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Morphological Study of the Heads of Pronator teres and its Clinical Importance

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ABSTRACT

Introduction: entrapment of the median nerve in the region of the elbow can be caused due to various structures, one of them being the variability of the heads of pronator teres muscle.

Methodology: the present study was done to determine the variations of the pronator teres muscle. The study was done in thirty four upper limbs (8 male and 9 female) of 17 cadavers by dissection. The course of the median nerve in relation to the heads of the pronator teres was observed.

Results: the humeral head originated from the medial epicondyle and medial intermuscular septum of humerus in 88.23% of limbs. The ulnar head originated from the coronoid process of ulna in 76.19%. The length and width of humeral head was 130.1 and 42.5 mm respectively. The length and width of ulnar head was 46.6 and 11.3 mm respectively. The ulnar head was fibromuscular in all specimens and morphologic subtype 'b' was most frequently seen (35%). The position of the median nerve was between the two heads of pronator teres in majority of the specimens (55.8%).

Conclusions: Knowledge of the heads of pronator teres is useful in the management of median nerve compression in the proximal forearm.

Keywords: Pronator teres; Median nerve; Entrapment neuropathy.

Introduction

There are several anatomical structures that can compress the median nerve in the proximal forearm. Potential factors that can cause compression are the humeral and ulnar heads of pronator teres muscle,[1,2] aponeurotic expansion of the biceps brachii muscle (*lacertus fibrosus*),[3,4] the fibrous arch of flexor digitorum superficialis muscle,[5] Struthers' ligament,[6,7] and the vascular network of the region.[8] Regardless of these sites where compression can occur, this condition is termed pronator syndrome, because the compression occurs most frequently between the two heads of pronator teres muscle.[9-11] The pronator syndrome was first described by Henrik Seyffarth in 1951. The main causes are the anatomic variations of the humeral and ulnar heads of pronator teres.

The pronator teres muscle belongs to the superficial flexor compartment of the forearm and arises by two heads – a humeral and an ulnar head. The humeral head originates from the common flexor tendon attached to the medial epicondyle of the humerus, from the intermuscular septum between the pronator teres and the flexor carpi radialis muscle, and from the antebrachial fascia. The ulnar head of pronator teres originates from the medial side of the coronoid process of ulna, joins the humeral head and gets attached to the middle of the lateral surface of the shaft of the radius. The median nerve enters the forearm between the two heads of the pronator teres.[12]

Compression of the median nerve in the proximal forearm is often caused as it passes between the two heads of the pronator teres muscle. The space between the two heads (pronator canal) can become narrowed due to muscle hypertrophy or rarely due to inflammatory or post traumatic changes, resulting in the pronator syndrome.[13] Patients experience pain and tenderness over the proximal forearm and paraesthesias of the hand. Nonsurgical management of rest, activity modification and anti-inflammatory medication provide relief in 29% to 100% of patients with the pronator syndrome.[14] In cases where symptoms persist for over 6 months, surgery is indicated. Most authors recommend a complete decompression of the median nerve throughout its course in the proximal forearm.[14]

The aim of the study was to determine the morphology and morphometry of the heads of pronator teres muscle in Indian cadaveric upper limbs, which can help the surgeon in the management of median nerve compression in the proximal forearm.

Materials and Methods

Thirty four upper limbs of 17 adult cadavers (8 male and 9 female) available in the Department of Anatomy of Christian Medical College, Vellore were used for the study. The age of the cadavers ranged from 48 to 110 years (mean age 77 years). Cadavers whose forearms were deformed by trauma, congenital malformations

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and scars were excluded from the study. The study was conducted after approveal from the Institutional Ethics Committee (IRB No.11635).

The dissection was carried out through a midline longitudinal ncision made from 5 cm above the cubital fossa to the middle of the forearm. The median nerve was identified in the distal third of the arm at the medial margin of the biceps brachii muscle and dissected distally into the forearm. Variations of the pronator teres muscle and the relationship of median nerve to the muscle were observed. The origin of the two heads and length and width of the heads, were determined. In addition, high insertion of humeral head, presence of accessory heads and types of ulnar head were recorded. The median nerve was dissected and the branches to the heads were traced.

