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Original Research Article

Innervation pattern, localization of primary motor branch and motor points of biceps brachii muscle, and its clinical application: A study from Myanmar

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ABSTRACT

Background: The biceps brachii muscle is known for its significant variability in the human body. This study aims to detail the distal branching patterns of the motor branches of the musculocutaneous nerve, with the goal of developing surgical guidelines tailored to the Myanmar population.

Materials and Methods: A total of 62 arms from 31 adult cadavers (26 males, 41.9%, and 36 females, 58.1%) were dissected. A reference line was drawn from the tip of the coracoid process to the humerus's lateral epicondyle. The primary motor nerve to the biceps originated from the musculocutaneous nerve, and the gross motor entry point (GMEP) for each muscle head was measured from the tip of the coracoid process, expressed as a percentage of the reference line.

Results: Innervation pattern Type I, characterized by a single primary motor branch (PMB), was present in 48 arms (77.4%), while Type II, with two separate PMBs, was identified in 11 arms (17.4%). Type III, where a common PMB bifurcated to supply both heads, with an additional motor branch innervating the common muscle belly, was seen in three arms (4.8%).

The mean distance of the PMB was 12.23 cm in males and 11.49 cm in females. The mean percentage of PMB relative to the reference line was 44.78% in males and 44.04% in females. The mean distance from the GMEP to the long head was 13.48 cm in males and 12.5 cm in females. The mean distance from the GMEP to the short head was 12.115 cm in males and 11.514 cm in females.

Conclusion: An anterior surgical approach is recommended for identifying the motor branches and locating the motor points, which facilitates clinical application and reduces errors due to anthropometric differences.

KEYWORDS: Biceps brachii muscle, Musculocutaneous nerve, primary motor branch to biceps, gross motor entry point.

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INTRODUCTION

The musculocutaneous nerve, a mixed peripheral nerve, originates from the lateral cord of the brachial plexus (C5, C6, and C7) near the lower border of the pectoralis minor. It passes through the coracobrachialis muscle and travels distally between the biceps and brachialis muscles, providing innervation to the muscles in the anterior compartment of the arm. At the lateral edge of the bicep's tendon, the musculocutaneous nerve transitions into the lateral cutaneous nerve of the forearm [1-3]. The muscles supplied by the musculocutaneous nerve include the coracobrachialis, biceps brachii, and brachialis. The branch to the coracobrachialis leaves the nerve before entering the muscle, while branches to the biceps and brachialis emerge after passing through the muscles [2].

Previous studies have mainly concentrated on the number of motor trunks [4–10], but the distal division pattern of the nerve remains underexplored. The motor nerve to the biceps is a short, stout branch originating from the musculocutaneous nerve, which travels obliquely between the biceps and brachialis muscles. After a brief course, the nerve divides into two branches, each penetrating the deep surface of each muscle belly at the same level [11]. Other studies have also described the motor branches of the biceps brachii [2,4–7,12–15]. Extensive anatomical details about the musculocutaneous nerve's relationship to other structures have been documented in the literature [1,3,8,11].

Yang et al. classified the innervation patterns of the biceps brachii muscle as follows: Type I: A single primary motor branch (PMB) divides into two secondary branches, each innervating the long and short heads of the biceps. Type II: Two PMBs originate from the musculocutaneous nerve trunk, with the proximal branch innervating the short head and the distal branch innervating the long head. Type III: The PMB arises from the musculocutaneous nerve trunk, bifurcating into two secondary branches that innervate both heads of the biceps, plus an additional distal primary branch that innervates the distal part of the biceps at the common belly (figure 1) [5].

Although various studies have been conducted globally, there is a lack of data from Myanmar. Thus, the goal of this study on the innervation of the biceps brachii muscle is to explore different patterns of motor branches from the musculocutaneous nerve, determine the average position where motor nerves enter the biceps brachii, and identify any variations.

