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Original Article

Some details of morphology of biceps brachii and its functional relevance

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ABSTRACT

Introduction: Functions of supination and flexion of the forearm and the origin of biceps brachii (BB) muscle by its two heads indicates separate role of each head. A detailed study of morphology of BB can throw light on this interesting observation.
Methods: In the present study, fifty cadaveric upper limbs (26 right and 24 left) were dissected. Tendons of the two heads were separated up to their insertion.
Results: Long head (LH) and short head (SH) were separated by a septum of loose areolar tissue in greater part of their length. Medial fibres of the SH contributed to the bicipital aponeurosis. Below the middle of the arm a thin tendon projected laterally from the posterolateral edge of SH, where some fibres of LH were seen inserting. The average length of distal biceps tendon (BT) was 7.56 cm on right and 7.64 cm on left. The width of BT was found to increase gradually towards its insertion. Above the elbow tendons were placed parallel to each other, that of LH being lateral and SH medial. Crossing the bend of the elbow twisting of fibres was observed so that SH was anterior to the LH tendon. At its insertion, SH tendon was distal to LH tendon and prolonged slightly beyond the radial tuberosity. A well defined inverted 'J' shaped bursa was found at the insertion.
Discussion: This morphological description helps in proper appreciation of the functions of Biceps brachii and may be helpful to the surgeons in the repair of ruptured BT.

1. Introduction

Biceps brachii is an important muscle of anterior compartment of arm. Its short head (SH) arises from the tip of coracoid process and long head (LH) from the supraglenoid tubercle of the scapula. The two tendons form elongated bellies. The two bellies are closely applied and can be separated to within 7 cm or so of the elbow. The tendon of biceps brachii (BT) is attached to the rough posterior area of the radial tuberosity. Before its insertion medial border of the tendon present a fibrous expansion, the bicipital aponeurosis (BA).[1] Biceps brachii is a powerful supinator and it flexes the elbow most effectively with the forearm supinated. Biceps brachii via the bicipital aponeurosis is attached to the posterior border of the ulna, the distal end of which is drawn medially in supination.[1] The dual

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function and dual origin of this muscle indicates separate role of each head. Distal tendon of SH was inserted more anteriorly than LH on the radial tuberosity. This finding may provide functional independence and cause isolated rupture of each portion.[2] The arrangement of fibres of long and short head in distal tendon indicates that long head is for supination and short head with bicipital aponeurosis is for flexion.[3]

The BT spirals, its anterior surface becoming lateral before being attached to the tuberosity.[1] Incidence of rupture of distal biceps tendon is 1.2 in 100,000 persons per year.[4] Distal biceps tendon rupture typically occurs in men who are manual labourer between 30 and 50 years of age as the result of forceful extension (straightening) of the arm from initially flexed elbow position. The tendon may completely rupture and retract upward leading to a noticeable bulge in the biceps muscle. Complete rupture of distal biceps results in a 40% decrease in elbow flexion strength.[5] Non-anatomic repair of these ruptures have been reported to cause significant (43%) loss of range of supination.[2] Successful surgical repair of a ruptured distal biceps tendon should be predicted on the basis of an understanding of the anatomy of tendon and bicipital aponeurosis. Current surgical techniques do not take into account the anatomy of aponeurosis and distal biceps tendon. Kulshtrestha et al (2007) stated that it is reasonable to assume that the best outcome of surgical repair of ruptured distal biceps tendon will be expected from the procedures replicating the anatomy of the tendon.[6] The aim of the present work was to study the morphology of biceps tendon and to correlate its role in the actions of biceps brachii.

2. Material and method

Fifty (50) upper limbs (26 right and 24 left) available in the Department of Anatomy were dissected. Skin, superficial and deep fascia over the biceps brachii muscle was carefully removed. Proximally the tendons of long and short head were identified and the angle between them was noted with the help of goniometer. Maximum width of belly of biceps brachii was measured. The bellies of two heads were separated from each other by blunt dissection and the presence of fascial septum between SH and LH was noted. At musculotendinous junction, SH and LH were separated from each other and presence of muscle fasciculi joining both heads with each other were noted. The distances between lowest levels of fleshy fibres of LH and SH were noted both superficially and on the deeper aspects of BT using digital Vernier caliper. The angle between the bicipital aponeurosis (BA) and BT was measured at the point of divergence of the BA from BT using goniometer.