Results

In the 34 dissected limbs, the humeral and ulnar heads of the pronator teres were well individualized and seen to consist of two distinct muscular portions that joined to form a tendon that inserted into the middle third of the diaphysis of the radius in 21 limbs.

On the studied upper limbs, the humeral head of pronator teres was present in all the 34 (100%) upper extremities. In most cases, the origin of the humeral head was from the medial epicondyle and the medial intermuscular septum [Table 1]. There was no duplication of the heads in any limb. An accessory humeral head was present in 1 (2.94%) limb [Figure 1]. No high attachment of humeral head was observed.

The ulnar head of pronator teres was present in 21 (61.76%) limbs. If the ulnar head was present, it began in the vast majority of cases from the coronoid process of ulna [Table 1]. The length and width of the heads of pronator teres are shown in table 2.

The ulnar head of pronator teres can be divided into 5 types[22]. In the present study, only type 1 was seen [Figure 2]. Type 1 PTu which was fibromuscular was seen in all 21 (100%) specimens. This type was further divided into 3 subtypes with regard to the width of the PTu. In type 1a, the width of PTu was less than10 mm (n = 8, 38%); in type 1b, the width was 10 to 20 mm (n = 12, 57%); in type 1c, the width was more than 20 mm (n = 1, 5%) [Table 3].

In 19 of the 34 limbs, the median nerve was positioned between the humeral and ulnar heads of the pronator teres [Table 6] [Figure 3]. In two forearms, the nerve was positioned posterior to the two heads of the muscle [Figure 4]. When both heads of the muscle were present, no cases of the median nerve passing through the muscle mass of the humeral head of the pronator teres was observed. In 13 of the 34 limbs, the ulnar head of the pronator teres was absent. In this situation, the median nerve was positioned posterior to the humeral head [Figure 5].

Table 1. Origin of heads of pronator teres.

Humeral head	
Medial epicondyle of humerus	Medial epicondyle of humerus + medial intermuscular septum
4 (11.76%)	30 (88.23%)
Ulnar head	
Coronoid process of ulna	Coronoid process of ulna + trochlea
16 (76.19%)	5 (23.81 %)

Figure 1. Accessory humeral head (asterisk) joining the humeral head (HH) of pronator teres Median nerve (arrow); BB – biceps brachii.

Table 2. Morphometry of heads of pronator teres.

Parameter	Mean ± SD (mm)	Range (mm)
Length of humeral head	130.1 ± 14.4	100 – 170
Width of humeral head	42.5± 16.3	23.8 - 97.5
Length of ulnar head	46.60 ± 11.63	30 - 68
Width of ulnar head	11.3 ± 5.5	2 - 20.8

