Pronator teres muscle: anatomical variations and predisposition for the compression of the median nerve

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ABSTRACT. The median nerve can be compressed at the level of pronator teres muscle (PTM), resulting in the pronator teres syndrome. This work aim was to analyze the PTM and its relationship with the median nerve. In order to do so, we have dissected 100 human upper limbs from anatomy laboratories. In 72% of the cases, the median nerve passed between the umeral and ulnar heads of PTM. In 15% of the cases, the ulnar head was absent, with the median nerve passing behind the umeral head or through it. In 9%, a fibrous bundle represented the ulnar head. In 2%, the median nerve passed through the ulnar head and in 2% through the umeral head, even in the presence of the ulnar head. The data suggest that the variations in the relationship muscle/nerve represent potential factors for the median nerve compression, for they make the passage for this nerve in the forearm even narrower.

Key words: pronator teres muscle, median nerve, round pronador syndrome, pronator teres syndrome, variation muscular.

RESUMO. Músculo pronador redondo: variações anatômicas e predisposição para a compressão do nervo mediano. O nervo mediano pode ser comprimido em nível de músculo pronador redondo (MPR), resultando na síndrome do pronador redondo. Objetivou-se analisar a constituição do MPR e sua relação com o nervo mediano na dissecação de 100 membros superiores humanos, oriundos de laboratórios de anatomia. Em 72% dos casos, o nervo mediano passou entre as cabeças umeral e ulnar do MPR. Em 15% a cabeça ulnar esteve ausente, com o nervo mediano passando posteriormente a cabeça umeral ou através dela. Em 9% a cabeça ulnar se fez representar por um feixe fibroso. Em 2% o nervo mediano passou através da cabeça ulnar e em 2% através da cabeça umeral, mesmo na presença da cabeça ulnar. Os dados sugerem que as variações na relação músculo/nervo representam fatores potenciais para a compressão do nervo mediano, por tornarem mais restrita a passagem desse nervo no antebraço.

Palavras-chave: músculo pronador redondo, nervo mediano, síndrome do pronador redondo, variação muscular.

Introduction

The pronator teres muscle (PMT) showed variations regarding the constitution of its humeral and ulnar heads with varied incidences.

The median nerve compression results in a syndrome characterized by sensivity and/or motor changes along the nerves distribution area.

Gessini *et al.* (1980) report that these syndromes are consequences of two main reasons: the first, of anatomical aspect, is represented by the fact that some nerves along their courses, pass through oblique passage, real straits, delimited by muscular fascia, tendons, fibrous bundles and osseo-ligaments channels; the second reason is represented by some factors which, through several mechanisms, tend to limit these passages even more, exerting pressure on the nervous trunk.

According to Spinner (1978), the pronator teres syndrome is caused mostly by the median nerve compression at the PTM level, although there are other potential compression areas in the forearm. However, researches regarding this syndrome are, in most cases, just publications about isolated clinical cases (Bayerl and Fischer, 1979; Gross and Jones, 1992; Olehnik *et al*., 1994; Tulwa *et al*., 1994; Ashworth *et al*., 1997; Stal *et al*., 1998). According to Solnitzky (1960), in order to better understand the

pathogeneses of the pronator teres syndrome, it is fundamental to know the median nerve relationships at the PTM level.

Gessini *et al.* (1980) state that the PTM presents several morphological variations. However, many classical works and text books in Human Anatomy do not make any mention about the PTM variations. Among those that mention these variations, few are the ones that make any relation between the variations and the median nerve, expressing its frequency (Testut, 1884; Le Double, 1987; Chiarugi and Bucciante, 1972).

The PTM may present variations related to its proximal and distal insertions and at the constitution of the humeral and ulnar heads (Macalister, 1868; Jamienson and Anson, 1952; Buch-Hansen, 1955; Lans and Wachsmuth, 1959; Didio and Dangelo, 1963; Nebot-Cegarra *et al*., 1992). These variations may compress the median nerve, causing the PTS (Spinner, 1978, Danielson, 1980; Gessini *et al*., 1980; Olehnik *et al*., 1994; Ashworth *et al*., 1997). Also, the pressure coming from a stiff PTM due to tension, hypertrophy due to professional and occupational activities (especially if this activities include movements in which the forearm remains pronated) may also lead to median nerve compression (Seyffarth, 1951; Spinner, 1978; Stal *et al*., 1998).

Although the PTM was studied in the beginning of the last century, only recently this muscle has been related to the nervous compression syndrome, justifying, therefore, new approaches to study this structure.

