

Insertional anatomy and clinical relevance of the distal biceps tendon

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Abstract

Purpose This study was undertaken to evaluate the incidence of bifurcated distal biceps tendons and the tendon's insertional footprint on the radial tuberosity.

Methods Twenty-five embalmed cadaveric specimens were dissected. The relationships and orientation of the muscle bellies and distal biceps tendon were examined. The insertional length, width, and footprint area of the distal biceps tendon on the radial tuberosity were evaluated.

Results In 12 specimens (48%), the distal biceps tendon was in 2 distinct, easily separated parts. The average footprint length, width, and area of the tendon's insertion on the radial tuberosity were $20.5 \text{ mm} \pm 2.0 \text{ mm}$, $9.7 \text{ mm} \pm 1.3 \text{ mm}$, and $156.3 \text{ mm}^2 \pm 29.4 \text{ mm}^2$, respectively. We calculated that the tendon's insertion occupied approximately 35.9% of the area of the radial tuberosity. In the specimens with a bifurcated distal biceps tendon, the long head of the tendon inserted at the posterosuperior portion of the radial tuberosity, and the average area was $71.4 \text{ mm}^2 \pm 11.3 \text{ mm}^2$. The short head of the distal biceps tendon inserted at the anteroinferior portion, and the average area was $88.3 \text{ mm}^2 \pm 24.1 \text{ mm}^2$.

Conclusion This study confirmed that bifurcated distal biceps tendon insertion is not a rare anatomical variation, showed by recent investigations, and found that the short head of the distal biceps tendon was inserted more anteriorly than the long head on the radial tuberosity. These findings may allow functional independence and isolated rupture of each portion. It can make correct diagnosis possible and allow for a more anatomical orientation of the tendon during surgical repair.

Keywords Distal biceps tendon · Radial tuberosity · Insertional anatomy · Bifurcated

Introduction

As interest in distal biceps repair has grown, and new techniques for repair have been developed; there has been an increased emphasis on the quantitative and functional anatomy of the distal biceps tendon [11, 13, 14]. A precise understanding of the anatomy of the distal biceps tendon and its relationship to the radial tuberosity is crucial to the successful surgical repair of a ruptured tendon [5, 15, 19, 21]. However, anatomy textbooks provide an ambiguous description of the tendon's insertion onto the radial tuberosity, and the detailed anatomy of the distal biceps muscle and tendon and its relationship to the radial tuberosity have received little attention. Recent reports have provided details of the anatomy of the distal biceps tendon and have described the shape and size of the footprint of the tendon's insertion [1, 4, 6, 7, 9, 12, 17, 18]. They have also demonstrated that in some individuals, the tendon may be bifurcated. Several authors have reported isolated rupture of a bifurcated distal biceps tendon [6, 16, 20, 22].

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The aim of the present study was to evaluate the incidence of bifurcated distal biceps tendons and its insertional footprint on the radial tuberosity. This study was conducted based on the hypothesis that bifurcated distal biceps tendon insertion is not a rare anatomical variation.

Materials and methods

After obtaining approval from our institutional review board, we dissected 25 embalmed cadaveric specimens under loupe magnification. All specimens were from Koreans; 14 specimens were from men and 11 were from women. The median age of each person at death was 68.7 years (range 45–89 years). The long and short heads of the biceps muscle were detached from their origins and dissected toward its insertion. The proximal radius was then removed en bloc with the biceps muscle. All soft tissue, except for the distal half of the biceps muscle belly and its tendon, was removed.

The relationships and orientation of the muscle bellies and the distal biceps tendon in each specimen were examined. We made note of the dimensions of the tendon insertion and the radial tuberosity, along with the orientation of the insertion and additional features of the radial tuberosity. The distance between the articular margin of the radial head and the upper margin of the radial tuberosity, the length and width of the radial tuberosity, the insertional length, and the width of the distal biceps tendon on the radial tuberosity were measured using calipers with a sensitivity of 0.1 mm. The area of the radial tuberosity and the insertional footprint area of the distal biceps tendon were also measured by using an acetate grid sheet and counting the number of $1 \times 1 \text{ mm}^2$ occupied by the marked area. To minimize intraobserver and interobserver variations and maximize accuracy, each measurement was repeated 3 times by 2 observers blinded to each other's results.