The distal BT was cleaned and traced from its beginning to its distal attachment to the radial tuberosity. The presence of the bursa at its insertion and its relation with the distal BT was noted. The contributions of short and long head of biceps in the formation of BT were noted and were separated to their insertion on radial tuberosity. The length of BT was noted from its commencement to its insertion. The width of the BT was noted at its insertion and 1 cm, 2 cm and 3 cm proximal to the insertion of the BT and the continuations of long and short head in the BT were traced from proximal to distal and their relationships with each other were noted.

3. Results

Above the middle of the arm, the SH and LH of biceps brachii were separated by a triangular interval, apex being directed inferiorly in all the cases. The average angle between SH and LH at the level of joining was 22.73° on the right and 22.67° on the left (Table 1). Below this, there was thick septum of loose areolar tissue separating the two heads (Fig. 1). The average maximum width of the biceps brachii was 31.30 mm on the right and 32.48 mm on the left. Bellow the middle of the arm, the two heads became partially fused. From the posterolateral edge of SH, a thin tendon projected laterally grooving the medial surface of LH. Into the anterior part of this tendon, few fibres of LH were seen inserting, whereas on its deep surface the fibres of the LH were found to be inserted right upto the level of bend of elbow (Fig. 2A–C). In the lower two third of fleshy part of LH, there was a well defined groove which lodge the fleshy and tendinous part of SH. A prominent muscle fasciculus separated from the medial margin of LH about the middle of arm to join the SH just at the musculotendinous junction (Fig. 2A–C).

Belly of the LH was divisible into two stratums – superficial and deep. Superficial stratum ended on the tendon of the biceps brachii at the higher level than that of SH (approximately 14.64 mm on right and12.58 mm on left). Deep stratum ended on tendon of biceps at a lower level than SH (approximately 20.09 mm on right and 18.69 mm on left). There was no statistical difference in these levels on right and left side (p value <0.05) (Table 1). Medial fibres of the SH mostly contributed to the BA while lateral fibres contributed to the formation of the BT. The average length of BT was 7.56 cm on right and 7.64 cm

Table 1 – Morphology of biceps tendon.[a]

Parameter	Right side ($n = 26$)	Left side ($n = 24$)	p-value[e]
Maximum width of biceps (mm)	31.30 ± 5.69	32.48 ± 5.94	0.476
Angle between SH and LH at the level of joining	22.73 ± 2.59	22.67 ± 2.36	0.932
Distance between lowest fleshy fibres of LH and SH			
Superficially (mm)	14.64 ± 7.40	12.58 ± 8.39	0.361
Deep (mm)	20.09 ± 7.50	18.69 ± 6.67	0.490
Length of BT[b] (cm)	7.56 ± 0.98	7.64 ± 1.07	0.763
Tendon width[c]			
At insertion (mm)	14.25 ± 3.47	14.49 ± 3.62	0.811
At 1 cm (mm)	8.73 ± 2.14	8.33 ± 2.17	0.515
At 2 cm (mm)	7.31 ± 1.49	7.19 ± 1.97	0.808
At 3 cm (mm)	6.38 ± 1.25	6.56 ± 1.83	0.684
Angle between BT and BA[d]	24.13 ± 5.58	26.49 ± 4.72	0.114

n = number of limbs.
[a] All values indicated mean ± standard deviation.
[b] Length of BT from its beginning to its lowest point of insertion.
[c] Width of BT was noted at its insertion and 1 cm, 2 cm and 3 cm proximal to the insertion of BT.
[d] Angle between tendon and aponeurosis was measured at the commencement of aponeurosis.
[e] Data of right and left side was compared using unpaired 't' test and difference was considered to be significant if p value <0.05.