Knowing the importance of the relationship between the PTM and the median nerve, as well as the variations that may interfere in this relationship, the present work aimed at studying the PTM constitution and its relation with the median nerve in humans. Our goal was to contribute to a better understanding of this muscle's anatomical aspects and its importance to the PTS.

Material and methods

To carry out this work, 100 human upper limbs were employed (50 right limbs and 50 left limbs), from Human Anatomy laboratories. The upper limbs were taken from adult cadaveres, males and females, previously fixed in a 10% formol solution.

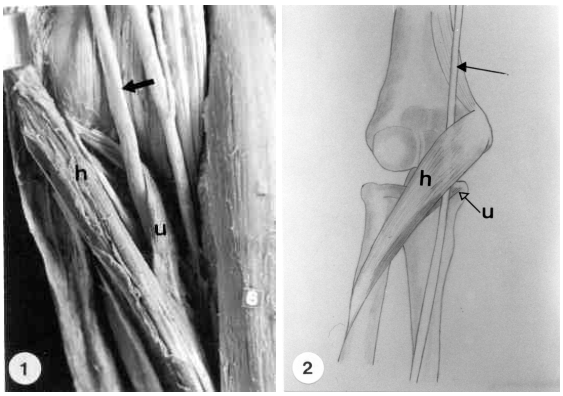
A macroscopic dissection was performed at the forearm's anterior region, to displace the skin: the subcutaneous screen, the muscle fascia and the fatty tissue were removed in order to expose the PTM and the median nerve. After exposing these structures, we went on with the observation and verification of the frequency and constitution of the muscle humeral and ulnar heads, describing the existing relationship between the muscle and median nerve, not considering the nerve ramification.

The limbs were photographed and, for each of them, we employed a schematic drawing to reproduce the muscle/nerve relationship.

Results

We have found anatomical variations at PTM related to the presence and to the constitution of the humeral and ulnar heads, as well as to the constitutional muscular belly of the humeral head. These variations were accompanied by alterations in the median nerve course, changing the relationship between this nerve and the muscle.

From 100 limbs studied, 72 (72%) presented the PTM constituted by humeral and ulnar heads, characterized by distinct muscular bellies. In these cases, the median nerve passed between the muscle-heads mentioned, showing no variation in its course in this region of the upper limb (Figures 1 and 2).



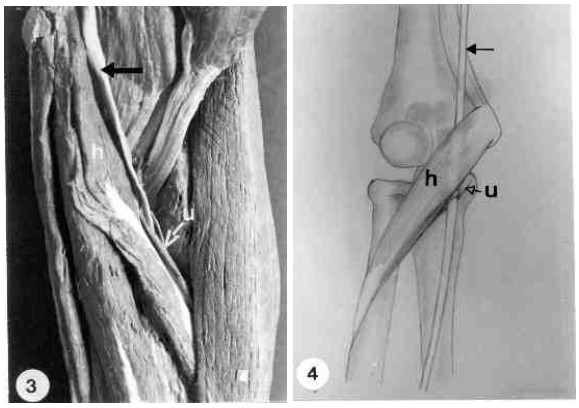
Figures 1 and 2. Forearm anterior region, showing the median nerve (black arrow) between the humeral (h) and ulnar (u) heads of the pronator teres muscle

We have observed in two of the studied limbs (2%) a variation regarding the ulnar head. In these two, the ulnar head showed a muscular belly divided in two bundles, with the median nerve passing between them (Figures 3 and 4).

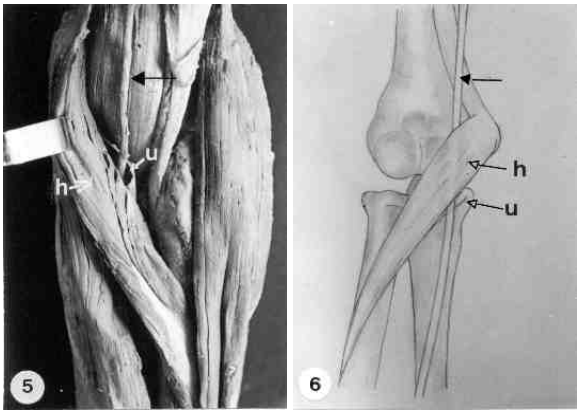
In nine limbs (9%), the ulnar head was represented by a narrow fibrous band which, coming out of the humeral head deep face, inserted itself proximally at the medial ridge of the coronoid process of the ulna, showing a muscle fibers absence in this muscle area. In these limbs, the median nerve passed between the humeral head and the fibrous band representing the ulnar head (Figures 5 and 6).