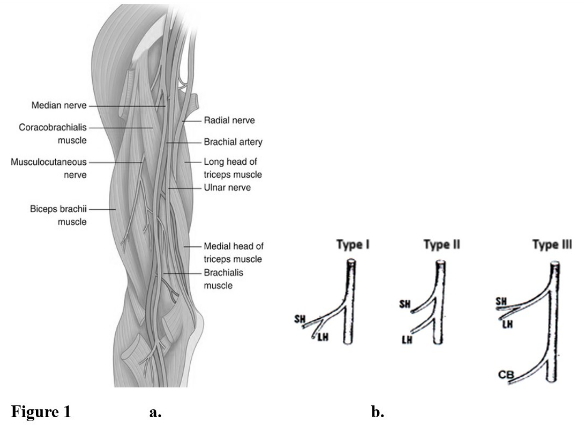

Fig. 1: a. Diagram showing biceps muscles and their nerve supply in the anterior compartment of the arm. b. Diagram showing innervation pattern of biceps brachii muscle [5] Short head (SH), Long head (LH), Common muscle belly (CB). (yang et al 1995 [5])

MATERIALS AND METHODS

Study design: A cross-sectional descriptive study was conducted on thirty-one adult embalmed cadavers, consisting of 13 males and 18 females, aged between 20 and 80 years. The cadavers were dissected for gross anatomical examination. The study was carried out at the Anatomy Departments of the University of Medicine 1 and 2, Yangon, Myanmar.

Data collection: The formalin-fixed cadavers were positioned appropriately for dissection. Dissection was performed with the cadavers in a supine position. A straight incision was made along the anterior compartment of the arm, following the anterior midline from the supraclavicular region to the cubital fossa. Two flaps, including the skin and subcutaneous tissue, were reflected medially and laterally. The same approach was applied to the arm fascia, allowing full exposure of the musculature.

To enhance the exposure of the brachial plexus, a tenotomy of both the major and minor pectoral muscles was performed. Dissection was carried out in a proximal-to-distal direction, following the musculocutaneous nerve and its motor branches to the biceps brachii muscle. Both the musculocutaneous nerve and its motor branches to the biceps were thoroughly examined.

A tape measure accurate to 0.5 cm was used to measure the distance between the coracoid process and the lateral epicondyle of the humerus, which served as the reference line. The primary motor nerve to the biceps arose from the musculocutaneous nerve trunk, and the gross motor entry point (GMEP) for each muscle head was measured vertically along the reference line from the tip of the coracoid process. These measurements were then expressed as percentages of the total length of the reference line. All measurements were recorded with the shoulder in 45 degrees of abduction and the arm in a neutral position. Photographs were taken during each dissection and cataloged for further analysis.

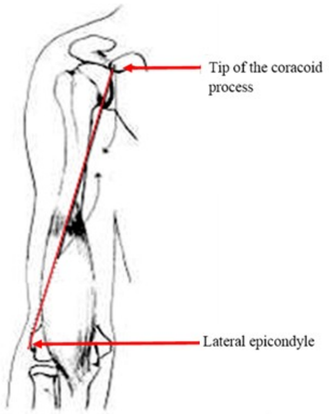

Fig. 2: Diagram showing reference line in the right arm.

Fig. 3: Photograph showing measurement of the reference line from the tip of the coracoid process of the scapula to the lateral epicondyle of the humerus in the left arm. (Cadaver No 29, female)

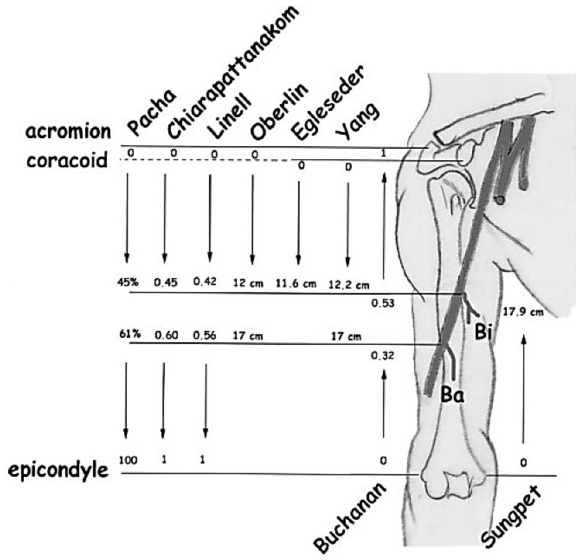

Fig. 4: Comparison of the measurements and results of the PMB for the biceps brachii muscle in different articles. The "0" indicates the point from which the measurements are taken. (7)

Inclusion and exclusion criteria

This study employed a dissection-based, cross-sectional descriptive approach using adult cadavers, examining a total of 62 arms. Of these, 26 arms (41.9%) were from male cadavers, while 36 arms (58.1%) were from female cadavers. The study included arms obtained from Myanmar adult cadavers aged between 20 and 80 years, which had been donated to the Anatomy departments of the University of Medicine 1 and the University of Medicine 2, Myanmar. Arms exhibiting upper limb deformities or any diseases or abnormalities affecting the upper limb were excluded from the study.