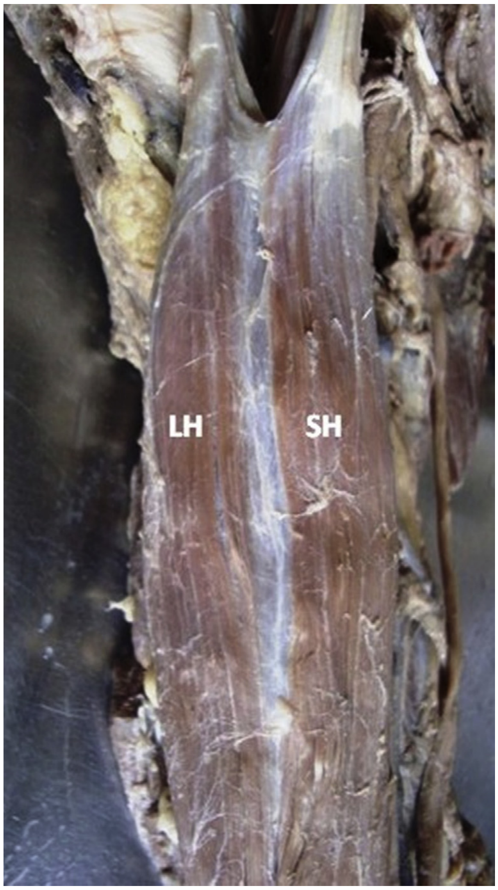

Fig. 1 – Septum of loose areolar tissue separating the two heads of biceps brachii [SH: Short head, LH: Long head].

on the left. The width of the tendon was found to increase gradually towards insertion. At the site of its attachment to radial tuberosity BT flared up (Fig. 4A and B, Table 1). There was no statistical difference in the length and width of BT on right and left side (p value <0.05) (Table 1).

When formed the ensuing tendons of LH and SH were placed parallel to each other; that of LH being lateral and SH medial. Crossing the bend of the elbow, the orientation became sagittal, wherein, the tendon of SH was anterior to that of LH. At the insertion, SH tendon was distal to LH tendon which it grooves before getting inserted on the radial tuberosity (Fig. 3A–C). It was primarily the tendon of LH that wraps round the tuberosity to be attached to its posterior part. The prolongation of SH slightly beyond the radial tuberosity was found in 88% cases on the right side while it was seen in all the cases on the left (Fig. 4A and B). A large well defined bursa was present over the anterior part of radial tuberosity extending upwards on the medial surface of neck of radius. Bursa was inverted 'J' shaped in 78% cases on the right side and in all cases on the left (Fig. 5A–C).

4. Discussion

The purpose of this study was to focus on morphological aspects of the formation of fleshy belly of biceps brachii and its distal tendon, insertion of BT on the radius and to ascertain correct tendon orientation. In the present study, the separation between the short and long head tendons could be achieved right upto its insertion except in the region where the fibres of the two bellies interdigitate. The findings of the present study are in agreement with the findings of Dirim et al (2008).[7] They have attempted to separate two muscle bellies of the biceps but they also found hindrance at myotendinous junction due to a partial decussation of the muscle and tendinous fibres (Fig. 2A–C). They termed this area as 'goose quill' because of its resemblances to a goose's feather. The goose quill contraindicates the postulate that the tendon can be split easily from the level of the muscle to the radial tuberosity. The function of goose quill may be to optimise the muscle contraction during flexion and supination at the same time by aligning the power of the two muscle heads. Present study showed that though the goose quill does not completely obscure visualization of the continuity of SH and LH in the distal BT, the two heads give varying contributions not only to the distal tendon of attachment but also to the bicipital aponeurosis as emphasised by Joshi et al (2013).[8] Athwal et al (2007) stated that despite being closely connected by areolar tissue the heads can easily be separated and that the muscle bellies coalesce distally just proximal of the elbow joint; but in some cases they found that the separation persists along the whole length of the biceps brachii belly until the commencement of the distal tendon.[9]