The ulnar head was absent in 13 upper limbs (13%). Only the humeral head constituted the PTM

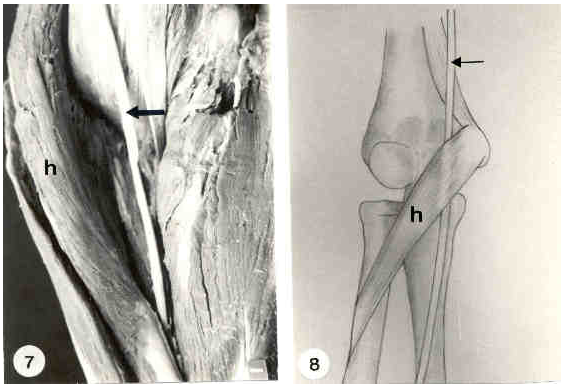
with the median nerve passing behind this head (Figures 7 and 8).



Figures 3 and 4. Forearm anterior region, with the median nerve (black arrow) perforating the ulnar head (u) of the pronator teres muscle. Humeral head (h)

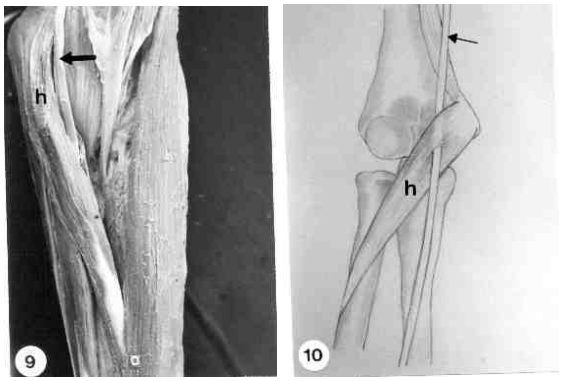


Figures 5 and 6. Forearm anterior region, with the median nerve (black arrow) passing between the muscular humeral head (h) and the fibrous ulnar head (u) of the pronator teres muscle



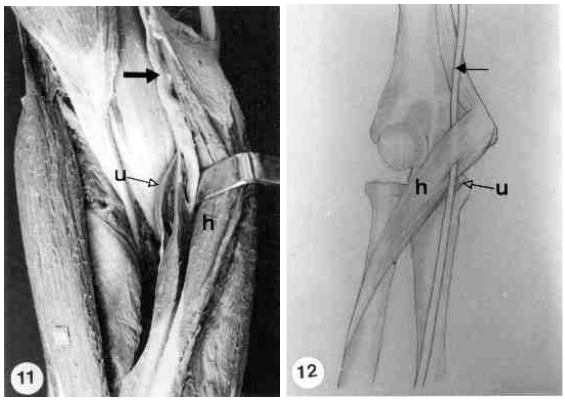
Figures 7 and 8. Forearm anterior region, with the median nerve (black arrow) passing behind the humeral head (h) of the pronator teres muscle in the absence of the ulnar head

The absence of the ulnar head and the division of the muscular belly of the humeral head in two bundles was present in two cases (2%). The median nerve passed between these two muscle bundles of the humeral head (Figures 9 and 10).



Figures 9 and 10. Forearm anterior region, with the median nerve (black arrow) perforating the humeral head (h) of the pronator teres muscle in the absence of the ulnar head

A variation was noticed in two cases (2%), related to the humeral head with its muscular belly divided into two bundles in the presence of the ulnar head. The median nerve passed between the muscular bundles of the humeral head, despite the ulnar head presence (Figures 11 and 12)



Figures 11 and 12. Forearm anterior region, with the median nerve (black arrow) perforating the humeral head (h) of the pronator teres muscle in the presence of the ulnar head (u)

These results are shown at Table 1.

Table 1. Percentage of humeral (Hh) and ulnar (Uh) head variations of pronator teres muscle and their respective relations with the median nerve found in 100 upper limbs

Pronator Teres Muscle (PTM)	Location of the median nerve	%
Presence of two heads	Between the two heads	72
Divided Uh	Between the bundles of the Uh	2
Fibrous Uh	Between the two heads	9
Absence of the Uh	Behind the Hh	13
Absence of the Uh with the Hh divided	Between the Hh bundles	2
Presence of two heads with the Hh divided	Between the bundles of the Hh	2
Total		100

Discussion

In 72% of the upper limbs, its humeral and ulnar heads constituted the PTM, with the median nerve passing between them, and positioning itself behind the fingers superficial flexor muscle. These results differ from those reported by Hofer and Hofer (1910), Lans and Wachsmuth (1959), Mori (1964); Nebot-Cegarra *et al*. (1972). According to them, these kind of muscle/nerve relationship occurs in 56%, 95.5%, 91.7% and 68.3% of cases, respectively. Jamienson and Anson (1952) state that the median nerve passes between the two muscle heads in 83.3%. These authors do not take the constitution of the ulnar head into consideration, i.e., they do not mention if, in these cases, the ulnar head was present with muscular or fibrous constitution. When we add to the 72 studied cases the other nine where the ulnar head was represented by a fibrous bundle, we obtain a total of 81 cases (81%) where the PTM was constituted by two heads separated from each other by the median nerve. This figure of 81% gets close to the 83.3% mentioned by Jamienson and Anson (1952).

