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A Third Head of The Biceps brachii: An anatomical insight

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ABSTRACT

Biceps brachii is a muscle belonging to the flexor compartment of the arm. It has been described as one of the muscles with most frequent anatomic variations. The objective of this study was to determine the prevalence of third head of the biceps brachii muscle. A total of 14 cadavers of both sexes (13 men and 1 women) with different age group were used for the study in the Morphology Laboratory at the University of Pamplona. On the right side the origin of extra head biceps brachii muscle was given bicipital groove level in relation to the distal portion of the pectoralis major muscle, the distal insertion was joining with the short head of the biceps brachii. In the left arm of the second body, extra head biceps brachii muscle originated from the anterolateral surface of the humerus between coracobrachialis muscle insertion and origin of brachialis muscle; its distal insertion occurred in the long head of biceps brachii muscle. The dual origin of the third head of the biceps might contribute to supination of forearm, as the muscle origin appeared in a lateral position relative to the rotational axis of the arm. The knowledge of such anatomical variations is important for anatomists in the academic study and clinicians in order to avoid errors in the diagnosis or undesirable consequences during surgery, procedures safer and more efficient rehabilitation.

Keywords: Anatomical variation, biceps brachii muscle, brachialis muscle, coracobrachialis muscle, third head of the biceps brachii, upper limb.

INTRODUCTION

Biceps brachii is a muscle belonging to the flexor compartment of the arm. It has been described as one of the muscles with most frequent anatomic variations. About one to five or even seven heads of Biceps brachii have been reported previously in the literature. The knowledge of such additional heads and associated variations in the architecture of the surrounding region is important because they can produce clinical symptoms by compressing surrounding neurovascular bundles [1-3]. This knowledge is also important for correct identification during imaging and to prevent iatrogenic injuries during surgery. The presence of the additional head of Biceps brachii can also affect the kinematics of the joints the muscle acts on. The third head of Biceps brachii muscle have clinical significance as they might confuse surgeons who perform surgeries on the arm and might lead to iatrogenic injuries or the third head might cause compression of vital neurovascular structures in the upper limb. Association of third head with unusual bone displacement following fracture has significance in surgical procedure [4-6]. Biceps brachii is a dual headed flexor muscle of flexor compartment of upper arm, originates proximally with a long head from supraglenoid tubercle and short head from coracoid process of scapula. Distally these heads join to form a common tendon, which gets inserted to the posterior part of the radial tuberosity. This muscle chiefly contributes to the flexion and supination of forearm. Some aponeurotic and tendinous fibers go and insert into the bicipital aponeurosis [7]. The third head may offer extra strength to the Biceps during supination of the forearm and elbow flexion regardless of shoulder position. The extra head of Biceps brachii muscle is remarkable not only to anatomists but also to the clinicians, from the phylogenetic point of view as well as from the surgical view due to the partial entrapment of either the musculocutaneous or median nerve in certain cases. From a clinical perspective, muscle anomalies are hard to discriminate from soft tissue tumors. The presence of an anomalous muscle in and around the elbow region may cause high median nerve palsy and compression of the brachial artery. It is recognized that the development of the Biceps brachii muscle is likely to affect the course and the branching pattern of musculocutaneous nerve. This may have clinical association as the musculocutaneous nerve is subjected to compression by the bulky third head. Thus, knowledge on such variations will be significant during surgical operations of the arm as well as in detecting the nerve injuries. Additionally, it has been stated that any variant nerve with an anomalous origin, course and distribution is liable to to accidental damages and impairments. This is further verified by the point that supernumerary heads of the biceps brachii muscle have been reported to compress the adjacent neurovascular structures leading to inaccurate interpretations during surgical procedures. Therefore, thorough understanding of this variation is significant for surgical interventions of the arm, nerve compression syndromes and in mysterious pain syndromes in the arm or shoulder region [7-13]. The aim of the present study is to determine the prevalence and describe the morphological features of third head of the biceps brachii muscle with its clinical significance.

