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Original article:

Surgical Anatomy of Median Nerve In Relation To Pronator Teres Muscle: a Cadaveric Study

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Abstract:

Introduction: Median nerve is the commonly involved nerve in the compression neuropathies. Pronator teres muscle is very frequently responsible for median nerve compression neuropathy. Pronator teres syndrome is the compression of the median nerve as it passes between the two heads of pronator teres muscle and the apponeurosis arch of flexor digitorum superficitialis. The anatomical knowledge of variations in pattern of nerve supply to the muscle is important. Hence the aim is: To note the number of muscular branches along with their branching levels and correlated with the location of the fibrous bands.

Material and methods: Our study was carried out on 40 upper extremities from 20 formalin fixed adult cadavers from the department of Anatomy. The median nerve was dissected and its branches to pronator teres muscle were identified. The distance between the origin of branches of median nerve and Hueter's line (line through the tips of the epicondyles of the humerus) was measured. Distance between the fibrous arches and hueter's line was measured.

Observations and Results: The level of origin of nerve to pronator teres varies between 0.5 to 6.1 cm proximal and 0 to 3.8 cm distal to the intercondylar line. The pronator teres muscle was innervated by single to five branches of median nerve. The pronator arches were found along the 5.6 cm segment of median nerve and the FDS arches were found along the 7 cm segment of median nerve distal to hueter's line.

Conclusion: These results will provide the safe anatomical knowledge during the surgery and will facilitate the exposure of the fibrous arches.

Keywords: Median nerve, Pronator teres , compression neuropathies, Hueter's line

Introduction:

The median nerve is formed by the terminal divisions of the medial and lateral cords of the brachial plexus. It receives contribution from the roots of the 5th, 6th, 7th, and 8th cervical nerves and the 1st thoracic nerve. It travels through the arm medial to the brachial artery. It does not give branch to muscles of arm, except sometimes for the branch that innervates pronator teres muscle. As it travels across the elbow and enters the forearm, median nerve passes under the bicipital apponeurosis superficial to the brachialis and lies medial to the biceps tendon and brachial artery. Median nerve then passes between the two heads of the pronator teres, humeral head lies deep and ulnar head lies superficial. When the superficial ulnar head is absent median nerve passes through humeral head, gives branch to pronator teres and then enters under FDS arch[(1)]. Or the nerve lies by the side of humeral head, given branch to pronator teres and then passes under FDS arch. After this, the nerve travels deep to the fibrous arch of the flexor

digitorum superficialis (FDS) and in forearm it lies plastered between the FDS and the flexor digitorum profundus (FDP). Approximately 4cm distal to the medial epicondyle anterior interosseous nerve (AIN) courses off from the main trunk of the median nerve to innervate flexor pollicis longus (FPL), lateral half of FDP (index and middle fingers), and the pronator quadrates[2]. 4 to 5cm proximal to the wrist crease, palmar cutaneous branch of the median nerve supplies skin of palm[3]. On its way to palm, it is at greatest risk for compression because median nerve passes through the carpal tunnel along with the tendons of FDS and FDP. Entrapment neuropathies are very common peripheral nervous system disorders in which nerve is compressed by adjacent anatomical structures. Median nerve is the commonly involved nerve in the compression neuropathies. Median nerve can be compressed by different structures like ligament of Struthers, the bicipital bursa, anomalous arteries and muscles [4, 5, 6]. Pronator teres muscle is very frequently responsible for median nerve compression neuropathy.

Pronator teres syndrome is the compression of the median nerve as it passes between the two heads of pronator teres muscle. The clinical symptoms include pain and burning sensation of skin supplied by the branches of median nerve, loss of thumb opposition, with loss of flexion of index and middle finger on prolonged compression, painful pronation, thenar tenderness, characteristic pain on compression of pronator teres muscle and in long standing untreated cases thenar atrophy. The etiology, clinical symptoms and surgical management of median nerve entrapment in the cubital fossa (pronator teres syndrome) are closely related to the underlying anatomy. The most important structure that can compress the median nerve is a fibrous band at the site where median nerve passes between the two heads of the pronator teres muscle and the apponeurosis bridge of the muscle flexor digitorum superficitialis (Superficial arch).