Sample size calculation

The required sample size was determined based on the expected occurrence of a normal Biceps Brachii muscle pattern in 80% of cases, with a 10% margin of error. Using the formula **$n = Z^2pq/d^2$,** the sample size was calculated as follows:

P = expected proportion (0.8), **Q** = 1 - P (0.2), **D** = margin of error (0.1), **Z** = 1.96 (standard normal value for a 95% confidence level)

N=(1.96)2×0.8×0.2(0.1)2=61.47N

= \frac{(1.96)^2 \times 0.8 \times 0.2}{(0.1)^2} = 61.47N=(0.1)2(1.96)2×0.8×0.2 =61.47

Rounding up, the final sample size was set at 62 arms (31 cadavers).

Data analysis and variables

The study focused on variations in the length and innervation pattern of the Biceps Brachii muscle as outcome variables, with gender being the explanatory variable. To ensure practical clinical application and minimize measurement errors caused by individual anthropometric differences, muscle lengths were expressed as a percentage of a reference line's total length.

The collected data were analyzed using SPSS 24.0 software. Differences in length and innervation patterns were compared between genders as well as between the left and right sides using the Student's t-test. A significance level of 5% was applied, with p<0.05 considered statistically significant.

Ethical approval: The cadavers used in this study were voluntarily donated to the Anatomy Departments of the University of Medicine 1 and University of Medicine 2, Myanmar, for educational and research purposes. Family members provided consent at the time of donation. The study received ethical clearance from the Ethical and Research Committees of the University of Medicine 1 and University of Medicine 2.

RESULTS

Table 1: Gross innervation pattern of biceps brachii muscle.

Sex	Male	Female	Total
1. Type I	19 (73.1%)	29 (80.5%)	48 (77.4%)
2. Type II	5 (19.2 %)	6 (16.7 %)	11 (17.8%)
3. Type III	2 (7.7 %)	1 (2.8 %)	3 (4.8 %)
Total	26 (100%)	36 (100%)	62 (100%)

Table 1 explains the gross innervation pattern of biceps by sex. Type I was the commonest pattern of innervation to the biceps brachii muscle in both sexes.

Table 2: The reference line for biceps brachii muscle.

Gender	The reference line for biceps brachii muscle			
	No (%)	Mean (cm)	SD* (cm)	P value
Male	26(41.9%)	27.31	0.618	0.000*
Female	36(58.1%)	26.08	0.604	
Total	62 (100%)			

*p<0.01

Table 2 explains the reference line for biceps brachii muscle by sex. The mean reference line for the biceps of males was significantly longer than that of females (P <0.01).

Table 3: Distance of the PMB from the tip of the coracoid process and the Percentage of PMB to reference line.

Distance of the PMB from the tip of the coracoid process				
Gender	Number	Mean (cm)	SD (cm)	P value
Male	26	12.23	1.351	0.009*
Female	36	11.49	0.806	
Percentage of PMB to reference line				
Gender	Number	Mean (%)	SD* (%)	
Male	26	44.78	4.87	0.457×
Female	36	44.04	2.94	

*p<0.05, ×p>0.05

Table 3 describes the distance of the PMB from the tip of the coracoid process and the percentage of PMB to reference line by sex. The mean distance of the PMB of the male was significantly longer than that of the female (P<0.01).

Table 4: Distance of GMEP* to long head from the tip of coracoid process

Gender	Distance of GMEP to the long head			
	Number	Mean (cm)	SD (cm)	P value
Male	26	13.48	1.59	0.006*
Female	36	12.5	0.756	
Distance of GMEP to short head from the tip of coracoid process				
Gender	Number	Mean (cm)	SD*(cm)	
Male	26	12.115	1.33	0.031*
Female	36	11.514	0.81	

*p<0.05

Table 4 describes the distances of the GMEP to long heads and short heads from the tip of coracoid processes by sex. It was found that the mean distance of the GMEP to the long head and the short head of males was significantly longer than that of females (P <0.01).