Regarding the muscle constitution and its relationship with the median nerve, the other authors only mention that the median nerve usually passes between the two PTM heads (Testut, 1884; Chiarugi and Bucciante, 1972; Testut and Latarjet, 1979) or they do not mention the variations of this relationship at all (Tandler, 1926; Bairati, 1971; Fazzari, 1971; Beninghoff and Goerttler, 1975).

Among the muscle variations found, it is worth mentioning the ulnar head absence in 15 limbs; the median nerve was positioned behind the humeral head in 13 cases (13%), and perforated the humeral head in two cases (2%). The absence of the ulnar head is reported by Rouviere (1971) e Testut and Latarjet, (1979) and, although they do not express the frequency of this variation, they mention that it might occur. Wood (1868), Lans and Wachsmuth (1959) and Nebot-Cegarra *et al*. (1992) report the absence of the ulnar head in 1%, 2.7% and 21.7% respectively. Mori (1964) mentions four cases of this variation.

Chudzinsk (1898) and Gessini *et al*. (1980) report that the ulnar head absence is the most common PTM variation. This fact is confirmed by this study, since it was the most frequently found variation (15%). These data are different from those found by Beaton and Anson (1939) and Lans and Wachsmuth (1950); for them, the median nerve passes behind the humeral head, with the ulnar head absent in 8.75% and 1% of the cases, respectively.

Barret (1936) and Buch-Hansen (1955) do not mention anything about the ulnar head absence in their reports about PTM.

We verified that the median nerve could relate to the PTM in two different ways, in the absence of the ulnar head. The most common relation, i.e., the nerve passing behind the humeral head, is mentioned by Jamienson and Anson (1952), Solnitzky (1960) and Lans and Wachsmuth (1959). The second kind of muscle/nerve relationship, found in 2% of the studied cases, was the median nerve going through the humeral head, dividing it in two muscle bundles. Hofer and Hofer (1910) affirm that the median nerve passes through the humeral head in the presence of the muscular ulnar head, in eleven cases; in the presence of the fibrous ulnar in two cases and in the absence of this muscle's portion in three cases. Jamienson and Anson (1952), Lans and Wachsmuth (1959), Didio and Dangelo (1958), Mori (1964) and Nebot-Cegarra *et al*. (1992) mention that in 2%, 1.5%, two cases among 54, 0.25% and 5% of the upper limbs, respectively, the median nerve passes through the humeral head. These same authors, with exception of Hofer and Hofer (1910), do not take into consideration whether the median nerve perforates the humeral head in the ulnar head presence or absence. When we add the two cases of humeral head division by the median nerve in the absence of the ulnar head, with the other two reported cases in which, even with the ulnar portion presence, the nerve passed through the humeral head, we can state that in 4% of the observations made, the median nerve passed between the humeral head bundles, regardless of the ulnar head presence or absence. These data differ from those reported by those authors.

Testut (1884) and Chiarugi and Bucciante (1972) mention the humeral head division in two bundles, but they consider this occurrence rare. However, these authors neither expressed these variations incidence in figures, nor related them to the median nerve.

Another variation observed in 2% of the studied limbs was the division of the ulnar head muscular belly, with the median nerve passing through this region. Hofer and Hofer (1910) also observed this variation in two cases. Testut (1884), Chiarugi and Bucciante (1972) and Testut and Latarjet (1979) state that both heads can be constituted by muscular bellies, divided in two bundles. Le Double (1897), on the other hand, states only the splitting of the ulnar head. The relation between this muscle variation and the median nerve is not mentioned by

any of the consulted authors except Hofer and Hofer (1910).

According to Testut (1884), Le Double (1897) and Bertelli (1932), the PTM humeral and ulnar heads can be found completely independent, with separated distal insertion tendons. This variation was not found in this work. In all upper limbs, when the PTM portion was present, the ulnar head fused to the humeral after a small course, always with a single distal insertion tendon.