The branch of median nerve to the pronator teres may be considered for neurotization of radial nerve in cubital fossa[7]. The pronator teres muscle can be used as graft for muscle transfer procedures. For this purpose the anatomical knowledge of variations in pattern of nerve supply to the muscle is important to restore the mobility of concerned part after trauma[8]. Study includes detail surgical anatomy of median nerve with respect to pronator teres. The number of muscular branches along with their branching levels were noted and correlated with the location of the fibrous bands which causes median nerve entrapment. These results will provide the safe anatomical knowledge during the surgery and will facilitate the exposure of the fibrous arches.

Aims and Objectives:

1) To study the ramifying pattern of nerve to pronator teres muscle.
2) To study and locate the fibrous bands which compresses the median nerve.
3) To study the presence of ligament of Struthers, anomalous vessels in relation to median nerve.

Material and Methods:

Our study was carried out on 40 upper extremities from 20 formalin fixed adult cadavers from the department of Anatomy; during routine dissection schedule. Ethical clearance has been taken from institute's ethical committee. Skin covering the cubital fossa is removed to expose the forearm flexor compartment. Cadavers with previous scar or surgical incisions in the region of cubital fossa were excluded from the study. The median nerve was dissected

and its branches to pronator teres muscle were identified. The distance between the origin of branches of median nerve and Hueter's line (line through the tips of the epicondyles of the humerus) is measured. The tendinous portion of the pronator teres and flexor digitorum superfitialis muscle is exposed and distance between the fibrous arches where it lies on the main trunk of the nerve and Hueter's line is measured. Number of branches to pronator teres was noted. Branches for humeral and ulnar head of pronator muscle are also noted separately. By noting the levels of origin of different branches from main trunk, the segment of median nerve which is potential site of ramification can be defined. By noting the levels of fibrous bands across the main trunk, the potential segment for entrapment can be defined. The measurements were carried out by caliper and scale.

The morphometric results of study of branching pattern and distance of fibrous band from Hueter's line will be analyzed for average and range. This will help to determine minimum and maximum value of the segment that can be entrapped. Statistically significant difference will be analyzed for distance of origin of branch to pronator teres from Hueter's line among right and left extremity by using t test.

Observations Results:

Table 1: Number of Branches of Nerve to Pronator Teres on Each Side.

Muscular Branch	**Number of Branches**	**Right (n=19) n (%)**	**Left (n=20) n (%)**	**Total**
Nerve to Pronator Teres	No visible branch	*2 (11%)*	-	*2 (5%)*
	1	-	*1 (5%)*	*1 (3%)*
	2	*3 (16%)*	*6 (30%)*	*9 (23%)*
	3	*11 (58%)*	*10 (50%)*	*21 (54%)*
	4	*1 (5%)*	*2 (10%)*	*3 (8%)*
	5	*2 (11%)*	*1 (5%)*	*3 (8%)*

The number of branches to pronator teres varied from 0 to 5 (Table No. 1). In 2 (10%) right upper extremities, Median nerve directly pierced the humeral head of pronator teres. Hence; there was no visible branch in cubital fossa supplying pronator teres. Further in right extremity (Table No. 1), the pronator teres muscle was innervated by 2 branches of median nerve in 3 cases (16 %), 3 branches in 11 cases (58%), 4 branches in 1 case (5%) and by 5 branches in 2 cases (11%). It was also observed that, in left extremity of 1 (5%) case among the 38 cases, pronator teres was innervated by a single branch, by 2 branches in 6 cases (30 %), 3 branches in 10 cases (50%), 4 branches in 2 cases (10%) and by 5 branches in 1 case (5%). On an average there were 3 branches to pronator teres on either side. Total number of branches supplying humeral head of pronator teres were ranges from 0 to 4 (average 2), similarly number of branches supplying ulnar head were ranges from 0 to 2 (average 1).