Table 5: Percentage of GMEP of long head and short head to reference line.

Percentage of GMEP of long head to reference line				
Gender	Number	Mean (%)	SD* (%)	P value
Male	26	49.38	5.87	0.243×
Female	36	47.92	2.53	
Percentage of GMEP of short head to reference line				
Gender	Number	Mean (%)	SD* (%)	
Male	26	44.36	4.84	0.81×
Female	36	44.13	2.75	

×p>0.05

Table 5 describes the percentage of GMEP of long head and short head to reference line by sex. It was also found that the mean percentage of GMEP long heads and short heads to the reference line of both genders was statistically insignificant.

Table 6: Distance of GMEP to third head from the tip of coracoid process.

	Distance of GMEP to the third head by sex		
Gender	**Number**	**Mean (cm)**	**SD (cm)**
Male	4	16	2.71
Female	3	13.2	0.29
	Percentage of GMEP third head to the reference line by sex		
Gender	**Number**	**Mean (%)**	**SD (%)**
Male	4	59.26	10.03
Female	3	50.64	1.1

Table 6 expedites the distance of GMEP to third head from the tip of coracoid process by sex. The mean distance of GMEP to the third head among males was longer than that of females. The percentage of GMEP third head to reference line was calculated as a percent age of the GMEP to third head divided by reference line. Mean percentages of GMEP third heads to reference line were compared between the male and female sexes. The mean percentage of GMEP third heads to reference line among 4 males was 59.26 with a standard deviation 10.03. The mean percentage of GMEP third heads to reference line among 3 females was 50.64 with a standard deviation of 1.1.

Table 7: Incidence of innervation patterns in the biceps brachii muscle, as reported in previous literature and the present study.

References	No of Cadavers	Status of cadavers	One (%)	Two (%)	Three (%)	Four or five (%)
Chiarapattanakom et al. (1998) [6]	112	Embalmed	62	33	5	0
Yang et al. (1995) [5]	24	Fresh-frozen	83.4	16.6	0	0
Kervancioglu et al. (2011) [10]	20	Formalin-fixed fetuses (12–36 weeks of gestation)	80	20	0	0
Kwolczak-Mc Grath et al. (2008) [8]	40	Formalin-fixed fetuses (16–27 weeks of gestation)	90	10	0	0
Oberlin et al. (1994) [4]	20	Fresh	55	45	0	0
Pacha Vicente et al. (2005) [7]	46	24 fresh-frozen, 22 embalmed	60.5	39.5	0	0
Lee et al. (2010) [9]	56	Fresh	57.1	39.3	3.6	0
Uysal et al (2009) [15]	70	Formalin-fixed fetuses	83.6	14.3	2.1	0
Kosugi K (1986) [16]	23	Embalmed	60.5	27.9	11.6	0
Linell (1921) [11]	18	Embalmed	100	0	0	0
Present Study	31	Formalin-fixed adults	77.4	17.8	4.8	0

Table 7 describes the incidence of innervation patterns in the biceps brachii muscle, as reported in previous literature and the present study.

Table 8: Comparison among the types of innervations pattern, measurements of GMEP, and PMB for biceps brachii muscle in different articles and results of the present study.

Name of author and year	No of arms	Mean length of reference line (cm)	Mean distance of PMB (cm)	Mean distance of PMB as % of reference line	Mean distance of GMEP (cm)	Mean distance of GMEP as % of reference line LH (cm)	Mean distance of SH (GMEP) (cm)	Mean distance of (GMEP) SH as% of reference line
Linell (1921) [11]	36	30.5 A:/Lat: Condyle	12.99+/-0.426		15.28+/-0.501		15.28+/-0.501	
Chiarapattan-akom et al (1998) [6]	224	-	-	-	-	-	-	-
Yang et al (1995) [5]	48	-	12.2+/-1.2cm	-	-	-	-	-
Pacha Vicente et al (2005) [7]	46		13.4 +/-2.6cm	45.3% +/-10%	-	-	-	-
Park et al (2007) [17]	46	26.76 Cora:/Lat: condyle	-	-	14.22+/-1.75	53.10% +/-6.21%	12.91+/1.9	48.24%+/-6.88%
Uysal et al (2009) [15]	140	-	-	-	-	-	-	-
Lee et al (2010) [9]	46	Cora:/Med: condyle	'-	-	13.4+/-1.5	47.9%+/-3.2%	12.2+/-1.1	44.3%+/-3.4%
Eglseder and Goldman (1997) [18]	108	-	-	-	11.66	-	11.66	-
Present Study	62	Cora:/Lat: condyle 27.31+/-0.618(M), 26.08+/-0.604(F)	12.23+/-1.351cm(M)11.49+/-4.87(F)	44.78%+/-4.87%(M)44.04%+/-2.94%(F)	13.48+/-1.59(M)12.5+/-0.75(F)	49.38%+/-5.87(M)47.92%+/-2.53(F)	12.115+/-1.3(M)11.514+/-0.81(F)	44.36%+/-4.84(M)43.13%+/-2.75(F)