EXPERIMENTAL SECTION

A total of 14 cadavers of both sexes (13 men and 1 women) with different age group were used for the study. Upper limb region (28 sides) of the cadavers were carefully dissected as per the standard dissection procedure in the Morphology Laboratory at the University of Pamplona. A vertical incision was made on the anterior aspect of the arm from the level of acromion to the level below the elbow crease by 5 cm. Another 2 transverse incisions were made perpendicular to the upper and lower ends of this vertical incision. Skin and subcutaneous fascia were removed to expose the biceps brachii muscle. The origin, insertion, presence of extra head, pattern of innervation of each biceps muscle were carefully observed, the topographic details were examined and the variations were recorded and photographed. The length of the supernumerary heads and the arm was measured by using a Verneir caliper of accuracy 0.01 mm. The history of the individual and the cause of death are not known.

RESULTS AND DISCUSSION

The morphological variations in the number of heads of origin of bíceps muscle were observed in 2 out de 28 upper limbs (7,1%). It was found in two male subjects in right and left arm unilaterally. The remaining 26 upper limb showed the normal origin, insertion, course and the supply of the biceps brachii and the course and branching patterns of the median and musculocutaneous nerve was normal having classic pattern of branching without communications.

In the male cadaver of 75 years old, at the level of the right upper limb, third head of biceps brachii muscle originated in the anteromedial surface of the humerus to 3.5 cm above the origin of brachialis muscle at the level of the bicipital groove in closely related and lateral to the distal insertion of the pectoralis major muscle and below insertion of latissimus dorsi muscle, its distal insertion was joining with the short head of biceps brachii. The short and long heads remain separate in all the way, 2.5 cm above the elbow joint the short head and the long head of the biceps brachii were a common tendon which is linked in the posterior part of the radial tuberosity and also insertion observed in the antebrachial fascia through the bicipital aponeurosis. Arm length was 322 mm, taken from the edge of the acromion to the lateral epicondyle of the humerus and the extra length of head of biceps brachii was 210 mm. Figure 1.

In the male cadaver of 59 years old, at the level of the right upper limb, third head of biceps brachii muscle originated in the anterolateral surface of the humerus, lateral to the distal insertion of the coracobrachialis muscle; medial to the insertion of the deltoideus muscle; above the origin of brachialis muscle and below the pectoralis major muscle insertion; its distal insertion was joining with the long head of biceps brachii. The short and long heads remain separate in all the way, 2.5 cm above the elbow joint, the short head and the long head of the biceps brachii were a common tendon which is linked in the posterior part of the radial tuberosity and also insertion observed in the antebrachial fascia through the bicipital aponeurosis. Arm length was 312 mm, taken from the edge of the acromion to the lateral epicondyle of the humerus and the extra length of head of biceps brachii was 130 mm. Figure 2.