Results

Gross findings

In 12 (48%) of 25 specimens, the distal biceps tendon was in 2 distinct and easily separated parts. Each muscle continued as a separated tendon distally. The long head of the distal biceps tendon continued on the radial side of the short head and passed deep to the short head to insert more superiorly on the radial tuberosity. The bicipital aponeurosis was found to originate from the proximal aspect of the short head of the distal tendon in the specimens with a bifurcated distal biceps tendon (Fig. 1).

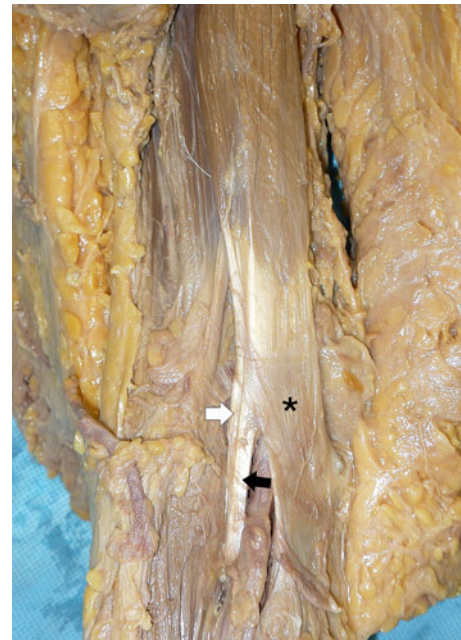


Fig. 1 In this specimen, the long head (white arrow) of the distal biceps tendon continues on the radial side of the short head (black arrow) and passes deep to the short head. The bicipital aponeurosis (asterisk) originates from the proximal aspect of the short head of the distal biceps tendon

The remaining 13 specimens (52%) had interdigitation of the muscle bellies and a completely united distal tendon. In all elbows, the biceps tendon twisted externally distal to the bicipital aponeurosis, and the insertion of the distal biceps tendon was located on the posterior rim of the radial tuberosity. Its configuration was semilunar, with concavity of the anterior surface of the footprint on the radial tuberosity (Fig. 2). The bicipital aponeurosis originated from the proximal aspect of the united distal tendon as it passed anterior to the elbow joint and expands medially, blending with the fascia of the forearm.

Measurements

The average distance from the articular margin of the radial head to the upper margin of the radial tuberosity was $19.5 \text{ mm} \pm 2.7 \text{ mm}$. The average length, width, and area of radial tuberosity were $25.5 \text{ mm} \pm 2.3 \text{ mm}$, $14.4 \text{ mm} \pm 1.3 \text{ mm}$, and $435.8 \text{ mm}^2 \pm 84.6 \text{ mm}^2$, respectively. In all specimens, the average footprint length, width, and area of the distal biceps tendon insertion on the radial tuberosity were $20.5 \text{ mm} \pm 2.0 \text{ mm}$, $9.7 \text{ mm} \pm 1.3 \text{ mm}$, and $156.3 \text{ mm}^2 \pm 29.4 \text{ mm}^2$, respectively (Table 1). On the basis of the dimensions of the tuberosity, the tendon insertion occupied approximately 80.4% of the length, 67.4% of the width, and 35.9% of the area of the radial tuberosity.

Fig. 2 In this specimen, (a) interdigitation of the biceps muscle bellies and a completely united distal tendon are apparent, and (b) the insertion of the distal biceps tendon is located on the posterior rim of the radial tuberosity in a semilunar configuration