Cucca et al (2010) reported mean distal BT length 57 mm and mean tendon width, at the termination of the muscle

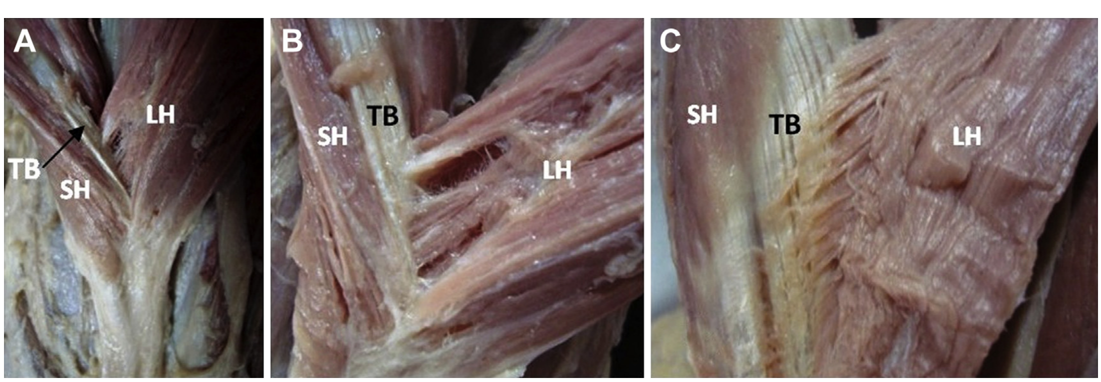

Fig. 2 – A–C: Insertion of fibres of LH on the flat tendinous band present on the posterolateral surface of SH [SH: Short head, LH: Long head, TB: Tendinous band].

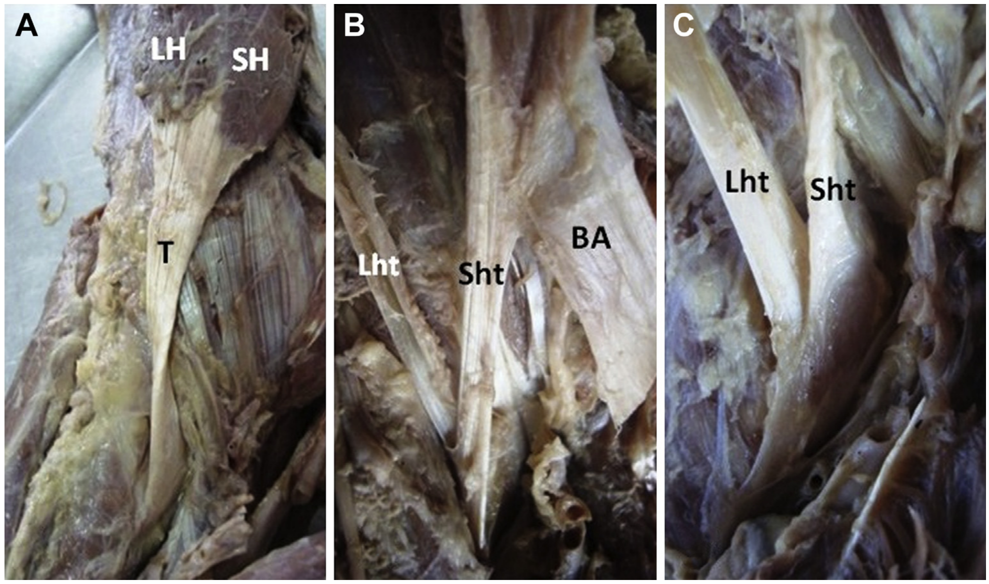

Fig. 3 – A–C: Spiralling course of SH and LH tendons: In the beginning, the tendons of LH and SH were placed parallel to each other, that of LH being lateral and SH medial. Crossing the bend of the elbow, the SH lie anterior to the LH tendon. At the insertion, SH tendon was distal to LH tendon. B: LH tendon shows grooving for SH tendon [SH: Short head, LH: Long head, T: Tendon of biceps brachii, BA: Bicipital aponeurosis, Sht: SH tendon, Lht: LH tendon].

