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MAIN ANATOMICAL VARIATIONS FOUND IN PATIENTS WITH CARPAL TUNNEL SYNDROME: LITERATURE REVIEW

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Abstract: Carpal tunnel syndrome (CTS) is a neuropathy caused by compression and/or traction of the median nerve in its portion located in the carpal tunnel at the wrist. The aim of this article is to report the main anatomical variations related to CTS. To do this, searches were carried out in the SciELO and PubMed databases, using descriptors from the DECS, and with inclusion factors for the last 5 years, and a total of 14 studies were found, 9 of which were chosen because they were more pertinent to the topic. The etiopathogenesis of CTS is variable, but it is known that anatomical variations can lead to pathology, being related to variations in symptomatology, possible iatrogenic lesions and compression of adjacent structures. Anatomical variations can include nerves, vessels, muscles and tendons. Determining and identifying anatomical variations is important not only for defining the cause of nerve compression, but also for avoiding complications during surgical procedures in the treatment of carpal tunnel syndrome. The presence of a bifid median nerve, persistent median artery and accessory lumbrical muscle are the anomalies most frequently found in patients with the syndrome studied.
Keywords: Carpal tunnel syndrome. Anatomical variation.

INTRODUCTION

The carpal tunnel is an osteofibrous tunnel, considered to be the space between the flexor retinacula. It is made up of nine bone, muscle and nerve structures, including the median nerve, which supplies muscles and sends sensory fibers to the skin. It is delimited on the ulnar border by the hamate, pyramidal and pisiform muscles and on the radial border by the scaphoid, trapezius and flexor carpi radialis tendon (CHAMMAS et al, 2014).

Carpal Tunnel Syndrome (CTS) is a compressive neuropathy of the median nerve and can be caused by any injury that significantly narrows the carpal tunnel or enlarges any of the nine structures or their linings that cross it. In this respect, anatomical variations in nerves, muscles, vessels and tendons are important factors that can cause CTS or make it difficult to treat (CHAMMAS et al, 2014).

CTS is more common in women, between 40 and 50 years of age, it can affect 4 to 10% of the population, it is a frequent peripheral neuropathy, most often idiopathic or post-traumatic. (DHAL et al, 2020)

Diagnosis of the syndrome is based on the clinical picture, which is represented by paresthesias and dysesthesias in the territory of the median nerve, and tests such as electroneuromyography of the upper limbs and ultrasound of the wrist can be carried out. (PIMENTEL et al, 2022)

Its cause is most often idiopathic, but it can be secondary to extrinsic compression, particularly bone (fracture or dislocation of the carpal bones, malformations, osteoarthritic lesions, osteosynthesis), infectious arthritis, acromegaly, but also intrinsic (tenosynovitis, inflammatory rheumatism, amyloidosis, intraductal tumor, hematoma) or even edema (pregnancy, hypothyroidism, arteriovenous fistula). The etiologies of the **acute** forms include traumatic causes (fractures or dislocations), infections, hematomas (hemophilia, anticoagulant accidents). However, several studies have reported that anatomical variations may be related to the development of carpal tunnel syndrome (AVENEL et al, 2019).

The aim of this article is to carry out a literature review to elucidate the main anatomical variations related to the development of Carpal Tunnel Syndrome reported in studies.

METHODS

To prepare this literature review, searches were carried out in the SciELO and PubMed databases, using the descriptors "Carpal Tunnel Syndrome" and "Anatomic Variation" for the former, and in English "*Carpal Tunnel Syndrome*" and "*Anatomic Variation*" for the latter, respectively, all of which are present in DECS.

Only one article from 2022 was found in the SciELO database, which was selected. In PubMed, 12 papers were found, using the inclusion factor for the last 10 years, and 5 of them were discarded because they were not related to the proposed topic. Therefore, 8 papers were chosen.

RESULTS AND DISCUSSION

The anatomical variations of the carpal tunnel were classified by Singer and Asworth into type I, intrinsic - when found inside the carpal tunnel, and type II, extrinsic or extra carpal tunnel - when they cover the transverse carpal ligament. (PIMENTEL et al, 2022)

The most frequently reported in studies in relation to CTS, according to our research, were:

Bifid Median Nerve

- Transverse carpal muscle
- Persistent Median Artery

Anomalous Musculature

Linburg-Comstock anomaly

BIFID MEDIAN NERVE AND TRANSVERSE CARPAL MUSCLE

According to the results found by Pimentel et al, anatomical variations were found in 63.5% [95% CI 54.5-72.4%] of the 115 patients who underwent surgical treatment for CTS. The bifid median nerve was the most commonly reported intra carpal tunnel variation, and the transverse carpal muscle was the most commonly found extra carpal tunnel variation.

In the same study, it is reported that in the presence of an extra carpal tunnel anatomical variation such as the transverse carpal muscle, there is a probability of over 90% that the recurrent branch of the median nerve is anomalous (PIMENTEL et al, 2022).

The bifid median nerve is an anatomical variation within the carpal tunnel represented by a high bifurcation of the median nerve, proximal to the carpal tunnel. In 45% of cases, this anatomical variation can coexist with a persistent median artery.

Figure 1 - Bifid Median Nerve Associated with Persistent Median Artery

Source: (Pimentel *et al*, 2022)

The transverse carpal muscle is an extra carpal tunnel anatomical variation described as transverse muscle fibers that cover or interpose with the transverse carpal ligament (PIMENTEL et al, 2022).

PERSISTENT MEDIAN ARTERY

The persistent median artery (PMA) originates from the axillary artery, but generally involutes during embryogenesis around the 8th week of gestation, after differentiation of the ulnar and radial arteries. It can also regress later in life, in the neonatal period or in childhood (AVENEL et al, 2019).

