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Original Article

Anatomy Section

Anatomical and Morphological Variations in Supernumerary Third Head of Biceps Brachii Muscle in Human Cadavers and its Clinical Significance

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ABSTRACT

Introduction: The biceps brachii muscle takes its name from its two proximally attached 'heads'. On rare occasions, an anomalous third head arises from the superomedial part of the brachialis and is attached to the bicipital aponeurosis and the medial side of the tendon of insertion. The slip frequently descends in front of and behind the brachial artery and often causes compression of the median nerve or brachial artery.

Aim: To calculate incidence of the supernumerary third head of the biceps brachii along with its anatomical and morphological variations to establish its clinical significance.

Materials and Methods: The observational study was conducted in Department of Anatomy, Dr. Kiran C Patel Medical College and Research Institute, Bharuch, Gujarat, India, from October 2021 to September 2022. It included 32 cadaveric upper limbs- 16 right-sided and 16 left-sided. The morphometric measurements were done with the use of digital vernier caliper. The findings were photographed and recorded. The mean and standard deviation deviation were hereby presented and analysed by Statistical Package for Social Sciences (SPSS) version 19.0.

Results: The biceps brachii was constituted of supernumerary third head in three (9.375%) limbs, one on the right and two on the left-side. In all cases, third head arose from the anteromedial aspect of the mid-humeral shaft; medial to the brachialis and inserted together with the other two heads of the biceps into bicipital aponeurosis and radial tuberosity. The mean length and mean width of the supernumerary head was measured as 141.16±43.63 mm, 25.22±4.99 mm, respectively. A significant difference was not found when compared for symmetrical sides.

Conclusion: Three specimens of upper limb were observed with distinct occurrence for the third head with the incidence of 9.37% and predominance on the left-side. In case of various arm surgical procedures knowledge can be used to avoid injuries.

Keywords: Coracobrachialis, Humerus, Hypertrophy, Median nerve, Musculocutaneous nerve, Nerve compression

INTRODUCTION

The two-headed biceps brachii muscle, which has a short head and a long head, is located in the anterior compartment of the arm. Proximally, the short head arises from the tip of the coracoid process of scapula and long head arises from the supraglenoid tubercle of scapula. Distally, the two fleshy bellies of the muscle unite to form biceps tendon just distal to the middle of the arm. The major insertion of biceps is to the posterior rough part of radial tuberosity; however a membranous band called bicipital aponeurosis, runs medially from the bicipital tendon to get attached to the posterior border of ulna by fusing with the deep fascia of the forearm [1]. This form of insertion provides an efficient supination of the forearm and decrease pressure of biceps tendon on radial tuberosity during supination and pronation of forearm [2]. The biceps muscle mainly contributes to flexion and supination of the forearm. It is innervated by the musculocutaneous nerve and vascularised by brachial and anterior circumflex humeral arteries and brachial vein [3].

An anomalous presence of third and fourth head of biceps brachii is infrequent variation reported in literature by several authors with varying frequencies. Supernumerary third heads may arise from the coracoid process of the scapula, head or humerus shaft, pectoralis major or minor tendon, shoulder joint capsule, or V-Shaped deltoid muscle insertion as a belly or as a group of the accessory fascicle [2]. The most common origin is from the proximal part of the humerus, known as the humeral head [2-4].

Understanding this variation is important because, regardless of shoulder position, the third head may give the biceps brachii more strength during supination of the forearm and elbow flexion. Following a fracture, the existence of such variances may result in bone displacement. Additionally, the course and branching pattern of the musculocutaneous nerve is likely to be impacted by the development of the biceps brachii muscle. The bulky third head compresses the musculocutaneous nerve. Also, the presence of an abnormal muscle in or near the elbow region may result in high median nerve palsy and brachial artery compression [5]. The knowledge of such variation is significant because the third head may provide additional strength to the biceps brachii. The anatomical knowledge of such variation may help to the surgeons while operating on the arm and relationship of the structures is essential for the accurate diagnosis, and for the development of improved surgical and operative procedures in the various pathologies related to the arm. Therefore, the purpose of the present study was to macroscopically review and focus on the anatomical and morphological variations in the supernumerary third head of the biceps brachii muscle.