fibres of biceps brachii as 15 mm. In the present study length of BT was 7.56 cm on right and 7.64 cm on the left. The difference in these findings may be explained as observational difference. Cucca et al considered length of tendon as visible length of the distal tendon, namely from the point of muscle fibre termination to its insertion on the radial tuberosity while in the present study we have considered the length of BT as maximum visible length of the distal tendon, namely from the point of its beginning to its insertion on the radial tuberosity.[10] Cucca et al did not measure the width of BT at different levels and did not comment on the distal expansion of tendon at insertion on radial tuberosity as we have shown in the present study. In the present study we have shown the changing relationship of SH and LH tendon along with the distal insertion and extension of SH tendon.

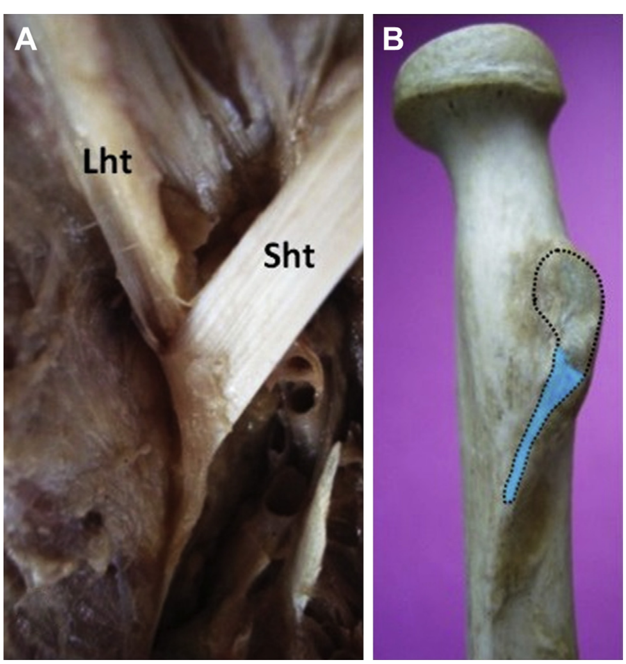

Fig. 4 – A and B: Extension of attachment of short head tendon beyond radial tuberosity. B: Extension of attachment is indicated by blue colour [Sht: SH tendon, Lht: LH tendon].

Athwal et al (2007) also reported that the SH tendon inserts distally and the biceps complex rotates 90° externally.[9] They also reported that the muscle terminates as a shared tendon which separates distally into two components as biceps tendon and BA. The insertion of the distal BT creates a so-called ‘footprint’ on the ulnar margin of tuberosity.[9] As in the present study, Kulshreshtha et al (2007) also showed that distal to the bicipital aponeurosis, the biceps tendon is twisted in a predictable manner; it spiralled clockwise in the right elbow.[6] They stated that the anteromedial fibres followed a straight course to the attachment inferiorly, whereas the posterolateral fibres coiled underneath the medial fibres to attach superiorly on the radial tuberosity; while in the present study we have focused on changing relationship of individual tendons of SH and LH.

The variations in shape, length, and width of the tendon of biceps brachii and its angulation and attachment to the tuberosity has received renewed interest as factors that may be important in surgical tendon reattachment.[11–13] Twisting of tendon presumably confers some biomechanical advantage such that it may in assist its action during supination. A thorough knowledge of the anatomy of the distal biceps tendon may enhance our understanding of its disorders. This information may assist surgeons for correctly orientating the distal BT during anatomic repair, which may help to restore normal muscle kinematics. The pull of the biceps long head is