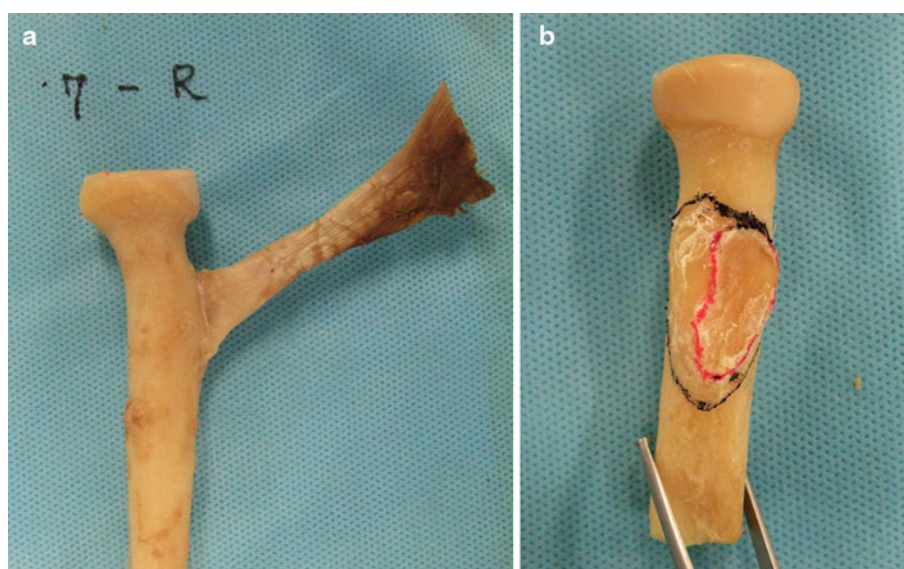


Table 1 Insertional length, width, and footprint area of the distal biceps tendon on the radial tuberosity according to gender

	RH–RT length (mm)	RT length (mm)	RT width (mm)	RT area (mm ²)	FP length (mm)	FP width (mm)	FP area (mm ²)
From men	20.9 (±2.4)	26.3 (±2.0)	14.8 (±1.3)	468.3 (±83.7)	20.6 (±1.8)	10.0 (±1.4)	163.7 (±33.8)
From women	17.7 (±2.0)	24.4 (±2.3)	13.8 (±1.2)	394.4 (±68.6)	20.4 (±2.2)	9.4 (±1.1)	146.7 (±20.5)

FP footprint, RH radial head, RT radial tuberosity

In 12 specimens, the exact dimensions and the area of the short- and long-head tendon insertions could be measured. The long head of the distal biceps tendon inserted at the posterosuperior portion of the radial tuberosity; the average length, width, and area of the long-head tendon insertion were $9.3 \text{ mm} \pm 1.4 \text{ mm}$, $8.4 \text{ mm} \pm 1.3 \text{ mm}$, and $71.4 \text{ mm}^2 \pm 11.3 \text{ mm}^2$, respectively. The short head biceps tendon inserted at its anteroinferior portion; the average length, width, and area of the short-head tendon insertion were $11.9 \text{ mm} \pm 1.4 \text{ mm}$, $9.1 \text{ mm} \pm 1.7 \text{ mm}$, and $88.3 \text{ mm}^2 \pm 24.1 \text{ mm}^2$, respectively (Fig. 3; Table 2).

Discussion

The most important finding of the present study was that there are 2 independent muscle bellies with a bifurcated distal biceps tendon in a significant proportion (48%) of specimens that confirms findings in another studies, and the short head of the distal biceps tendon was inserted more anteriorly than the long head onto the footprint of the radial tuberosity.

The most common injury to the distal biceps tendon is a complete tear at the insertion site of the radial tuberosity [3, 5, 15]. However, partial tears are being increasingly diagnosed with the use of ultrasound and magnetic

resonance imaging [2, 6, 8, 10, 14, 22]. Most anatomical descriptions have suggested that 2 proximal heads of the biceps muscle coalesce into a single distal tendon inserting on the radial tuberosity [1, 7, 17]. As interest in distal biceps repair has grown, the concept of the distal biceps tendon as a simple cylindrical tendon has been challenged. More details about the tendon's insertion have been revealed in recent years [1, 4, 6, 7, 9, 12, 17, 18, 22].