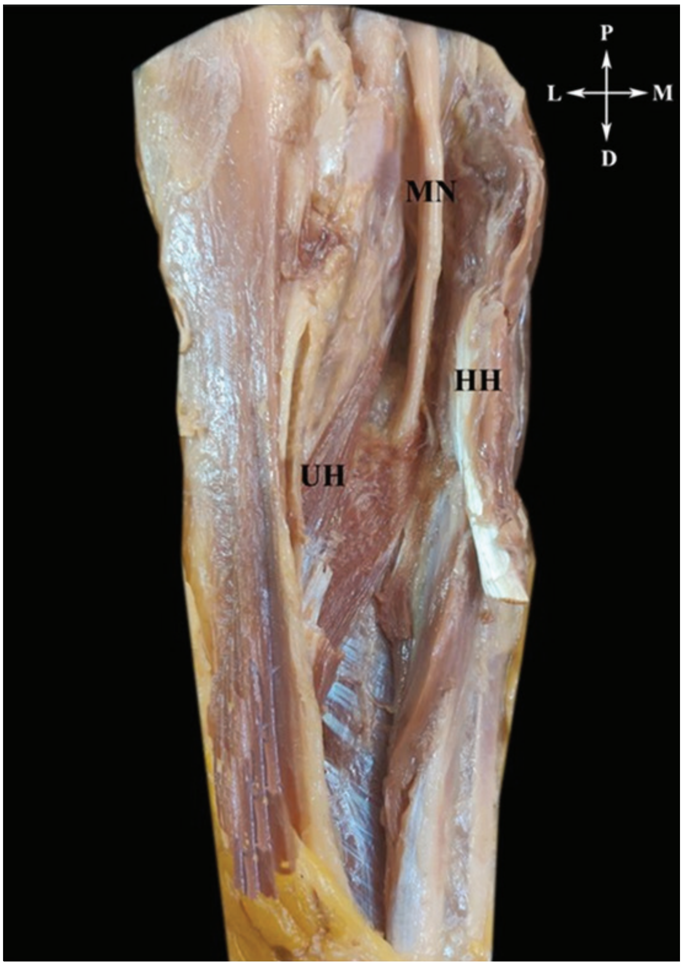

Figure 2. Fibromuscular type of ulnar head (UH)
HH – Humeral head of pronator teres; MN – Median nerve.

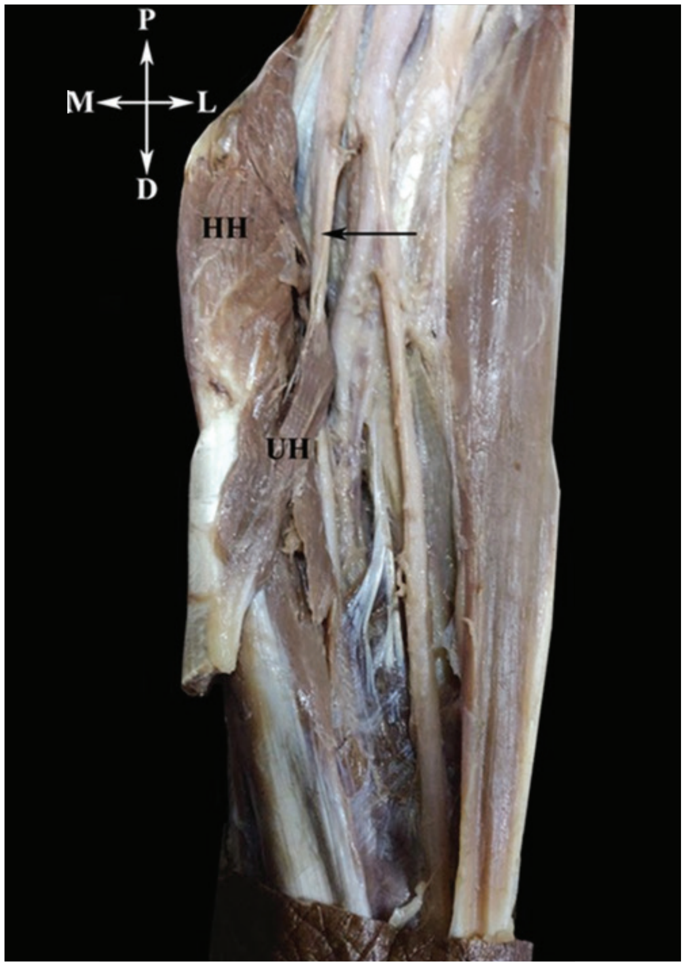

Figure 3. Median nerve (arrow) between humeral head (HH) and ulnar head (UH) of pronator teres.

Table 3. Morphologic subtypes of ulnar head of pronator teres.

PTu morphology	Definition	Number	Frequency (%)
Type 1	PTu was fibromuscular	21	62
Morphometric subtype			
a	PTu width was < 10 mm	8	24
b	PTu width was 10 to 20 mm	12	35
c	PTu width was > 20 mm	1	3

PTu: ulnar head of the pronator teres muscle.