Table 2: Number of branches of Nerve to Pronator Teres Muscle with relation to Hueter's line.

Muscular branch	Number of branches	No. of cases Above the hueter's line (n)	No. of cases At the hueter's line (n)	No. of cases Below the hueter's line (n)	Total (n)
Nerve to Pronator Teres	1	*17 (44%)*	*14 (37%)*	*7 (18%)*	*38*
	2	*8 (22%)*	*12 (32%)*	*17 (46%)*	*37*
	3	-	*1 (4%)*	*27 (96%)*	*28*
	4	-	*4 (57%)*	*3 (43%)*	*7*
	5	*1(33%)*	*1(33%)*	*1 (33%)*	*3*

One branch:

Amongst the branches to pronator teres (Table No. 2) the origin of 1st branch in 17 (45%) cases above the Hueter's line, in 14 cases (37%) at the level of Hueter's line and in 7 cases (18%) below the level of Hueter's line.

Two branches:

In 8 cases (22%) 2nd branch originated above the hueter's line, in 12 cases (32%) at the level of hueter's line and in 17 cases (46%) it originated below the hueter's line.

Three branches:

In 28 cases 3rd branch was seen. Out of them only one branch (4%) originated at the level of the hueter's line, remaining all (27 cases, 96%) originated below the hueter's line.

Four branches:

In 7 cases, 4th branch was seen. In 4 (57%) cases, it originated at the level of hueter's line remaining all (3 cases, 43%) it originated below the level of hueter's line.

Five branches:

In 3 cases, 5th branch was observed. In one case it originated above in another case it originated below and in yet other case it originated at the hueter's line.

Table 3: The distance (cm) of origin of Nerve to Pronator Teres (NPT) above the Hueter's Line.

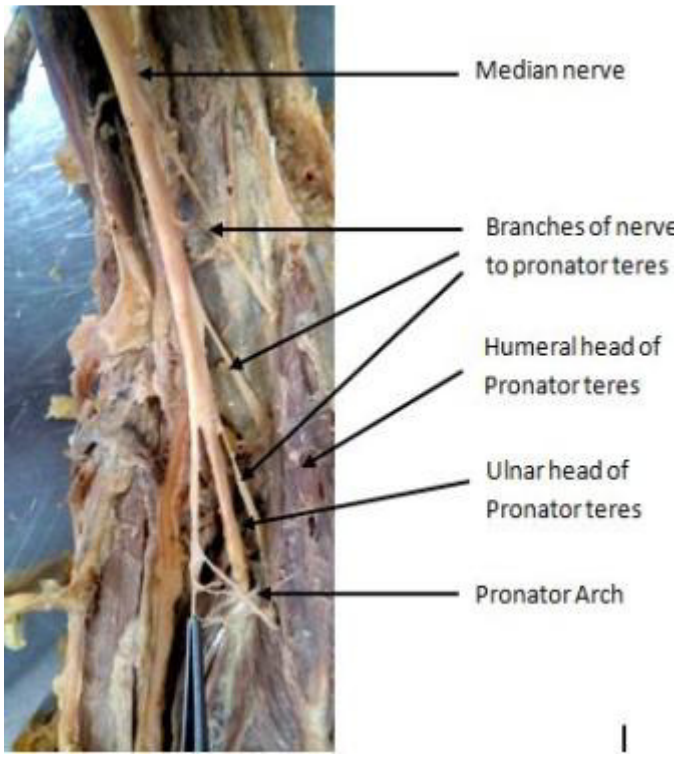
Level of origin	Right (n)	Left (n=)	Total (n=39)
Range (cm)	*0.5 to 4.1*	*1 to 6.1*	*0.5 to 6.1*
Mean (cm)	*2.2*	*2.7*	*2.5*
Std. Deviation (cm)	*1.23*	*2.1*	*1.7*

Table 4: The distance (cm) of origin of Nerve to Pronator Teres (NPT) below the Hueter's Line.