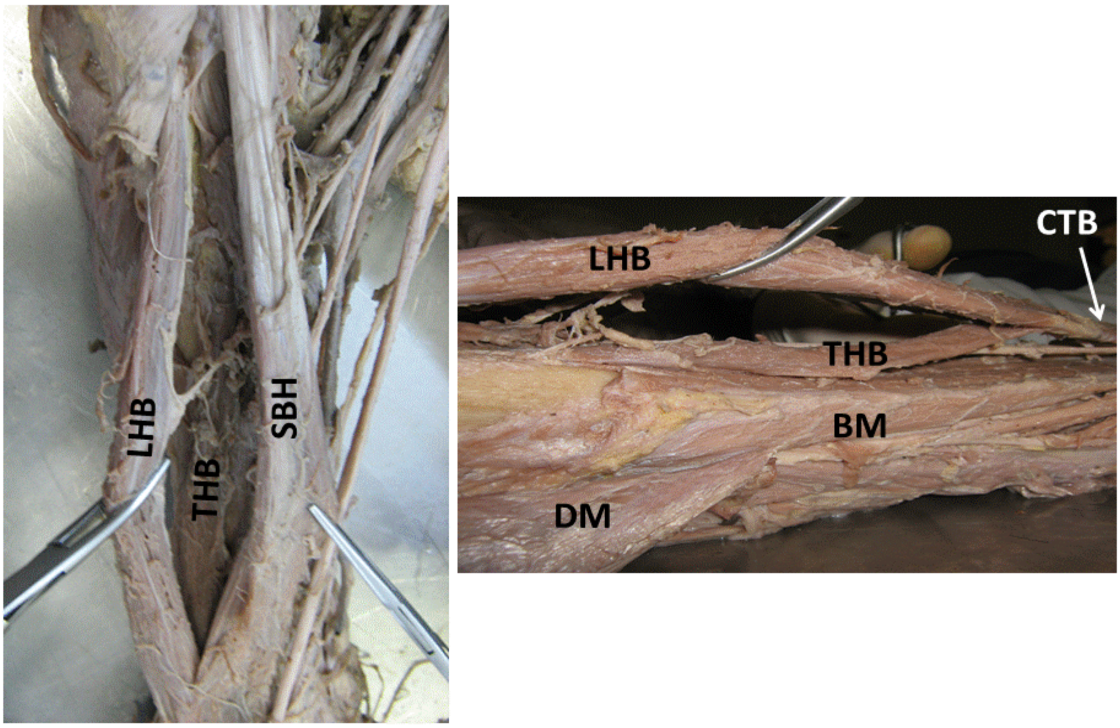

Figura 1. Case 1. Anterior and lateral view of right arm: LHB: long head of biceps; THB: third head of biceps biceps brachii; SBH: short head of biceps; CTB: common tendón of biceps; BM: Brachialis muscle ; DM: deltoideus muscle

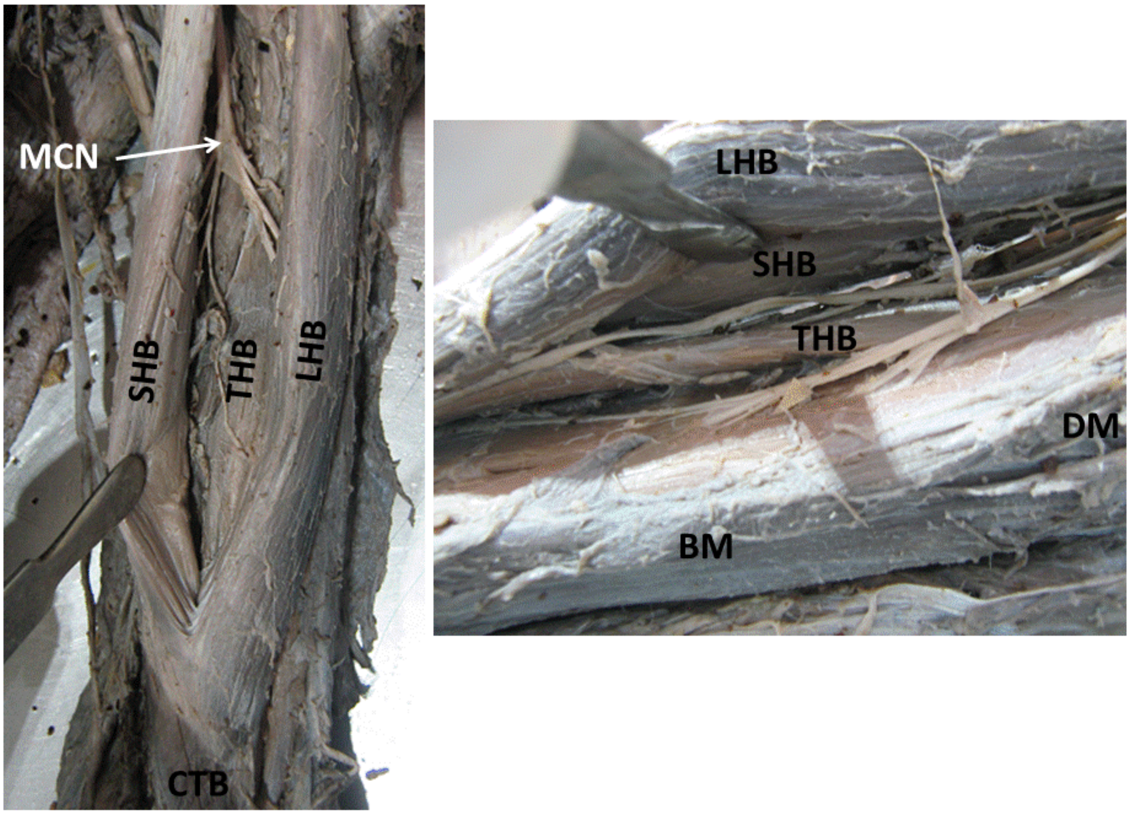

Figure 2. Case 2. Anterior and lateral view of left arm: LHB: long head of biceps; THB: third head of biceps biceps brachii; SBH: short head of biceps; CTB: common tendón of biceps; BM: Brachialis muscle ; DM: deltoideus muscle. MCN: Musculocutaneus nerve

All the third heads of the biceps muscle were supplied by the musculocutaneous nerve through separate branch or from the motor branches of short and/or long heads of the biceps muscles.