Discussion

Entrapment syndromes of the median nerve in the region of the elbow can be due to compression of the nerve due to muscular (pronator teres muscle), fibrous (Struthers' ligament) and bony structures (supracondylar process of the humerus). Due to the low frequency of occurrence of the Struthers' ligament and the supracondylar process of the humerus, the pronator teres muscle is mostly implicated in the compression of the median nerve. Knowledge concerning morphologic variations of the pronator teres muscle that are potential risk factors of median nerve entrapment neuropathy are important to the clinician for proper diagnosis and treatment.

In 21 of the 34 dissected limbs (62%), the humeral and ulnar heads of the pronator teres muscle were present, which is in agreement with the results reported by Hofer and Hofer (56%),[15] and Nebot-Cegarra *et al.* (68%).[16] Other authors observed different percentages: Stabille *et al.* (83.5%),[2] Jamieson and Anson (81%),[17] and Hollinshead (91%).[18]

Textbooks of Anatomy mention that the humeral head of pronator teres takes origin from the medial epicondyle of the humerus and the ulnar head from the coronoid process of the ulna. The pronator teres, however, has a relatively large degree of variability, especially in terms of its origin and in its relation to the median nerve. The humeral head of the pronator teres has been reported to originate from the supracondylar process or Struthers' ligament[19,20] however, Struthers' ligament was not observed in the present study.

The majority of the specimens (88.23%) had the humeral head originating from both the medial

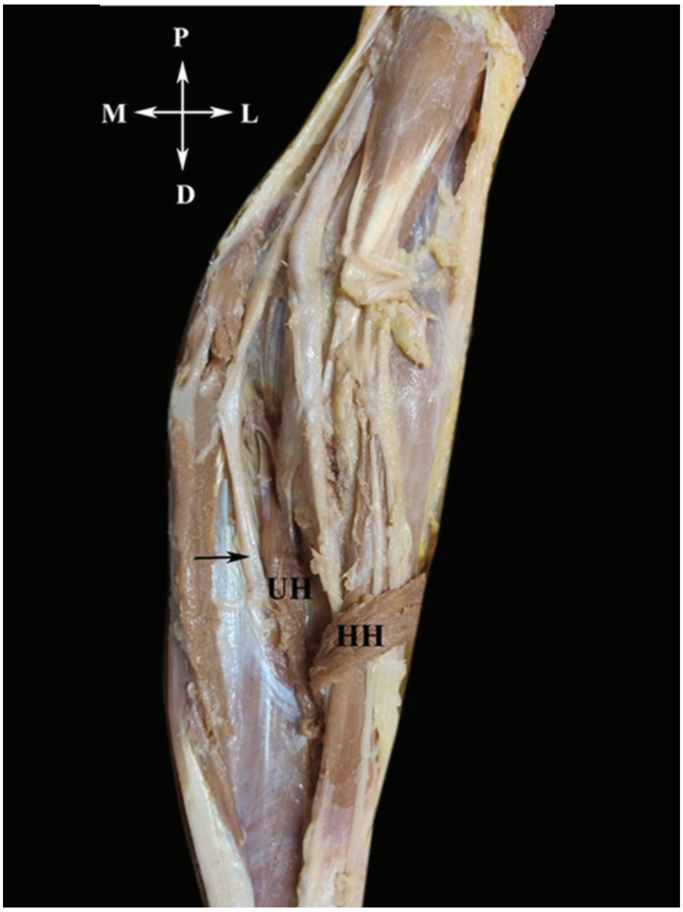

Figure 4. Median nerve (arrow) posterior to both heads of pronator teres HH – humeral head; UH – ulnar head.