Several cadaveric and radiologic studies have shown the incidence of bifurcated distal biceps tendons to be anywhere between 11.8 and 58.8% [1, 4, 6, 7, 17, 22]. Athwal et al. [1] reported complete separation of the muscle bellies and distal biceps tendon in 2 (13.3%) of 15 specimens. Eames et al. [7] reported that in 10 (58.8%) of 17 specimens, the distal biceps tendon was in 2 distinct parts, each a continuation of the long head and short head of the muscle. Dirim et al. [6] reported that on visual inspection, confirmed by correlative magnetic resonance images and histology, 2 (25%) of 8 specimens had 2 separate muscle bellies that continued distally as individual tendons. In that group's magnetic imaging study, the distal biceps tendon appeared bifurcated in 8 (11.8%) of the 68 elbows that had a distal biceps tendon injury. Tagliafico et al. [22] also demonstrated the ultrasound appearance of the distal biceps tendon separation in normal cadavers and volunteers and in those affected by various disease processes. Also, isolated

Fig. 3 In this specimen, (a) the distal biceps tendon has 2 distinct, bifurcated parts, (b) with the long head of the tendon inserting at the posterosuperior portion and the short head inserting at the anteroinferior portion of the radial tuberosity

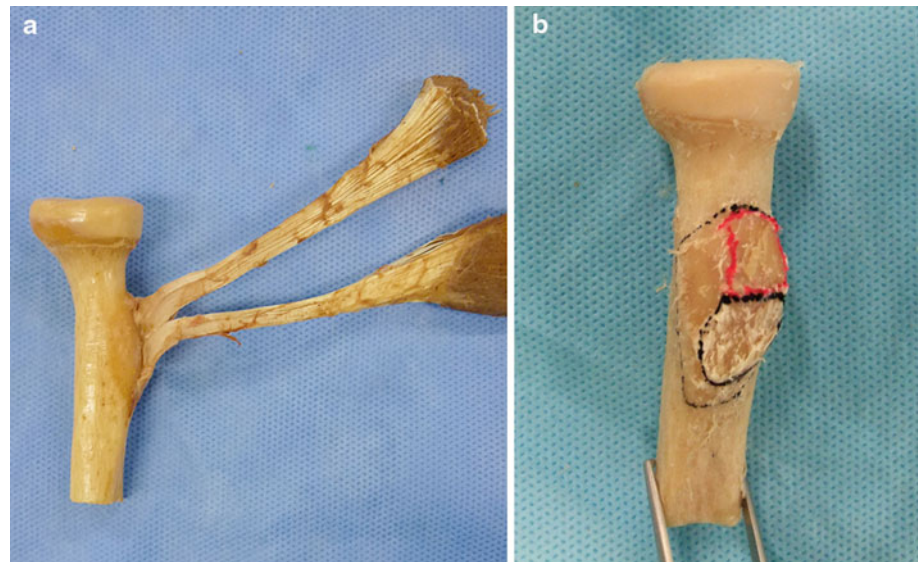


Table 2 Insertional length, width, and footprint area in specimens with a bifurcated distal biceps tendon according to gender

	LHB length (mm)	LHB width (mm)	LHB area (mm ²)	SHB length (mm)	SHB width (mm)	SHB area (mm ²)
From men	9.7 (±2.0)	9.4 (±1.2)	77.0 (±13.1)	12.7 (±0.9)	10.0 (±1.8)	100.8 (±25.2)
From women	9.0 (±0.9)	7.6 (±0.9)	67.4 (±8.7)	11.4 (±1.6)	8.5 (±1.4)	79.4 (±20.6)

LHB long head of biceps tendon, *SHB* short head of biceps tendon

ruptures of a bifurcated distal biceps tendon were recently reported by several authors [6, 16, 20, 22]. Sassmannshausen et al. [20] reported a case of a bifurcated distal biceps tendon with selective disruption of a short-head bundle that was surgically confirmed. This study was the first clinical report that the possibility of a bifurcated distal biceps tendon. Koulouris et al. [16] also reported 2 cases of isolated short-head bundle rupture of a bifurcated distal biceps tendon. They suggested that accurate preoperative detection is paramount because this injury may be confused with a partial-thickness tear of a nonbifurcated distal biceps tendon or a distal musculotendinous junction strain, both which are typically treated conservatively, if the clinical scenario demands surgical restoration because of functional disability.

The present study demonstrated that the distal biceps tendon was in 2 distinct, easily separated parts and each muscle continued as a separated tendon distally in 12 (48%) of 25 specimens. From our observations, it can be inferred as other studies [6, 16, 20, 22] that isolated ruptures of bifurcated distal biceps tendons have been misdiagnosed as partial-thickness or full-thickness tears. Therefore, we suggest that awareness of the existence and anatomy of bifurcated tendons is important so that surgeons can correctly diagnose injuries to tendon components.