All the Biceps brachii studied were supplied by direct branches from the brachial artery, so also branches from anterior circumflex humeral, ulnar collateral or by anterior ulnar recurrent arteries.

Various authors [7,12,14-29] have reported the incidence of the accessory heads of the biceps brachii to be between 0.18% to 37.5% in different populations. It was encountered in two limbs (7,1%) in the present study. Table 1.

Author	Incidence of third head of biceps brachii
Greig et al. South African Black.(14)	21,5%
Bergman et al. (15) Chinese European white African black Japanese	 8% 10% 12% 18%
Khaledpour (16)	0,18%
Higashi and Sone (17)	18,3%
Kosugui et al. (18)	12,5%
Asvat et al. (19) South African black South African white	 20,5% 8,3%
Williams et al.(20)	10%
Nakatani et al. (21)	8%
Neto et al. (22) Brazilian white Brazilian black	 20% 9%
Kopuz et al.(23) Turkish	 15%
Rincon et al.(24) Colombian population	 37,5%
Ravindranath et al. (25)	1,8%
Rai et al. (26)	7,1%
Kumar et al. (12)	3,33%
Poudel and Bhattarai. (27)	12,5%
Cheema et al. (28)	2,3%
Ashraf et al.(29)	7%
Gupta et al. (7)	12,5%
Ferreira H. (present study)	7,1%

Table 1. Comparison of incidence of third head of biceps brachi

The presence of the extra heads of the biceps brachii muscle has been associated with variations of the musculocutaneous nerve; likewise, it has been associated with the presence of communicating branches, between the median nerve and musculocutaneous nerve. The embryological development of the upper limbs may help in explaining this anatomical variation. The mesenchyme, which forms the upper limb muscles, is penetrated by the ventral primary branches of the appropriate spinal nerves, located opposite to the bud. Contact between nerves and muscle cells, is necessary to provide mesenchymal condensation to form muscles. Nerves supplying the limbs are joined by loops connection of nerve fibers to form plexuses. The median nerve is formed by a combination of ventral segmental branches and the musculocutaneous nerve arises from it. The development of the biceps brachii third humeral head may have influenced the course or the ramification patterning of variant musculocutaneous nerve, or vice versa, and could explain the coexistence of such neuromuscular anomaly [30-32].

Rodríguez-Niedenführ et al, classifies the supernumerary heads of biceps brachii muscle according its location, as a superior humeral head, inferomedial and inferolateral. The superior humeral head, presents a proximal attachment in the surface of the humerus, between the lesser tubercle, the brachial and coracobrachial muscles. Then it continues inferiorly, deep to the short head of biceps brachii muscle and superficial to the anterior humeral circumflex artery, and merges with muscle fibers of the short head of biceps brachii muscle in its join with the long head. The inferomedial head has a proximal attachment in the anteromedial surface of humerus, continues with the insertion of coracobrachialis muscle and closely related to the medial intermuscular septum and brachial muscle; then continues inferiorly, deep to the biceps brachii muscle and superficial to the brachial muscle, inserting in the medial border of the biceps brachii tendon. The inferolateral head originates in the lateral intermuscular septum, between the insertion of the deltoid and the origin of the brachioradialis muscle, and joins to the long head of the biceps brachii muscle at the level of lower third of arm. According to this classification, the third head of biceps brachii muscle found in this case corresponds to an inferomedial humeral head. According Rodríguez-Niedenführ et al. this is the most common variation (9%) of the cases [30]. The insertion sites of the extra-heads of biceps were classified into 4 main groups, but with different occurrence rates. The highest incidence site of the extra-head insertion was the common belly of the biceps that received 73.3% of the extra-heads, while the least one was the insertion into the long head (2.7%). The biceps tendon and the short head received the extra-head insertion in 14.7% and 9.3%, respectively [18,33]. The extra-heads of biceps can be inserted into the muscular belly or the aponeurosis of the biceps muscle [30]. A racial or a developmental factor might be the actual cause of the incidence difference of the insertion of the extra-head in this present study and the other previous literatures. The origin of the extra-heads from the anteromedial surface of humerus might support the opinion that the pronation of forearm occurs in any position of the shoulder joint. The presence of third head of the biceps muscle might increase the strength of flexion of the elbow [33]. Rare variations regarding the insertion of biceps have been reported and also the absence of its long or short heads [29,34].