Level of origin	**Right (n)**	**Left (n=)**	**Total (n=39)**
Range (cm)	*0 to 8*	*0 to 4.4*	*0 to 3.8*
Mean (cm)	*2.0*	*0.8*	*1.1*
Std. Deviation (cm)	*2.96*	*1.5*	*2*

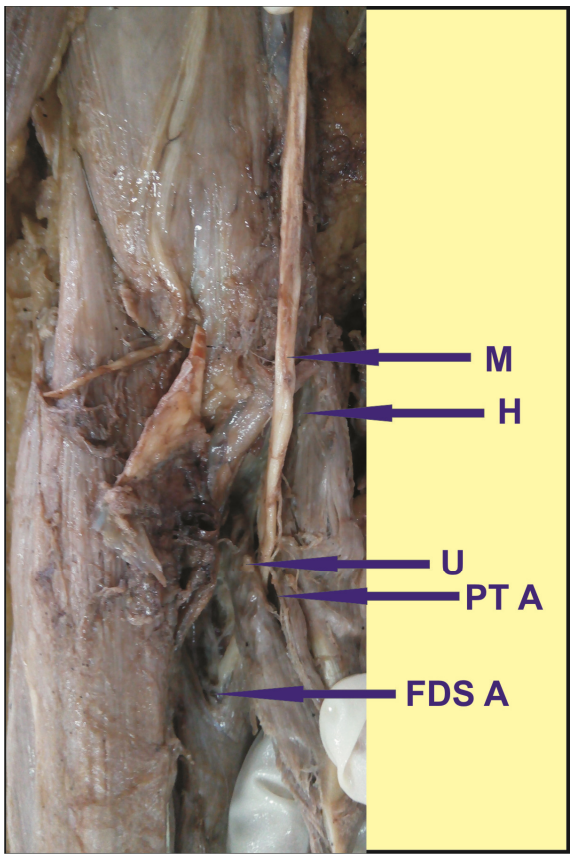
As evident from table number 3 & 4: The mean distance (cm) of Nerve to Pronator Teres (NPT) originating above the Hueter's Line was 2.2 cm in right sided extremities (range 0.5 cm to 4.1 cm) and 2.6 cm in left sided extremities (range 1 cm to 6.1 cm). While, the mean distance (cm) of Nerve to Pronator Teres (NPT) originating below the Hueter's Line was 2 cm among right sided extremities (range 0 cm to 8 cm) and 0.8 cm among the left sided extremities (range 0 cm to 4.4 cm). However there was no statistically significant difference found for distance of origin from Hueter's line among right and left side**.**

Fig no. 1:



As evident from the Fig. number 1; the branches of nerve to pronator teres originates from lateral side of trunk of median nerve. At the site of origin they made an acute angle with that of main trunk of median nerve. There was no evidence of any recurrent branch.

Fig. no. 2:



[**M:** Median nerve, **H:** Humeral and **U:** Ulnar head of Pronator teres,
PT A: Pronator Teres Arch, **FDS A:** Flexor Digitorum Superficialis Arch]

When looked for both heads of the pronator teres i.e. humeral and ulnar, as in Fig. number 2; 36 (92%) extremities both the heads were present and median nerve leaved the cubital fossa by passing through the musculotendinous arch formed by the ulnar and humeral head of pronator teres called as pronator arch. The pronator arches were found along the 5.6 cm segment of median nerve, ranging from 3.1cm to 8.7 cm distal to Hueter's line. The mean distance of pronator arch was 5.1 cm distal to Hueter's line. In 3(8%) extremities, ulnar head being absent, the median nerve pierced the humeral head and directly entered the forearm by passing below the flexor digitorum superficialis muscle (superficialis arch). The distance of FDS arch ranges from 3.5 cm to 10.5 cm. The mean distance of superficialis arch was 7.3 cm distal to hueter's line

Discussion:

There are many reports about specific entrapment neuropathies of median nerve, especially carpal tunnel syndrome. The study of the structures related to the entrapment neuropathies of the median nerve in arm and forearm are scarce. Compression by adjacent structures may tether a nerve and restrict its mobility, thereby causing stretching in response to joint motion[9, 10].