MATERIALS AND METHODS

This was an observational study carried out in 32 properly embalmed and formalin-fixed upper limbs of adult cadavers; dissected during October 2021 to September 2022, from the cadaveric laboratory of the Anatomy Department at Dr. Kiran C. Patel Medical College and Research Institute, Bharuch, Gujarat, India. The study was done to evaluate variations in the origin and insertion of the biceps brachii muscle along with its innervations.

Inclusion criteria: Study group consisted of 32 cadaveric upper limbs-16 right-sided and 16 left-sided. Specimens of adult male and female which did not have any visible external abnormalities in their upper limb were included.

Exclusion criteria: The specimens previously operated in the arm region, which may prevent the cadaveric analysis of biceps muscle were excluded from this study.

Procedure

A vertical incision was made on the skin at anterior aspect of the arm above from the shoulder level to the elbow joint crease level below. Another two transverse incisions were made perpendicular to the upper and lower end of the vertical incision. Skin and subcutaneous fascia were removed. The biceps brachii muscle was exposed carefully and dissected to identify for any anatomical and morphological variations. The origin, insertion, presence of extra-head, innervations of each biceps muscle was macroscopically observed. The incidence of third head of the biceps muscle was observed and calculated. The length of third supernumerary head was measured in millimeter using measuring tape while mid-width diameter was measured using digital vernier caliper.

STATISTICAL ANALYSIS

The findings were photographed and recorded and the mean and standard deviation was analysed by Statistical Package for Social Sciences (SPSS).

RESULTS

Several variations of the biceps brachii muscle for its origin, innervations, presence of supernumerary extra head, and different relationship of the structures were observed. In the present study, the short and long head had a normal origin, insertion and innervations in all specimens. All the specimens showed short head arose from the tip of the coracoid process, and long head arose from the supraglenoid tubercle; both the heads had common tendon insertion on the posterior rough part of the radial tuberosity in radius bone; both the heads received innervations from the musculocutaneous nerve, branch from the lateral cord of brachial plexus. However, the presence of supernumerary third head of the biceps brachii was observed as a most frequent variation (9.37%).

Three specimens of upper limb were observed with distinct occurrence for the third head with the incidence of 9.37% and predominance on the left-side 2 (6.25%). while the four-headed biceps brachii was not observed in any specimen [Table/Fig-1,2,3,4]. There was unilaterally three headed biceps brachii muscle, one belonging to the right-side and two to left-side observed.

In first specimen, third head originated from the anteromedial aspect of the lower part of the middle shaft of humerus just below the insertion of the coracobrachialis muscle; at the origin of the brachialis and it fuses with the other two heads to get inserted into the posterior rough part of radial tuberosity [Table/Fig-1]. In second specimen, third head was observed longest with 190.7 mm in length and 30.5 mm in width [Table/Fig-2]. It was infrequently originated from the upper-two third anteromedial surface of humeral shaft; below the medial lip of bicipital groove and some muscle fascicle were fused with medial head of triceps brachii [Table/Fig-3]. In third specimen, third head originated from the middle two-third humeral shaft; medial to the origin of brachialis muscle and fused with the tendon of biceps brachii. In all three specimens, the supernumerary third head runs distally; merged with the other two heads to form a common tendon of biceps brachii inserted onto the posterior rough part of radial tuberosity and received its innervations from the musculocutaneous nerve [Table/Fig-4].

In first specimen (right-sided), unusual course of the musculocutaneous nerve without piercing to the coracobrachialis muscle was observed. The nerve passed between the biceps and brachialis muscle and continued as a lateral cutaneous nerve of forearm [Table/Fig-1]. In second specimen (left-sided), the musculocutaneous nerve was joining the median nerve by communicating nerve after supplying all three heads of biceps brachii [Table/Fig-3]. In third specimen (left-sided) the third head was innervated by musculocutaneous nerve which had its normal course [Table/Fig-4]. The mean of the supernumerary third head length was 141.7±7.9 in all the limbs.