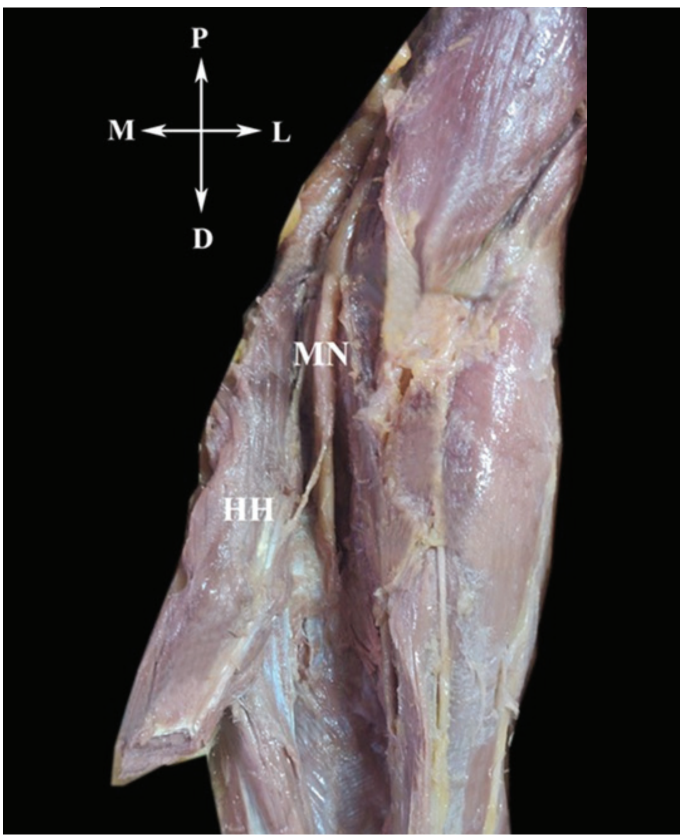

Figure 5. Median nerve (MN) posterior to humeral head (HH) of pronator teres Ulnar head absent.

epicondyle as well as the medial intermuscular septum, a finding which is similar to those of Vymazalova *et al.* (70.6%)[13] and Olewnik *et al.* (72%)[21] [Table 4].

The humeral head was duplicated in 1 specimen (1.5%) in the study by Vymazalova *et al.*[13] and in 3 specimens (5%) in the study by Nebot - Cegarra *et al.*[16] Duplication of the humeral head was not seen in the present study, as was the case in the study by Olewnik *et al.*[21]

Vymazalova *et al.*, found that the ulnar head of pronator teres originated from the coronoid process of ulna in the majority of specimens (96.9%)[13] The findings in the present study (76.19%) were in accordance with those of Vymazalova *et al.*[13] Olewnik *et al.*, found the ulnar head originated only from the coronoid process of ulna in all the specimens studied[21] [Table 4].

Table 4. Comparison of origin of heads of pronator teres in different studies.

Origin	Vymazalova *et al.*[13]	Olewnik *et al.*[21]	Present study
Humeral head			
i) Medial epicondyle	29.4	28	11.76
ii)Medial epicondyle + MIS	70.6	72	88.23
Ulnar head			
Coronoid process	96.9	100	76.19
ii) Coronoid process + trochlea	3.1	-	23.81

MIS – Medial Intermuscular septum

Caetano *et al.*, found the ulnar head of pronator teres to be absent in 14% of the dissected limbs.[22] Other workers that found the ulnar head to be absent were Stabille *et al.*,[2] in 15%, Hollinshead,[18] in 9%, and Nebot-Cegarra *et al.*,[16] in 21.7%. The absence of the ulnar head was higher in the present study (38.23%) as compared to previous studies. Absence of the ulnar head may reduce the risk of entrapment of the median nerve.[21]

The ulnar head of pronator teres is considered as a major cause of compression of the median nerve in majority of the cases of pronator syndrome. Gurses *et al.*, in their study of 112 fresh upper extremities found that the fibromuscular ulnar head was the commonest type (53.6%).[23] Similar findings were seen in the present study (61.8%). The muscular type and the fibrotic band type of ulnar head were not seen in the present study [Table 5]. The fibrous tissue present in the fibromuscular type of ulnar head can compress the median nerve leading to the pronator syndrome, for which open or endoscopic release of the ulnar head of pronator teres is done. Johnson *et al.*, found that in 40% of the forearms, the ulnar head had a fibrous band dorsal to the median nerve. They also observed in some cases, where the ulnar head was absent, a single fibrotic band passed dorsal to the median nerve.[9]

Table 5. Comparison of types of ulnar head.