Variations of the nerve and adjacent structures may present clinically or may be observed at surgery, autopsy or cadaveric dissection. For a correct diagnosis of entrapment neuropathies, these variations must always be kept in mind. An anomalous muscle usually does not cause any symptom but has academic value. It becomes a surgical problem when anomalous muscle will produce symptoms or are difficult to differentiate from soft tissue tumors and are important in entrapment neuropathy[11].

In present study, median nerve passes between ulnar and humeral head in 36(92%) extremities hence the median nerve leaves cubital fossa by passing between them. In 3(8%) among the 39 extremities, ulnar head was absent and median nerve was passing below humeral head.

Earlier Nebot-Cegarra et al found that humeral head was present in all the cases while ulnar head was present in 47 (78.3%) out of 60 cases. The double humeral head of Pronator teres in 3 cases (5%) out of 60 limbs and they further observed that median nerve was passing between two humeral heads in 2 cases (3%) and between ulnar and humeral head in 58 cases (96.6%)[12] . In a study conducted by Jamieson and Anson Ulnar head of Pronator teres was found absent in 26(8.7%) out of 300 limbs [13]. These finding coincides with our study. Anson observed that the median nerve was passing between ulnar and humeral heads in 198 cases (82.5%) out of 240 arms, passing beneath the humeral head in 21 cases (8.75%) where ulnar head was lacking, behind the ulnar head in 15 cases (6.25%) and the nerve pierced the humeral head in 6 cases (2.5%) only [14].

Gray, found in 16% of the studied corpses that in the absence of an ulnar head the median nerve was in a deep situation in relation to the humeral head of this muscle, or even going through the belly of this head[15]. Beaton & Anson, observed that in 82% of the cases, the median nerve was located between the deep and superficial head of the teres pronator muscle during the dissection of 240 superior extremities; in 9% of the cases the ulnar head of the teres pronator muscle was absent; in 7% of the cases the median nerve was deeply located in relation to the ulnar head of the teres pronator muscle and in 2% of the cases the nerve went through the belly of the humeral head of the teres pronator muscle[16].

Chantelor et al observed the classical pattern of two branches of median nerve innervating the pronator teres muscle separately in 13 cases (26%). He reported one branch supplying the muscle in 28 specimens, three branches in one specimen[17]. Demirci et al observed the classical pattern of two branches in 55.9% cases, one branch in 11.8% and three branches in 29.4% of cases[18]. Pushpalatha observed the single branch in 34 specimen, two branches in 14 specimen and three branches innervating the muscle in two specimens out of 50 specimens[19]. Alves in a study of 18 forearms observed one to three branches to pronator teres[20]. In present study out of 39 specimens, the pronator teres muscle was innervated by single branch in one (3%) specimen, two branches in 9 (23%), three branches in (54%), four branches in 3 (8%) and five branches in 3 (8%). None of the studies mentioned above found more than 3 branches of median nerve supplying pronator teres. There are two (5%) specimen, where median nerve directly runs through humeral head, hence there is no visible branch to pronator teres muscle. Similar finding has been reported by Gray, Anson, Anson and Betel.

