jig can give consistent outcome during biceps tenodesis which is different from other techniques.

Using a digital caliper manually could have variation in the readings obtained. Lancaster et al. in their paper, used Computer tomography (CT) scan to get accurate measurements which were probably one of the pitfalls in our study [9]. CT scan was not economically viable for our study.

Conclusions

The axillary nerve is not injured during bicortical drilling when keyhole biceps tenodesis is performed at the distal limit of the bicipital groove. It is possible to achieve a safe and predictable result using the jig and technique correctly, in conjunction with a good understanding of anatomy.

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Data availability statement All the individual data collected during the study will be made avaialable to all who wish to access the data following publication with no end date for any purpose after deidentification.

Declarations

Conflict of Interest Dr. Rajkumar S. Amaravathi, Dr. Manu Jacob Abraham, Dr. Keith Behram Tamboowalla, Dr. Anoop Pilar, Dr. Jean Kany, Dr. Sunil Lakshmipura Krishnamurthy, Dr. Padmanaban Sekaran and Dr. Dan Isaac Luke declare that they have no conflict of interest.

Ethical Standard Statement This article does not contain any studies with human or animal subjects performed by the any of the authors.

Informed Consent For this type of study informed consent is not required.

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