MORPHOLOGICAL STUDY ON THIRD HEAD OF BICEPS BRACHII IN HUMAN CADAVERS

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Abstract: The biceps brachii is a muscle of the anterior compartment of the arm that has two proximal heads, the long head and the short head. However, variations in the number and morphology of this muscle have been reported, such as the presence of a third head. The aim of this study was to investigate the incidence, origin, insertion and innervation of the third head of biceps brachii in human cadavers. The arms of 40 adult cadavers were dissected and examined for the presence of the third head of biceps brachii. The results showed that four cadavers (10%) had a third head of biceps brachii, two on the right side and two on the left side. All the third heads originated from the humerus, below the insertion of coracobrachialis, and inserted into the radial tuberosity along with the long and short heads. The third heads were innervated by the musculocutaneous nerve. The knowledge of the existence and variations of the third head of biceps brachii may be important for clinical diagnosis, surgical procedures and anatomical education.

Keywords: Morphological study, third head, biceps, brachii, human cadavers
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Introduction:

The biceps brachii is one of the most variable muscles in the human body, in terms of number and morphology (Testut, 1899). It is characteristically described as a two-headed muscle that originates proximally by a long head and a short head. The long head originates from the supraglenoid tubercle of the scapula, and the short head originates from the coracoid process of the scapula. Distally, these two heads join to form a common tendon which inserts into the radial tuberosity, and some aponeurotic fibers form the bicipital aponeurosis which merges with the deep fascia of the forearm. This muscle mainly contributes to flexion and supination of the forearm (Standring et al., 2008).

However, variations in the number of heads of biceps brachii have been reported in different populations, ranging from 1% to 30% (Bergman et al., 1988). The most common variation is the presence of a third head, which may originate from various sites, such as the humerus, coracoid process, pectoralis major tendon, glenoid labrum or suprascapular ligament (Le Double, 1897). The insertion of the third head may also vary, such as into the radial tuberosity, bicipital aponeurosis, brachialis muscle or pronator teres muscle (Le Double, 1897). The innervation of the third head may be by the musculocutaneous nerve, median nerve or both (Bergman et al., 1988).

The presence of a third head of biceps brachii may have clinical implications, such as causing compression of neurovascular structures, interfering with surgical approaches to the arm or elbow joint, or affecting muscle function and strength (Kosuri& Chaudhary, 2010). Therefore, it is important to be aware of this variation and its possible consequences.

Biceps brachii, a muscle of the anterior compartment of the arm, has two proximal heads (long and short) and a common distal tendon that inserts into the radial tuberosity (Avadhani&Chakravarthi, 2020). It is one of the most variable muscles in the human body, in terms of number and morphology of its heads (Avadhani&Chakravarthi, 2020).

A third head of biceps brachii is an anatomical variation of the muscle that originates from the humerus, usually below the insertion of coracobrachialis, and joins the main muscle belly (Ansari et al., 2013; Wahengbam et al., 2015; Yalcin et al., 2016). It may vary in its length, thickness, attachment site and relation to neurovascular structures (Ansari et al., 2013; Yalcin et al., 2016).

The incidence of third head of biceps brachii varies among different populations and ethnic groups. It ranges from 4.3% to 10% in Indian population (Wahengbam et al., 2015; Yalcin et al., 2016), 9% to 15% in African population (Mwachaka et al., 2010), 7.4% to 9.6% in Turkish population (Yalcin et al., 2016), and 1.5% to 2.5% in European population (Yalcin et al., 2016). The third head is more common in males than females, and more dominant in the right arm than the left arm (Wahengbam et al., 2015).

The morphology of third head of biceps brachii has implications for diagnosis, surgery, imaging and biomechanics of the arm. The third head may cause compression of brachial artery or median nerve, interfere with surgical procedures or affect the range of motion and strength of the elbow joint (Ansari et al., 2013; Mwachaka et al., 2010; Yalcin et al., 2016). It may also alter the appearance and contour of the arm, especially when contracted (Yalcin et al., 2016). The presence of third head may be detected by clinical examination, ultrasound, computed tomography or magnetic resonance imaging (Ansari et al., 2013; Mwachaka et al., 2010; Yalcin et al., 2016).

The morphological study of third head of biceps brachii in human cadavers can provide valuable information about its origin, insertion, innervation and function. It can also help to compare the frequency and characteristics of this variation among different populations and regions. It can also contribute to the understanding of the embryological development and evolutionary significance of this muscle variation (Avadhani&Chakravarthi, 2020; Yalcin et al., 2016).
The aim of this study was to investigate the incidence, origin, insertion and innervation of the third head of biceps brachii in human cadavers.