Paval and Mathew [34] who reported that some fibres from the medial side of the biceps brachii tendon formed a separate narrow tendinous slip that was subdivided into lateral superficial and medial deep slips surrounding the brachial artery and median nerve. The later authors added that, this case was mimicking the situation of the median nerve compression underneath the bicipital aponeurosis and this variation might be one of the causes of pronator teres syndrome. The variants of biceps muscle insertion were also noticed, where some slips of this muscle might extend to the medial epicondyle, the medial intermuscular septum of the arm, the brachialis muscle or the pronator teres muscle [10]. The later authors added that variations had important clinical significance regarding surgical approaches. Lateral superficial and medial deep slips surrounding the brachial artery and median nerve. The later authors added that, this case was mimicking the situation of the median nerve compression underneath the bicipital aponeurosis and this variation might be one of the causes of pronator teres syndrome. The variants of biceps muscle insertion were also noticed, where some slips of this muscle might extend to the medial epicondyle, the medial intermuscular septum of the arm, the brachialis muscle or the pronator teres muscle [10]. The later authors added that variations had important clinical significance regarding surgical approaches. Embryologically, the third head of the biceps muscle was considered as a part of brachialis muscle that was separated by the musculocutaneous nerve, where its lower insertion migrated from ulna to radius [24]. The presence of the third head of the biceps muscle in humans might represent the remnant of long head of the coracobrachialis of some other primates [29,35].

The presence of the extra heads of the biceps muscle with or without neural variation might be due to change of signal between a group of mesenchymal cells and neuronal growth factors of forearm muscles developed from the paraxial mesoderm during embryonic development, or it might be caused by the presence of the circulatory factors during the time of formation of brachial plexus [29,33]. Muscles of front of arm develop from myogenic precursor cells that arise from ventral dermomyotome of somites. Molecular changes occurring in these precursor cells induce muscle development. Muscle regulatory genes like Pax 3 and Myf 5 are activated and transcription factors like Myo D, myogenin and myogenic regulatory factors are expressed. Further growth of muscle occurs by fusion of myoblasts and myotubes and later are invested by connective tissue. Variation of muscle patterns may be a result of altered signaling or stimulus between mesenchymal cells. Different views exist for the presence of supernumerary heads of biceps brachii especially the inferomedial type. One school of thought is that these accessory heads of biceps may be due to the musculocutaneous nerve that pierces biceps and cause a longitudinal splitting of myotubules which get a covering of connective tissue and becomes a separate belly. The accessory head may or may not give extra strength to the muscle but these heads become relevant during surgical intervention of the arm especially after humeral fracture, where they may or may not cause displacement of fracture fragments of humerus. Because of its close relation with median nerve and brachial artery neurovascular symptoms have been reported due to compression. Accessory heads without an intervening artery or nerve are useful for flap surgery as they would be expandable than the two main heads. Embryological studies by Testut, described the variation as a portion of brachialis muscle where its distal insertion has been translocated from ulna to the radius. This supports the hypothesis of functional adaptation. Lokanatham suggested that presence of supernumerary medial heads was due to the musculocutaneous nerve piercing the brachialis muscle and producing a supernumerary separate head [4,36,37]. From the functional point of view, the extra head of the biceps brachii muscle with a humeral origin might allow flexion of the elbow joint in any position of the shoulder joint [38]. The dual origin of the third head of the biceps might contribute to supination of forearm, as the muscle origin appeared in a lateral position relative to the rotational axis of the arm. The medial brachial origin of the third head might contribute to pronation of the forearm in any position of the shoulder joint. In addition, the third head could strengthen the flexion of the elbow [39].

CONCLUSION

The third head of biceps brachii muscle have clinical importance as they may confuse surgeons, orthopaedic surgeons who perform procedures on the arm and may lead to iatrogenic injuries or they may cause compression of important neurovascular structures in the upper limb. Association of third head with unusual bone displacement subsequent to fracture has relevance in surgical procedure. In addition to allowing elbow flexion independent of shoulder joint position the third head of biceps brachii may enhance the strength of the elbow flexion. The knowledge of such anatomical variations is important for anatomists in the academic study and clinicians in order to avoid errors in the diagnosis or undesirable consequences during surgery of the upper limb especially for plastic surgeons in flap surgery.

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