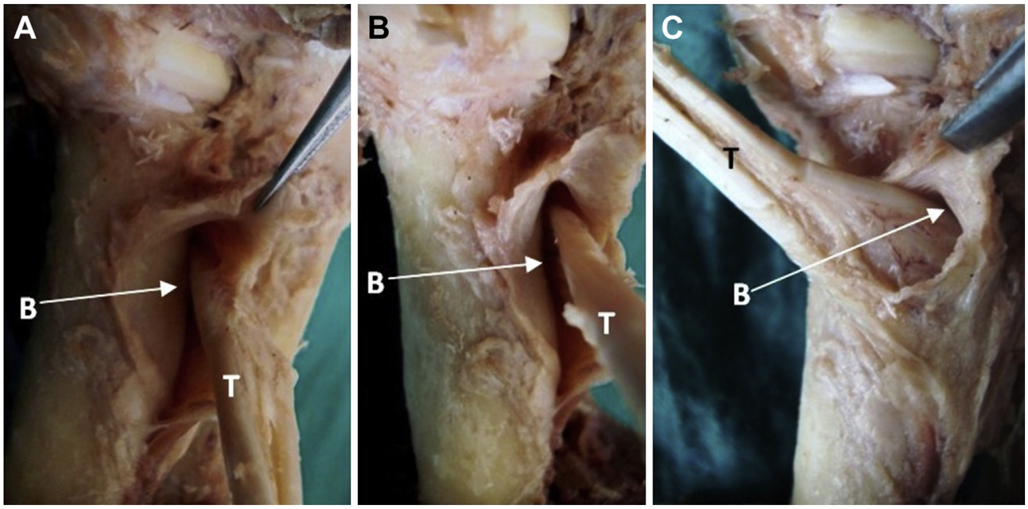

Fig. 5 – A–C: A large well defined bursa over the anterior part of radial tuberosity extending upwards on the medial surface of neck of radius [B: Bursa, T: Tendon of biceps brachii].

mainly concentrated on the radial tuberosity, while the pull through the BA is of the fibres from the short head onto the ulna.[8] Incidence of BT injury is 1.2 per 100,000.[11] The most common injuries to the distal biceps tendon are complete tears, however, partial tears are being increasingly diagnosed with the advent of improved imaging techniques and an awareness of the existence of the condition.[14] Distal BT rupture usually occurs with unexpected forced extension of a flexed elbow.[11] Most tears occur 1–2 cm above the radial tuberosity, where there is hypovascularity and a histological structural transition point. Chew et al, 2005 have suggested that with increasing age, there is a progressive decrease in perfusion, elasticity, and hydration. Further, mechanical impingement during pronation and irritation by an osteophyte–enthesophyte at the radial tuberosity (a common finding) may also lead to tears of the distal biceps tendon.[14] Operative intervention is becoming a more common form of management for these cases especially, where full functional recovery is desirable. However, it has been recently demonstrated that the arrangement of the distal tendon may be of significance when considering suture and endobutton repairs.[7,13] Davison et al (1996) reported a decrease in supination greater than 30° in some patients.[15] Many other (Bain et al, 2000; Bell et al, 2000) have also reported decrease in strength of the supination.[16,17] In earlier study, we have showed that the BA is contributed by the SH and LH both. The fascial sling seems to be a mechanism of nature to keep the tendon of biceps angulated so that it can work efficiently as a supinator, while the two heads together can bring about flexion at the elbow joint. Thus, by repairing a disrupted bicipital aponeurosis accompanying a rupture of the distal biceps brachii tendon, the traction on the ulna can be restored. The present study attempts to describe and quantify several of the anatomical arrangements of biceps brachii that may be of relevance to surgical intervention in biceps muscle and distal tendon repair. Angle between BT and BA can be used as a landmark to correctly orientate the tendon during repair [Table 1].

5. Conclusions

The presence of two easily separable tendons of biceps brachii corresponding to the two heads of the muscle may function as separate entities or the two heads may jointly acts in the biomechanics of biceps brachii. The partial decussation indicates complimentary role of both the heads to each other.

Conflicts of interest

All authors have none to declare.

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