[Table/Fig-1]: Third head of the biceps brachii originated from the anteromedial aspect of the lower part of the middle shaft of the humerus. **[Table/Fig-2]:** THB originated from the anteromedial surface of the humeral shaft. **[Table/Fig-3]:** THB originated from the middle two-third humeral shaft. (Images from left to right)
LHB: Long head of biceps brachii; SHB: Short head of biceps brachii; THB: Third head of biceps brachii; CB: Coracobrachialis; MCN: Musculocutaneous nerve; MN: Median nerve; CN: Communicating nerve; BA: Brachial artery; AA: Axillary artery.

Biceps brachii variant	Limb side	Origin of supernumerary THB	Insertion of super-numerary THB	Length of supernumerary THB (in mm)	Mid-width of supernumerary THB (in mm)
Case 1	Right	Anteromedially on lower part of the mid-shaft of humerus	Common on radial tuberosity	108.4±43.63	20.56±4.99
Case 2	Left	Upper-2/3rd anteromedial surface of humeral shaft; muscle fascicle were fused with medial head of triceps brachii (rare)	Common on radial tuberosity	190.7±43.63	30.5±4.99
Case 3	Left	Middle two-third humeral shaft	Common on radial tuberosity	124.5±43.63	24.6±4.99
Mean±SD		-	-	141.16±43.63	25.22±4.99

[Table/Fig-4]: Morphology and morphometry of supernumerary third head of biceps brachii (THB).

DISCUSSION

Research studies on the anatomical variations of the biceps brachii muscles are rare in the literature. Several authors have reported the biceps brachii as the most frequent muscle showing variation for the presence of supernumerary third head and fourth head, a condition which is also made known in other mammals [6-9].

The biceps is a two-headed 'three-joint muscle,' capable of effecting movement at the shoulder, elbow, and radio-ulnar joint [10]. Unlike the long and short heads of the biceps brachii, the third head only crosses the elbow joint. Therefore, biomechanically, a third head with a humeral origin allows flexion of the elbow joint irrespective

of the position of the shoulder joint accordingly may enhance the strength of elbow flexion.

The third head of the biceps brachii in humans most likely originated from the muscles in the anterior compartment of the arm given its innervations and connections. Notably, humans lack the coracobrachialis' long head, which is present in other primates. When the third head develops from the coracobrachialis insertion site, it is most likely a remnant of the coracobrachialis long head, the ancestor hominoid condition. The long head of the coracobrachialis may attach onto the radial tuberosity similarly to the biceps brachii, as Dobson (1881) discovered in Cercopithecus [6-9].

Embryologically, during the 7th week of intrauterine life; the mesenchymal condensation close to the origin of the limb buds developing from dorsolateral cells of the somites is considered as the first sign of limb musculature development. The upper limb bud further becomes compact to form dorsal muscle mass and ventral muscle mass; which derives the triceps brachii and biceps brachii muscle respectively. Developmentally, the supernumerary third head of the biceps brachii arises due to variable segmentation of this ventral muscle mass of the upper limb bud [11].

In the study done by Lee H et.al third head of biceps was observed in 14 of the 214 upper extremities [12]. The Incidence of variation was approximately 6.5%. Study also observed third head was in 10 male limbs (7.1%) and 4 female limbs (5.4%), and none of the cases was bilateral. Gupta C et.al observed the three headed BB unilaterally in three male cadavers, one belonging to the left side and two to right side [13]. Further, Wahengbam S et.al reported the incidence of 4.3% of unilateral presence of third head was made [14]. Unusual insertion of biceps brachii was observed by the author Agarwal J and Gopal K where dividing into three distinct parts. The tendon of long head of biceps was inserted on radial tuberosity ends in musculotendinous slip runs towards the pronator teres muscle belly; lying superficial to brachial artery and median nerve. The tendon of short head ends in musculotendinous slip runs towards flexor carpi radialis muscle belly and did not insert on radial tuberosity [15]. The findings of present study are similar to those by Ravi PK et al. [16]. Previous studies demonstrated that supernumerary third head of biceps brachii muscle commonly originated from anteromedial aspect of humerus, between the coracobrachialis insertion and the origin of brachialis muscle and from the inferomedial margin of the humerus; similar observation was reported in the first specimen of present study [16,17,18]. Similar type of study was carried by various other authors and their results are compared with the result of the present study as elicited in [Table/Fig-5] below [3,4,12,13,15-19].