Type of ulnar head	Gurses *et al.*[23]	Present study
Type 1 – Fibromuscular	53.6	61.8
Type 2 - Muscular	20.5	-
Type 3 – Fibrotic band	16.1	-
Type 4 – Absent	8	38.2
Type 5 – Ulnar head has 2 arches	1.8	-

In the subtypes of type I (fibromuscular ulnar head), 1b was more in number (28.6%) in the study by Gurses *et al.*, followed by type 1c (20.5%) and then type 1a (4.5%).[23] In the present study, type 1b (35%) was more in number, followed by type 1a (24%) and then type 1c (3%). Gurses *et al.*, found type 2 (muscular ulnar head) in 20.5%, type 3 (fibrotic ulnar head) in 16.1%, type 4 (absent ulnar head) in 8% and type 5 (ulnar head with 2 arches) in 1.8%, unlike in the present study.[23]

No cases of absent humeral head or hypertrophied pronator teres were observed in the present study. A hypertrophied pronator teres can cause compression of the median nerve.[1,24]

Caetano *et al.*, found the median nerve was positioned between the humeral and ulnar heads of the pronator teres in 74 of the 86 limbs; in 11, the median nerve passed through the musculature of the ulnar head. In three limbs, the median nerve was positioned posterior to both heads.[22] In the present study, the median nerve was positioned between the humeral and ulnar heads of the pronator teres in 19 of the 34 limbs (55.88%). In 2 limbs (5.88%), the median nerve was positioned posterior to both heads which is in accordance with Jamieson and Anson (6%)[17] and Di Dio and Dangelo (2.5%).[25] In cases, in which the ulnar head of the pronator teres was absent (38.23%), the median nerve lay posterior to the humeral head, but did not pass through it. Table 6 shows the position of the median nerve seen in different studies.

The most frequent anatomical variation was the absence of the ulnar head of the pronator teres (38.2%). Anatomical variations and the presence of fibrous component in the fibromuscular type of ulnar head, can result in narrowing of the space through which the median nerve passes, thus causing nerve compression and the motor and sensory symptoms associated with the pronator syndrome. The present authors are in agreement with Spinner[3] and Stabille *et al.*[2] who stipulated that the proximal fibrous component that is part of the coronoid process of the ulna may be responsible for nerve compression.

Compression of the median nerve can be the result of variations in the origin and morphometric characteristics of the pronator teres. The outcome of decompression procedures will be successful, if these variations are known. Surgeons should be aware of the variations that can occur in the region of the elbow, as they change the position of the nerves and vessels in their neighbourhood, putting them at risk during arthroscopic procedures and open surgical approaches in the region.

Conclusion

The anatomical variations of the humeral and ulnar heads of the pronator teres can alter the position of the median nerve, resulting in its compression. In cases, where the ulnar head of the pronator teres had a fibromuscular constitution, nerve compression can occur due to a narrowing of the nerve passage space. It is clear that the passage of the nerve between the heads of pronator teres, places a greater potential to cause the pronator syndrome. The findings from the study can help the surgeon during decompression procedures of the median nerve in the proximal forearm.

Table 6. Comparison of the course of the median nerve in relation to the pronator teres.

Course of median nerve	Mori[26] Japan n =80	Nebot-Cegarra *et al.*[16] Spain n = 80	Jamieson and Anson[17] USA n = 60	Vymazalova´ *et al.*[13] Czech Republic n = 68	Olewnik *et al.*[21] Central Europe n =50	Presen study India n =34
Between both heads	95%	75%	83.3%	85.3%	74%	55.8%
Beneath both heads	0.25%	-	6%	2.9%	12%	5.8%
Beneath HH	-	21.6%	8.7%	4.4%	14%	38.23%
Through HH	0.25%	1.7%	2%	-	-	-
Through UH	-	3.4%	-	5.9%	-	-
Together with UV	-	-	-	1.5%	-	-

HH:Humeral head; UH:Ulnar head; UV:Ulnar veins

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