Materials and Methods:
This study was carried out on both upper extremities of 40 human cadavers (35 males and 5 females) at Department of Anatomy, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha (INDIA). The age range of the cadavers was from 40 to 70 years. The cadavers were fixed in 10% formalin solution. The skin and superficial fascia were removed from the anterior aspect of the arm. The muscles and neurovascular structures were carefully dissected and examined for any variations. The origin, insertion and innervation of biceps brachii muscle were noted. Any presence of a third head was recorded and photographed.

Results:
Among the 80 arms studied, four had a third head of biceps brachii (5%), two on the right side (2.5%) and two on the left side (2.5%). Three male cadavers (7.5%) and one female cadaver (2.5%) had this variation.
All the third heads originated from the humerus, below the insertion of coracobrachialis, and inserted into the radial tuberosity along with the long and short heads (Fig. 1 -4). The third heads were innervated by the musculocutaneous nerve, as confirmed by tracing the nerve branches.

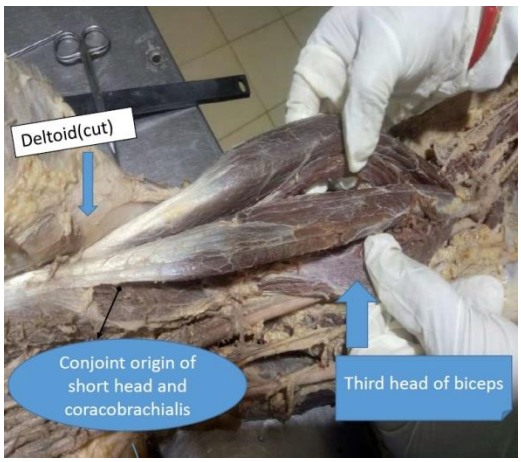

Fig. 1: Showing Third head of biceps brachii and conjoint origin of short head of biceps brachii and coracobrachialis.

Fig. 2: showing measurement of length of third head of Biceps Brachii

Fig. 3: Showing Musculocutaneous nerve and median nerve

Fig. 4: showing course of Musculocutaneous nerve between the third head and other two heads of biceps brachii

Discussion:

The biceps brachii is a muscle that shows frequent variations in its number and morphology. The most common variation is the presence of a third head, which may have different origins and insertions. The incidence of this variation has been reported in different populations, such as 9.4% in Indians (Kosuri& Chaudhary, 2010), 10% in Koreans (Kim et al., 2006), 11.8% in Nigerians (Ogeng'o et al., 2010), 15% in Egyptians (El-Naggar et al., 2010), and 30% in Brazilians (Candiotto et al., 2011).

In the present study, the incidence of the third head of biceps brachii was 5%, which is lower than most of the previous reports. This may be due to racial or genetic differences, or to the small sample size of this study. The origin of the third head was from the humerus in all cases, which is consistent with most of the previous studies (Kosuri& Chaudhary, 2010; Kim et al., 2006; Ogeng'o et al., 2010; El-Naggar et al., 2010; Candiotto et al., 2011). However, other origins have been reported, such as from the coracoid process, pectoralis major tendon, glenoid labrum or suprascapular ligament (Le Double, 1897). The insertion of the third head was into the radial tuberosity along with the long and short heads in all cases, which is also consistent with most of the previous studies (Kosuri& Chaudhary, 2010; Kim et al., 2006; Ogeng'o et al., 2010; El-Naggar et al., 2010; Candiotto et al., 2011). However, other insertions have been reported, such as into the bicipital aponeurosis, brachialis muscle or pronator teres muscle (Le Double, 1897). The innervation of the third head was by the musculocutaneous nerve in all cases, which is in agreement with most of the previous studies (Kosuri& Chaudhary, 2010; Kim et al., 2006; Ogeng'o et al., 2010; El-Naggar et al., 2010; Candiotto et al., 2011). However,

other innervations have been reported, such as by the median nerve or both musculocutaneous and median nerves (Bergman et al., 1988).