Table 8: Comparison among the types of innervations pattern, measurements of GMEP, and PMB for biceps brachii muscle in different articles and results of the present study.

OBSERVATIONS

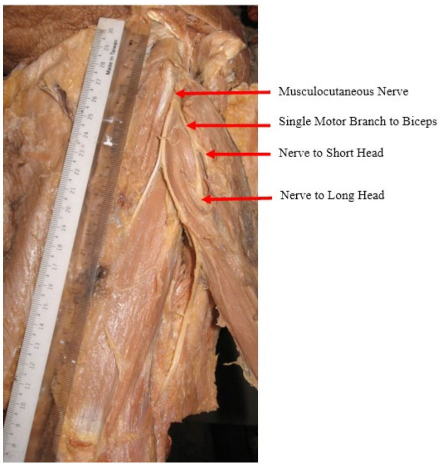

Fig. 5: Photograph showing type I innervation pattern of biceps brachii. Right arm (Cadaver No 19, male).

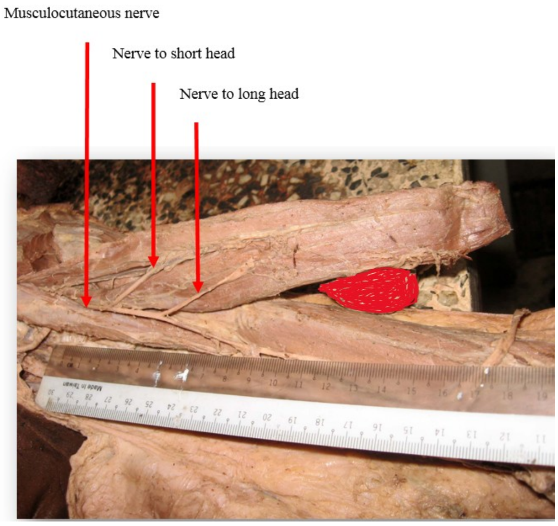

Fig. 6: Photograph showing type II innervation pattern of biceps brachii. Left arm (Cadaver No 29, female).

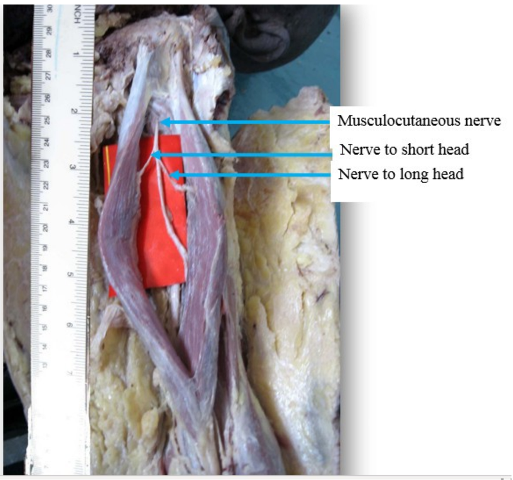

Fig. 7: photograph showing the type II innervation pattern of the Biceps brachii muscle in the left arm. (Cadaver No, 27, male)