Gunther et al reported that branch to pronator teres originated from the first branch of median nerve and its mean point of origin is 3 cm above the interepiconylar line[21]. According to Linell the level of origin of branches of

median nerve to pronator teres is variable but it seldom originated proximal to elbow line and main nerve was found to arise 1-2 cm below the lateral epicondyles[22]. Median nerve gives its first branch from its medial aspect approximately 1 cm to 3 cm proximal to elbow which penetrates and innervates pronator teres[23]. In the study of 18 forearms done by Alves, taking elbow line as articular reference point most branches of median nerve, nerve to pronator teres arose in distal third of arm and penetrate at proximal third part of forearm. The level of origin of nerve to pronator teres was between 4 cm proximal to interepicondylar line and 1 cm distal to interepicondylar line in right upper limbs whereas in left upper limb, it was 4.9 cm proximal to interepicondylar line and 1.6 cm distal to interepicondylar line[18].

In present study; the level of origin of nerve to pronator teres varies between 2.2 ± 1.2 cm proximal to intercondylar line and 2 ± 2.9 cm distal to intercondylar line in right forearms whereas 2.7 ± 2.1 cm proximal to interepicondylar line and 0.8 ± 1.5 cm distal to interepicondylar line in left forearms. Our findings are similar to above studies. The topographical relation of median nerve and both the heads of pronator teres are important. The median nerve may pass between the two heads of pronator teres or posterior to them or may pierce the humeral head. In first two situations, a fibrous arch is impinging on the median nerve. If ulnar head is muscular, there is fibrous arch that develops at fusion site with humeral head. When ulnar head is tendinous the ulnar head itself act as fibrous arch over the median nerve. If ulnar head is absent there will be no pronator arch. The pronator arch may compress the median nerve segment which eventually innervates the deep anterior muscles of forearm. Further median nerve enters in the forearm by passing below the aponeurotic bridge of the flexor digitorum superficialis muscle.

Fuss and GH Wurzl reported that pronator arches were found along the segment of 4.5cm. The length of segment ranges from 3 cm to 7.5 cm below the Hueter's line (interepicondylar line), the flexor digitorum superficialis arch spans over the median nerve 6.5 cm below the hueter's line[24]. In present study, the pronator arches were found along the 5.6 cm segment of median nerve, from 3.1cm to 8.7 cm distal to Hueter's line. The mean distance was 5.1 cm distal to Hueter's line. The mean distance of flexor digitorum superficialis arch was 7.3 cm distal to Hueter's line. The authors propose to extend the work further by studying morphology of all the branches of median nerve in cubital fossa before median nerve leaves under FDS arch and presence of anomalous/accessory vessels crossing superficial to median nerve along its course of median nerve in arm and forearm which is lacking in the present study.

Conclusion:

In present study, in majority of specimens (92%) the median nerve passes between ulnar and humeral head hence the median nerve leaves cubital fossa by passing through pronator arch. In very few specimens (8%), ulnar head was absent and median nerve was passing below humeral head. The level of origin of nerve to pronator teres varies between 0.5 to 6.1 cm proximal and 0 to 3.8 cm distal to the intercondylar line in all the forearms specimens. The pronator teres muscle was innervated by single to five branches of median nerve. There are some specimens, where median nerve directly runs through humeral head; hence there is no visible branch to pronator teres muscle. The pronator arches were found along the 5.6 cm segment of median nerve distal to hueter's line. The FDS arches were

found along the 7 cm segment of median nerve distal to hueter's line. All the branches arising from median nerve on its way to pronator teres were inclined downwards and laterally. This information will be useful in planning the site for incision for better cosmetic results.

As previously discussed; pronator teres syndrome is one of the important compression neuropathies of median nerve in forearm. Also the branch of median nerve to pronator teres may be considered for neurotization of radial nerve and pronator teres muscle can be used as donor for muscle transfer procedures. This anatomical information of ramification pattern of nerve to pronator teres and morphology of pronator teres muscle is of use to neurosurgeons, clinicians, orthopedicians, and physiotherapists in surgical interventions in cubital fossa region and also helpful to plan the treatment of pronator teres syndrome.

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