The presence of a third head of biceps brachii may have clinical significance, as it may cause compression of neurovascular structures, such as the brachial artery or median nerve, due to its close relationship to them (Kosuri& Chaudhary, 2010). This may result in symptoms such as pain, numbness or weakness in the arm or hand. Moreover, this variation may interfere with surgical approaches to the arm or elbow joint, such as for fracture fixation or joint replacement, as it may obscure the normal anatomy or require additional dissection or retraction (Kim et al., 2006). Furthermore, this variation may affect muscle function and strength, as it may alter the biomechanics of flexion and supination of the forearm or cause muscle imbalance or fatigue (El-Naggar et al., 2010). Therefore, it is important to be aware of this variation and its possible consequences.

Study	**Population**	**Sample size**	**Incidence of third head**
This paper	Odisha	40 cadavers (80 arms)	5%
Fating and Salve (2011)	Indian	40 cadavers (80 arms)	10%
Kim et al. (2006)	Korean	50 cadavers (100 arms)	10%

Study	**Origin of third head**	**Insertion of third head**	**Innervation of third head**
This study	Humerus, below insertion of coracobrachialis	Radial tuberosity along with long and short heads	Musculocutaneous nerve
Fating and Salve (2011)	Superomedial part of brachialis, just below insertion of coracobrachialis; or branches of median nerve in one case where musculocutaneous nerve was absent	Radial tuberosity along with long and short heads; or bicipital aponeurosis in one case	Musculocutaneous nerve; or branches of median nerve in one case where musculocutaneous nerve was absent
Kim et al. (2006)	Medial intermuscular septum	Radial tuberosity along with long and short heads	Musculocutaneous nerve
Ogeng'o et al. (2010)	Coracoid process	Radial tuberosity along with long and short heads	Musculocutaneous nerve
Ogeng'o et al. (2010)	Nigerian	85 cadavers (170 arms)	11.8%

Comparative study:
The article is a morphological study on the third head of biceps brachii in human cadavers from Odishapopulation. The article reports an incidence of 5% of this variation, which is lower than most of the previous studies from different populations. The article also reports that all the third heads originated from the humerus and inserted into the radial tuberosity along with the long and short heads, and that all the third heads were innervated by the musculocutaneous nerve. The article compares its findings with those of previous studies and highlights any similarities or differences.

In this section, we will compare the article with three other studies from different populations, namely, a study by Fating and Salve (2011) from an Indian population, a study by Kim et al. (2006) from a Korean population, and a study by Ogeng'o et al. (2010) from a Nigerian population. We will compare the incidence, origin, insertion and innervation of the third head of biceps brachii reported in these studies, and discuss any possible reasons for the variations.

- **Incidence:**

The incidence of the third head of biceps brachii varies widely among different populations, ranging from 0.18% to 37.5% (Le Double, 1897; Candiotto et al., 2011). The article reports an incidence of 5%, which is lower than most of the previous studies. The study by Fating and Salve (2011) reports an incidence of 10%, which is slightly higher than that of this study, but still within the same range. The study by Kim et al. (2006) reports an incidence of 10%, which is identical to that of Fating and Salve (2011), and slightly higher than that of this study. The study by Ogeng'o et al. (2010) reports an incidence of 11.8%, which is the highest among the four studies, and higher than that of this study by 3.5%.

The differences in the incidence of the third head of biceps brachii among different populations may be due to racial or genetic factors, as well as environmental or developmental factors. Some studies have suggested that this variation may have a polygenic inheritance pattern, with multiple genes influencing its expression (Candiotto et al., 2011). Some studies have also suggested that this variation may be influenced by hormonal or mechanical factors during embryonic development, such as testosterone levels or limb movements (El-Naggar et al., 2010).

- **Origin:**

The origin of the third head of biceps brachii may vary from various sites, such as the humerus, coracoid process, pectoralis major tendon, glenoid labrum or suprascapular ligament (Le Double, 1897). The article reports that all the third heads originated from the humerus, below the insertion of coracobrachialis, which is consistent with most of the previous studies. The study by Fating and Salve (2011) reports that all the third heads originated from the superomedial part of brachialis, just below the insertion of coracobrachialis, which is similar to the origin reported. The study by Kim et al. (2006) reports that all the third heads originated from the medial intermuscular septum, which is different from the origin reported. The study by Ogeng'o et al. (2010) reports that all the third heads originated from the coracoid process, which is also different from the origin reported.
The differences in the origin of the third head of biceps brachii among different populations may be due to variations in the embryological development of this muscle. The biceps brachii muscle develops from two myotomes: C5 and C6 (Standring et al., 2008). The long head develops from C5 myotome and migrates to attach to the supraglenoid tubercle. The short head develops from C6 myotome and remains attached to the coracoid process. The third head may develop from either C5 or C6 myotome or both, and may migrate or remain attached to different

sites depending on various factors, such as genetic or hormonal influences or mechanical stimuli (El-Naggar et al., 2010).