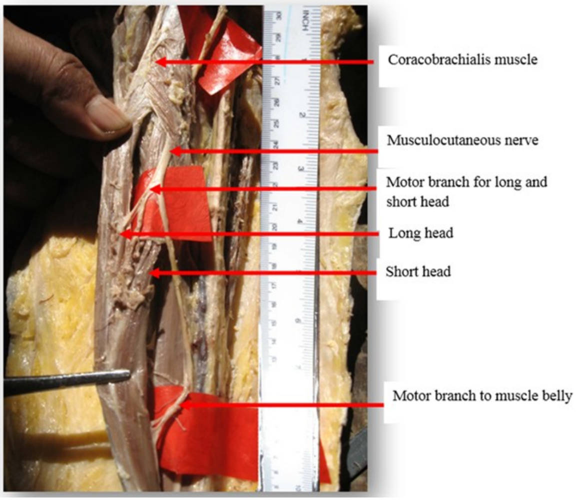

Fig. 8: Photograph showing the type III innervation pattern of the biceps brachii. Right arm (Cadaver No 30, male).

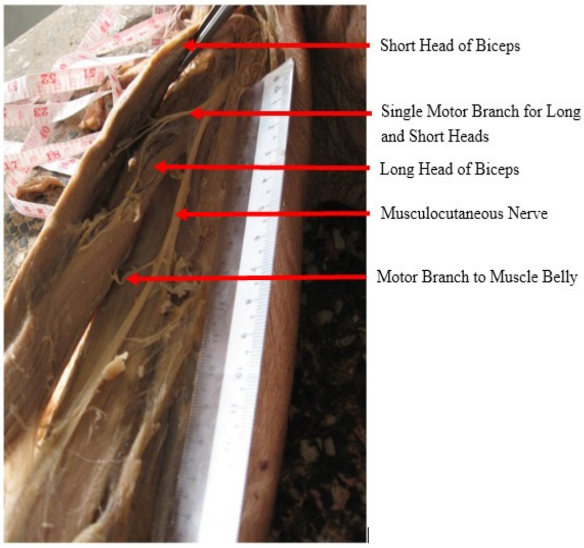

Fig. 9: Photograph showing type III innervation pattern of biceps brachii. Right arm (Cadaver No 10)

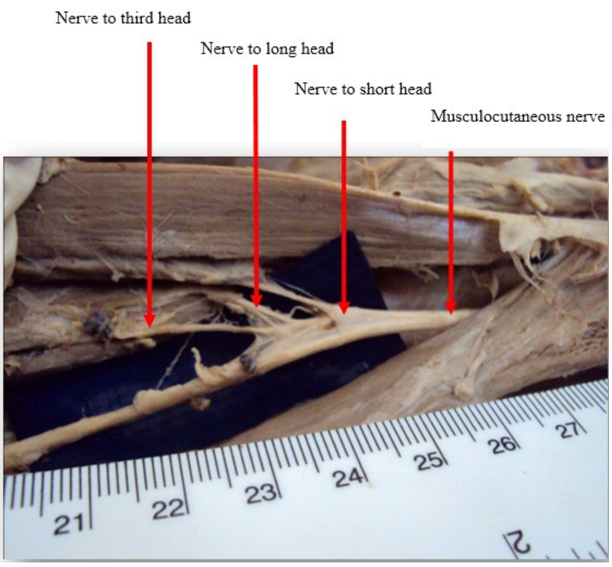

Fig. 10: Photograph showing innervation of the third head in the right arm. (Cadaver No 7, female).

DISCUSSION

Innervation pattern: This study identified three distinct branching patterns of the biceps brachii muscle. The classification system established by Yang et al. (5) was used as a reference (Figure 1). The most common pattern, t**ype I**, was found in 48 out of 62 arms (77.4%) (Figure 5), t**ype II** appeared in 11 arms (17.8%) (Figures 6 and 7), while **type III** was observed in 3 arms (4.8%) (Figures 8 and 9) (Table 1). Notably, the descriptions of Type III given by other researchers varied, identifying three primary branches supplying each head and the common muscle belly; this specific variation was not observed in the current study [5,6].