Author's Name	Year of study	No. of sample	Place of study	Incidence of presence of supernumerary third head	Incidence of presence of more than three heads
Cheema P and Singla R [19]	2011	126 limbs	North Indian (Chandigarh and Amritsar)	2.3 %	-
Avadhani R and Chakravarthi KK [20]	2012	24 cadavers	Andhra pradesh	16.67%	2.08%
Shalini G and Anupama M [3]	2013	100 upper limbs	North Indian (Lucknow and Meerut)	6%	--
Al-Kushi AG [4]	2013	40 upper limbs	Kingdom of Saudi Arabia	15%	--
Gupta C and D'souza S [13]	2014	24 upper limbs	Manipal	--	--
Wahengbam S et al., [14]	2015	70 upper limbs	Imphal	4.3%	--
Agarwal J and Gopal K [15]	2020	32 upper limbs	Bareilly, Uttar Pradesh	6.25%	--
Ravi PK et al., [16]	2020	50 upper limbs	Eastern Indian	8%	2%
Sthapak E et al., [17]	2016	20 upper limbs	Lucknow	15%	--
Present study	2023	32 upper limbs	Gujarat	9.37%	--

[Table/Fig-5]: Incidence of morphological variations of supernumerary third head of the biceps brachii muscle in published studies.

The incidence of supernumerary third head of biceps brachii was observed highest in the study done by Avadhani R and Chakravarthi KK and Sthapak E et al., [20,17]. The findings of present study are similar to those by Ravi PK et al., [16].

Ravi PK et al., also observed few fibers of the four-headed biceps originated from the deeper lamina of the pectoralis major tendon. No such observations were made in the present study [17]. In the study done by Nasr AY and Hussein AM observed middle of the medial border of the humerus gave origin to the third head of the biceps muscle in 30% of the variants [18]. Moreover, the studies have reported supernumerary head rarely originates from the deltoid muscle, the greater tubercle near the long head of the biceps brachii muscle [21], the lesser tubercle, intertubercular groove, anterior investing fascia of the brachialis muscle and the pectoralis major [22]. Rodriguez-Niedenfuhr M et al., depending on their origin and location, the supernumerary heads classified third head of biceps as superior, infero-medial and infero-lateral humeral heads and reported incidence of in 27(15.4%) limbs [23].

In the study done by Szewczyk B et al., supernumerary biceps brachii heads were classified into four types; Type I as two headed biceps brachii (64%) and was most common; it was further subdivided into Type IA and Type IB as single muscle belly and with two muscle bellies respectively [24]. Type II, three-headed biceps brachii, this type was further divided into four subtypes (A-D): attachment to the mid humeral shaft was considered Type IIa; origin of muscle from the coracoid process together with the short head was considered Type IIb; origin of the muscle from the tendon of the pectoralis major muscle was considered Type IIc; while muscle attachment to the capsule of the humeral joint was considered Type IId. No such diverse classification of the biceps brachii has been drawn up in the present study. Ansari M M et.al have reported incidence of third head of biceps brachii is more common in female than in males [25]. Moreover, Most of the study mention supernumerary head of biceps occurs unilaterally, and bilateral occurrence is rare and incidence is more commonly in males [26].

Unusual insertion of biceps brachii was observed by the author Agarwal J and Gopal K where dividing into three distinct parts. The tendon of long head of biceps was inserted on radial tuberosity ends in musculotendinous slip runs towards the pronator teres muscle belly; lying superficial to brachial artery and median nerve. The tendon of short head ends in musculotendinous slip runs towards flexor carpi radialis muscle belly and did not insert on radial tuberosity [16]. Such infrequent insertion pattern of biceps brachii was not observed in any specimens of the present study [9,12,18].