The variation in length, width, area, and shape of distal biceps footprints and radial tuberosities may be important

in anatomical restoration of the distal biceps tendon. The radial tuberosity and distal biceps insertion footprint are critical structures affecting forearm supination mechanics, and anatomical repair of a ruptured tendon is necessary for restoration of power, endurance, and terminal forearm rotation [11]. The supination torque of the biceps is related to its insertion site on the radial tuberosity [7, 11, 13]. Several authors have reported significant loss of supination range and strength after distal biceps tendon repair with an anteriorly located footprint on the radial tuberosity and have noted that a posteriorly located footprint repair is important for restoration of supination torque [7, 11–13].

In all specimens of the present study, the average footprint area of the distal biceps tendon insertion on the radial tuberosity was 156.3 mm², and it occupied approximately 35.9% of the area of the radial tuberosity. The distal biceps tendon was inserted on the posterior rim of the radial tuberosity. Its configuration was semilunar, with a concavity of the anterior surface of the footprint on the radial tuberosity. Knowledge of the size and location of the normal footprint can assist surgeons during surgical repair of distal biceps tendon ruptures. Familiarity with the normal footprint dimensions can assist with correct suture-anchor and bone-trough placement. Anatomical repair and restoration of the native footprint will maximize clinical outcomes.

As the long-head tendon inserts onto the radial tuberosity proximally and is furthest from the axis of rotation of

the radius, it is thought to provide a more stable lever arm for supination. The distal insertion of the short-head tendon, situated further distally, allows for increased power during elbow flexion [1, 7, 16].

In 12 specimens with a bifurcated distal biceps tendon, the long-head tendon inserted at the posterosuperior portion of the radial tuberosity, and the average insertional area was 71.4 mm². The short-head tendon inserted at its anteroinferior portion, and the average insertional area was 88.3 mm². The short head of the distal biceps tendon was inserted more anteriorly than the long head on the radial tuberosity. In this point, the current study is differing from previous studies [1, 7, 16]. There is evidence that posterosuperior insertion of the long-head tendon allows to act as forearm supinator and anteroinferior insertion of the short-head tendon allows to act as elbow flexor. These findings suggest that bifurcated distal biceps tendon insertion may allow functional independence as well as isolated rupture of each portion.

In the specimen with an united distal biceps tendon, the bicipital aponeurosis originated from the proximal aspect of the united distal tendon as it passed anterior to the elbow joint and expands medially, blending with the fascia of the forearm. But it originated from the proximal aspect of the short head of the distal tendon in the specimens with a bifurcated distal biceps tendon. Our findings are concordant with those of recent investigations [1, 6, 9]. Tagliafico et al. [22] emphasized that there is an important difference between patients with isolated short-head-component rupture and those with long-head-component rupture: The former did not present with retraction of the muscle belly, whereas the latter presented the typical Popeye sign, mimicking a complete rupture. It is possible that the contiguity of the short head with the bicipital aponeurosis prevented retraction of the muscle belly.

Limitations of this study include the small sample size, the use of embalmed cadaveric specimens, and the lack of consideration of demographic information, such as height, weight, and hand dominance. Furthermore, there was no biomechanical or histological investigation.

The present study provided more precise anatomical data on the dimensions and orientation of distal biceps tendon insertion on the radial tuberosity, including sex-related differences. The existence of 2 individual muscle bellies and a bifurcated distal biceps tendon has not been widely accepted yet, and its clinical implications are yet to be determined. However, the information that we have presented may serve as a baseline for developing techniques to enable anatomical restoration of the footprint in ruptures of the distal biceps tendon.

Conclusion

This study confirmed that bifurcated distal biceps tendon insertion is not a rare anatomical variation, showed by

recent investigations, and found that the short head of the distal biceps tendon was inserted more anteriorly than the long head on the radial tuberosity. These findings may allow functional independence and isolated rupture of each portion. It can make correct diagnosis possible and allow for a more anatomical orientation of the tendon during surgical repair.

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