However, it is important to know this variation, as the persistent artery of the median nerve can participate significantly in the vascularization of the hand. Accidental injury to this artery during wrist surgery can therefore lead to disabling clinical manifestations (AVENEL et al, 2019).

Most of the time asymptomatic, the presence of a persistent median nerve artery can be complicated by thrombosis, which is then responsible for a secondary Carpal Tunnel Syndrome. The clinical picture is compatible with pain in the median nerve at the level of the carpal tunnel, with paresthesias and dysesthesias in the median nerve territory. However, although the neurological symptoms are typical, the sudden onset, cold sensation and swelling should alert the clinician to perform imaging tests to check for vascular causes. (AVENEL et al, 2019)

Figure 2 - AMP Doppler ultrasound Color Doppler ultrasound of the arteries in the patient's upper limb. Highlighting the median nerve (black arrow) and a persistent artery of the median nerve, with thrombosis inside (white arrow).

Source: (Avenel et al, 2019).

The meta-analysis carried out by Bernard *et al*, revealed that PMA is commonly found in the general population and that the antebrachial pattern is much more prevalent (34.0%) than the palmar type (8.6%). He emphasized that there is not enough evidence to believe that the sole presence of PMA alone is a risk factor for developing CTS. What studies do suggest is that the relationship of the persistent median artery with phenomena such as thrombosis, aneurysm and/or calcification, which can lead to the development of Carpal Tunnel Syndrome.

The most frequent cause of PMA thrombosis reported is traumatic, whether from cycling, hyperextension, direct trauma, water polo or the use of a screwdriver (SOLEWSKI, 2021).

ANOMALOUS MUSCULATURE

Lumbrical muscles: an extension of the intratunnel insertion or an abnormal insertion on the flexor digitorum superficialis can be seen, possibly causing compression of the median nerve (DHAL et al, 2020).

Palmaris longus muscle: a variation of the palmaris longus muscle with an intratunnel tendon, called palmaris longus profundus, which inserts into the deep aspect of the palmar aponeurosis and can cause a constriction of the median nerve or a palmar muscle.

(CHAMMAS et al, 2014), the long palmar muscle in reverse position with intratunnel muscle bodies, called reverse long palmar, can also cause compression.

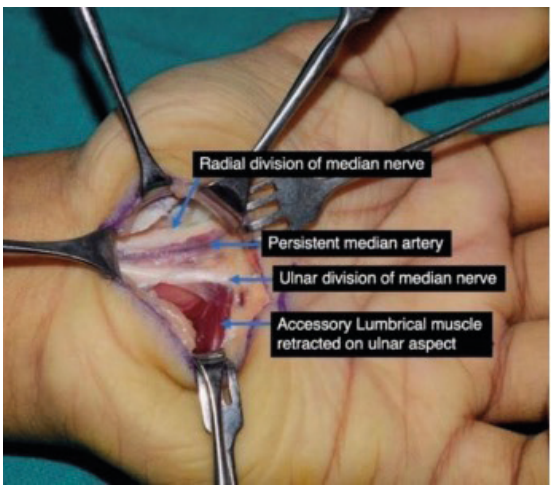

Figure 3 - Photograph of the case report by Dhal *et al of* a 15-year-old male adolescent with carpal tunnel syndrome and three anatomical variations

Source: (Dhal et al, 2020)

LINBURG-COMSTOCK ANOMALY (LAC)

The anomalous connection between the flexor pollicis longus (FLP) and flexor digitorum profundus (FPD) tendons was described by Linburg and Comstock (SILAWAL et al, 2018).

For the clinical diagnosis of CLA, we performed the two tests described by Linburg and Comstock in 1979. The first is a flexion test, investigating whether active flexion of the interphalangeal joint of the thumb causes concomitant flexion of one or more fingers, indicating a connection between the FPL and FDP tendons. (SILAWAL et al, 2018)

The second is a pain test, assessing pain in the distal and volar portion of the forearm and wrist when the examiner holds the index finger in extension and the patient actively flexes the interphalangeal joint of the thumb. (FERNANDES, 2021a)

Studies show that the prevalence of the anomaly was statistically higher in a group of women diagnosed with CTS than in a group of healthy female volunteers, however, the research carried out by Fernandes *et al*, showed that there is still not enough data to prove the relationship. (FERNANDES, 2021b)

It is believed that the relationship was made in other studies because the patient may present symptoms such as intermittent pain in the distal region of the forearm and wrist. Some authors have also reported the presence of symptoms such as numbness in the fingers, tingling and nocturnal pain. Anatomical anomalies in the carpal tunnel, such as persistent median artery, lumbrical and flexor tendon anomalies, have been associated with CTS. Therefore, considering these symptoms, a link was made. (FERNANDES, 2021b)

FINAL CONSIDERATIONS

Carpal Tunnel Syndrome can have various causes, and several studies have shown that anatomical variations can influence its development. However, of the five variations mentioned in this literature review, two have so far not been proven in studies with a satisfactory level of evidence, or it has been shown that there was no statistical difference between patients with the anatomical variation and those without it, as was the case with the Linburg-Comstock anomaly.

Only the presence of the Persistent Median Artery, which was asymptomatic and not affected by phenomena such as thrombosis, also proved to have no significant relationship with the occurrence of CTS.

Finally, the variations that studies have shown to be related to the syndrome, given that any condition that increases the volume of intracarpal structures or reduces the volume of the carpal tunnel can cause compression of the median nerve, were the bifid median nerve, transverse carpal muscle and anomalous musculature, such as variations of the palmaris longus muscle and the lumbricals.

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