Understanding the presence of a supernumerary third head of the biceps brachii may aid in preoperative diagnosis and improved upper limb surgery, thus preventing iatrogenic injuries. In addition, the knowledge of surface landmarks, and anatomical and morphological variant of the present study is a pre-requisite for orthopaedic surgeons while surgically accessing the arm region to minimise various complications. Since unusual clinical signs and symptoms at the upper limb can be attributed to the compression or entrapment of neurovascular bundles by the anomalous anatomical Structure of the third head of the biceps brachii may result in sensory

deficits leading to a decrease in the propriocepive sensation and joint stabilization [27,28,29]. Further, while treating bone fractures in this region, orthopaedic surgeons should be aware of all study differences since the existence of a third head occasionally results in unexpected bone displacement after a fracture [15, 30]. Additionally, a third head with a different origin may give rise to an intramuscular musculocutaneous nerve course, which could result in nerve compression during biceps contraction, particularly in professional body builders whose biceps have hypertrophied as a result of strenuous activity [25,31].

The biceps brachii is recognised for its powerful elbow flexion and forearm supination. It can be argued that the existence of extra biceps brachii muscle heads optimises its kinematics. [32,33]. Furthermore, any unusual muscular bands in the arm's anterior compartment that may compress the median, ulnar, and medial antebrachial cutaneous nerves, along with the brachial artery and vein, resulting in entrapment at and above the elbow. [34]. According to the study's author Khaledpour C. et al., the incidence of accessory heads of the biceps brachii is relatively rare in the white race, high in the yellow race, and intermediate in blacks. [35]. From data in the in the literature, it is concluded that the differences in findings may be multifocal, and a larger case study should be performed. Further, extensive evidence suggests a wide range of racial differences in the incidence of the third head of biceps brachii. So, the present study was aimed to give most important input as shown in [Table/Fig-6] below [9,14,20,30-34].

Further, while treating bone fractures in this region, orthopaedic surgeons should be aware of all study differences since the existence of a third head occasionally results in unexpected bone displacement after a fracture [15]. Additionally, a third head with a different origin may give rise to an intramuscular musculocutaneous nerve course, which could result in nerve compression during biceps contraction, particularly in professional body builders whose biceps have hypertrophied as a result of strenuous activity [25].

Author/Reference	Type of population	Incidence of presence of supernumerary third head of biceps brachii
Asvat R et al., [9]	South African black	20.50%
Asvat R et al., [9]	South African white	8.30%
Lee JH [12]	Korean	6.5%
Nasr AY and Hussein AM [18]	Saudi Arabian	10%
Radhika PM et al., [30]	Indians (South)	10%
Kosugi K et.al., [31]	Japanese	13.70%
Ilayperumas et al., [32]	Sri lankan population	3.70%
Poudal PP and Bhattarai C, [33]	Nepalese population	6.25%
Paraskevas G et al., [34]	Greek	1.6%
Asvat R et al., [9]	European white	10%

[Table/Fig-6]: Incidence of supernumerary third head of biceps brachii in various populations [9,12,18,30-34].

Limitation(s)

The present study was not conducted based on the gender of cadaver; further a large sample size research study would enlighten aspiring researchers. Another limitation is that, there was no baseline for the occupation of cadaver which could have influenced in establishing occurrence of the result.

CONCLUSION(S)

This study highlights the several anatomical and morphological variants of the biceps brachii muscle including supernumerary head. The detail knowledge of this kind of variants is important in performing various surgical procedures by orthopaedic surgeons and general surgeons. Nevertheless, fewer attempts have been observed in literature to understand the native cadaveric structural evaluation and morphometric evaluations en bloc. Furthermore, the preoperative radiological investigations of the biceps brachii may be helpful to the operating surgeons to prevent the neurovascular injury and subsequent difficulties during the various surgical procure of the arm.

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