Testut (1884), Le Double (1897), Bertelli (1932) and Solnitzky (1960) mention that a tendinious bundle may sometimes replace the PTM ulnar head. Macalister (1868), Spinner (1978) and Gessini *et al*. (1980) considered this occurrence frequent. This fact was not as frequent at the present study, and represented 9% of the cases. In these, the median nerve passed between the humeral head and the PTM fibrous ulnar head. Chudzinski (1868) and Farrel (1976) only mention the presence of a single case, Hofer and Hofer (1910) the presence of three cases among 50 studied specimens and Nebot-Cegarra *et al*. (1992) report six cases among 60. Mori (1964), studying 80 upper limbs of Japanese specimens, states that in 3% of them the ulnar head was weak. However, he did not explain whether a fibrous bundle replaced this portion or not. In all our nine specimens, we have observed that the ulnar head did not have its proximal insertion place changed, i.e., the ulna coronoid process, even though they existed under a fibrous bundle shape.

We did not find the median nerve passing behind the ulnar head in any of the studied limbs. Jamienson and Anson (1952), Buch-Hansen (1955) and Didio and Dangelo (1958) report this fact in 6%, in five cases and in 2.5% of the specimens studied by them, respectively.

According to Gessini *et al*. (1980), some nerves pass through straits delimited by muscular fascias, tendons, vessels, fibrous bundles and osteo-ligament channels in their course. For those authors, these structures may limit the passage of these nerves through several mechanisms, compressing them.

Our observations lead us to agree with Gessini *et al*. (1980) regarding the median nerve course between the two heads of the PTM, since these muscular structures, subject to variations, form a "strait" for the passing of the median nerve at the forearm proximal region.

Solnitzky (1960), Cantero (1974), Spinner (1978) and Wertsch and Melvin (1982) report that the median nerve may be compressed in its trajectory between the two heads of the PTM.

The report by Gessini *et al*. (1980) and our own observations allow the assumption that the presence of any variation at the PTM, resulting in a reduction in the existing space for the median nerve passing, may represent a potential median nerve compressing factor and, therefore, may cause the pronator teres syndrome. This syndrome may denervate the PTM and the forearm more distal muscles (Gross and Jones, 1992).

Seyffarth (1951), Cantero (1974), Spinner (1978), Danielsson (1980) and Wiggins (1982) do not record pronator teres syndrome cases resulting from median nerve compression by muscular bundles of the splitted ulnar head. Although representing only a small percentage of the findings (2%), making this variation less frequent, it is believed that the median nerve is likely to be compressed in these cases, since the nervous segment was entrapped by the ulnar head muscular bundles, giving the impression that the median nerve perforated this muscular head, making the existing space very narrow for its passage.

Among the 100 studied muscles, we found that, in nine (9%) of them, the ulnar head was constituted by a fibrous bundle. Spinner (1978) states that the presence of these bundles at the PTM and the ulnar head tendinious origin may compress the median nerve. This last variation is the most frequent etiological factor for the anterior interosseous nerve syndrome.

In 13% of the upper limbs the ulnar head was not found, and the median nerve passed behind the humeral head. However, Solnitzky (1960) and Gessini *et al*. (1980) did not relate this variation to the pronator teres syndrome by. As a matter of fact, in these cases, the space left for the median nerve passage was not narrow and, therefore, this fact alone does not contribute for the nerve compression.

Solntizky (1960) mentions that the median nerve may pass through the muscular bundles of the humeral head and Gessini *et al*. (1980) mention that the duplication of one or both muscular heads may occur. We found that, in four cases (4%), the median nerve passed through the humeral head bundles; in two cases, the ulnar head was absent. Also, the space through which the median nerve passed was reduced, when compared to other situations. This leads us to believe, as also did Nebot-Cegarra *et al.* (1992) and Tulwa *et al*. (1994), that the presence of this variation is also a potential median nerve compression factor, thus originating the pronator syndrome.

Spinner (1978), Gessini *et al*. (1980) e Wiggins (1982) state that the median nerve is subject to being compressed by passing behind both PTM heads. We did not find a similar case, i.e., no upper limb studied showed the median nerve passing behind the humeral and ulnar heads.

Through the dissections performed, it may be concluded that the PTM presents variations regarding its constitution and the humeral and ulnar heads frequency, which are accompanied by changes in the median nerve course. The most frequent variation is the ulnar head absence. In the cases where the ulnar head has a tendinious constitution, or in cases where the median nerve passes through the ulnar or humeral head muscular bundles, the space for nerve passing becomes really reduced, creating potential conditions for the median nerve compressing and predisposing the pronator teres syndrome appearance.

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