Chiarapattanakom et al [6] reported that none of the 112 dissected upper limbs had more than three trunks. Type I, characterized by a single motor branch to the biceps brachii, is the most frequently documented pattern, ranging from 55% to 90% across various studies [4–10]. **Type II** consists of two separate branches, each supplying a different head of the muscle. Two trunks are present in Type III, with one branching to supply each head and a second, more distal branch for the common belly. This consistency across studies supports the idea that Type I is the most common anatomical variant, likely representing the most functionally stable pattern during limb development. Another researcher [19] identified as many as five trunks, attributing this variation to precise dissection methods performed on fresh adult cadavers rather than embalmed specimens or fetuses (Table 7). Similarly, studies by previous researchers only observed Type I and Type II patterns. Some researchers [4,14] also reported Type I and II but described a Type III pattern differing from that of Yang et al., [5] where the three primary branches separately supply the long head, short head, and common belly [5,6]. According to Carbon-binder et al. (2014), the biceps muscle was innervated by one to five primary motor branches. These variations hold clinical relevance, particularly in surgical planning, peripheral nerve repair, and regional anesthesia, where an accurate understanding of the motor innervation becomes vital to avoid iatrogenic nerve injury.

Innervation of the third head: The presence of an additional **third head** of the biceps brachii can influence the musculocutaneous nerve's course and branching pattern, which is essential for both anatomical and clinical considerations [3,12,20]. In this study, a third head was present in 7 out of 62 arms (11.3%). It was observed in **4 of 26 male** arms (15.4%) and **3 of 36 female arms (8.3%).** The motor branch to the third head originated directly from the main musculocutaneous nerve trunk, distal to the branches supplying the long and short heads, resembling **Type V** as classified by Yamamoto et al. (2017) (Figure 10). Based on these findings, no direct relationship between the number of muscle heads and nerve branching patterns could be established.

Motor point localization: Several prior studies have examined the anatomical **motor point,** defined as the location where the motor nerve penetrates the muscle [4,6,7,11,14,17,19,20]. The motor branch's origin from the musculocutaneous nerve trunk has been a focal point of research. The methods and results of previous studies, by [4–7,11,14] are summarized in Table 7 and Figure 4. The methodology used in the current study aligns with comparable results [17,19].

PMB in the present study: The findings indicate that the PMB of the biceps brachii arises from the musculocutaneous nerve trunk at an average distance of 12.23 cm (44.78% of the reference line) in males and 11.49 cm (44.04% of the reference line) in females (Table 3). No significant gender-based difference was observed in the reference line's total length (Table 2).

According to Carbon-Binder et al., the PMB originates at an average of 37.1% of the arm length (range: 17.9–45.3%), with the most distal terminal branch located at 55.7% of the arm length from the coracoid process to the lateral epicondyle. Differences between these findings and the present study may be attributed to anatomical variations between Asian and European populations. Numerous studies have attempted to define the motor nerve locations of the biceps brachii, but variations in methodology have led to differing results [9,11,13,17,21].

Communication between the musculocutaneous and median nerve: Several studies have described **connections between the musculocutaneous (MCN) and median nerve**, with reported prevalence rates ranging from **5% to 46.4%,** averaging **33% [**2,19,22–25]. In this study, communicating branches were identified in **3.22% (2 out of 62 upper limbs)**, which is lower than previously reported averages.

CONCLUSION

The variability in the nerve supply of the biceps brachii muscle holds significant clinical implications, particularly for surgical planning and the management of nerve injuries. Standard anatomical references may not provide sufficient detail for complex cases, making detailed studies like this present research essential.

Limitations and Future Directions: Future research should incorporate optical surgical microscopy to enhance the dissection of intramuscular nerve pathways and terminal branches.

Relevance of the Study: The accurate mapping of motor points is vital for optimizing motor point blocks and improving surgical outcomes in brachial plexus injuries. The findings from this study provide essential guidance for clinicians performing nerve transfers, managing spasticity, and conducting reconstructive procedures, ultimately leading to improved patient outcomes.

Clinical Implications and Future Scope: The precise localization of the biceps brachii motor points have critical applications in clinical and surgical settings. Neurolytic injections targeting motor points are used to treat spasticity of the elbow flexors, particularly in stroke patients. Non-surgical treatments often provide only short-term relief, necessitating more permanent interventions, such as selective neurectomy—a procedure that requires detailed knowledge of the musculocutaneous nerve's branching pattern. Additionally, surgeons performing brachial plexus reconstructions or nerve transfers (e.g., intercostal nerve transfer) must be aware of these anatomical variations. The results of this study provide valuable data that can help guide the localization of motor points, improving the accuracy and effectiveness of clinical procedures.

ABBREVIATIONS

GMEP - Gross motor entry point

MCN - Musculocutaneous nerve

PMB - primary motor branch

Conflicts of Interests: **None**

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