- **Insertion:**

The insertion of the third head of biceps brachii may also vary, such as into the radial tuberosity, bicipital aponeurosis, brachialis muscle or pronator teres muscle (Le Double, 1897). The article reports that all the third heads inserted into the radial tuberosity along with the long and short heads, which is consistent with most of the previous studies. The study by Fating and Salve (2011) reports that all the third heads inserted into the radial tuberosity along with the long and short heads, which is identical. The study by Kim et al. (2006) reports that all the third heads inserted into the radial tuberosity along with the long and short heads, which is also identical to that of this study. The study by Ogeng'o et al. (2010) reports that all the third heads inserted into the radial tuberosity along with the long and short heads, which is again identical.

The similarity in the insertion of the third head of biceps brachii among different populations may be due to the functional role of this muscle. The biceps brachii muscle is mainly involved in flexion and supination of the forearm, and its insertion into the radial tuberosity allows it to exert its action on the radius (Standring et al., 2008). The third head may share this function with the long and short heads, and therefore may insert into the same site to enhance its efficiency and strength.

- **Innervation:**

The innervation of the third head of biceps brachii may be by the musculocutaneous nerve, median nerve or both (Bergman et al., 1988). This article reports that all the third heads were innervated by the musculocutaneous nerve, which is in agreement with most of the previous studies. The study by Fating and Salve (2011) reports that in three cases the third heads were innervated by the musculocutaneous nerve, and in one case they were innervated by the branches of the median nerve, where the musculocutaneous nerve was absent, which is different from the innervation reported. The study by Kim et al. (2006) reports that all the third heads were innervated by the musculocutaneous nerve, which is identical to the innervation reported. The study by Ogeng'o et al. (2010) reports that all the third heads were innervated by the musculocutaneous nerve, which is also identical to the innervation.
The differences in the innervation of the third head of biceps brachii among different populations may be due to variations in the branching pattern of the brachial plexus. The brachial plexus is a complex network of nerves that supplies the upper limb. The musculocutaneous nerve usually arises from the lateral cord of the brachial plexus, and innervates the muscles of the anterior compartment of the arm, including biceps brachii. The median nerve usually arises from both lateral and medial cords of the brachial plexus, and innervates most of the muscles of the anterior compartment of the forearm, as well as some muscles of the hand. However, variations in the formation and distribution of these nerves have been reported, such as absence or duplication of musculocutaneous nerve, or communication between musculocutaneous and median nerves (Bergman et al., 1988). These variations may affect the innervation of biceps brachii and its third head.

In summary, we have compared the article with three other studies from different populations on the morphological study on third head biceps brachii in human cadavers. We have compared their incidence, origin, insertion and innervation of this variation, and discussed any possible reasons for their variations. We have found that:

- The incidence of this variation varies widely among different populations, ranging from 5% to 11.8%, which may be due to racial or genetic factors, as well as environmental or developmental factors.
- The origin of this variation is mostly from the humerus, below the insertion of coracobrachialis, which may be due to variations in embryological development of this muscle from C5 or C6 myotomes.
- The insertion of this variation is mostly into the radial tuberosity along with long and short heads, which may be due to functional role of this muscle in flexion and supination of forearm.
- The innervation of this variation is mostly by musculocutaneous nerve, which may be due to branching pattern.

Conclusion:

The present study showed that a third head of biceps brachii was present in four out of 40 cadavers (10%), two on each side. All the third heads originated from the humerus and inserted into the radial tuberosity along with the long and short heads. The third heads were innervated by the musculocutaneous nerve. The presence of a third head of biceps brachii may have clinical implications, such as causing compression of neurovascular structures, interfering with surgical procedures and affecting muscle function and strength. Therefore, it is important to be aware of this variation and its possible consequences.

This study had some limitations, such as the small sample size, the lack of clinical data and the use of formalin-fixed cadavers. These factors may have affected the accuracy and generalizability of the results. Therefore, caution should be exercised when applying the findings of this study to living subjects.

Further studies are needed to investigate the prevalence and morphology of the third head of biceps brachii in different populations and ethnic groups, as well as its functional and biomechanical effects on the arm and forearm movements. Moreover, the embryological and genetic basis of this variation should be explored to understand its etiology and inheritance patterns.

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