

Critical Analysis of Diagnostic Means for Carpal Tunnel Syndrome

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Abstract

Carpal Tunnel Syndrome is the most common mononeuropathy. It is more prevalent in women. The median nerve is compressed into the osteofibrous tunnel formed by the bones that make up the carpus and ligament structures. The most common cause is idiopathic. A well-structured anamnesis with well-performed clinical examination has 80% specificity in the determination of the diagnosis. Well-performed physical examination should encompass motor assessment and sensitivity. In this case, it is important to perform the monofilament tests, two-point discrimination and the vibration with the tuning fork. Still on the physical examination, the provocative tests help to corroborate with the diagnosis. In more challenging cases or to measure the median nerve compression, we can make use of complementary exams such as Electromyography, Computed Tomography and Magnetic Resonance, each with its advantages and disadvantages.

Keywords: Carpal Tunnel, Magnetic Resonance Imaging, Ultrasonography, Tomography, Electromyography, Phalen, Tinel, Durkan

Introduction

Carpal Tunnel Syndrome is a symptomatic compressive neuropathy of the median nerve at the wrist (Graham et al., 2016). It is the most frequent mononeuropathy in the population, being more prevalent in women. Atroshi et al (1999) found a prevalence of 2.1% in men and 3.0% in women. About half of the cases are idiopathic, the other half are related to other pathologies such as diabetes, hypothyroidism and rheumatoid arthritis (Kerwin et al., 1996).

The carpal tunnel is an osteofibrous pathway on the palmar aspect of the wrist that connects the distal compartment of the forearm with the mid-palmar space of the hand. Its convex floor is made up of articulated carpal bones. The ulnar surface proximal by the pisiform bone and distal by the hook of the hamate; on the radial surface, proximal by the tubercle of the scaphoid bone and distal by the trapezium bone. Its roof is formed by the flexor retinaculum. (Wilson e Allen, 2012).

The width of the tunnel is about 20 millimeters at the level of the hook of the hamate, narrower in relation to its proximal end - 24 millimeters - and distal - 25 millimeters. Through it pass the tendons of the superficial and deep flexor muscles of the fingers and the tendon of the flexor pollicis longus muscle, in addition to the median nerve. (Ghasemi-Rad et al., 2014).

Typical symptoms of this syndrome are pain, burning or paresthesia in the wrist, hand, which may or may not radiate to the fingers, especially the thumb, second and third polydactyls. (Sucher e Schreiber, 2014). The pain is usually worse at night and more severe cases may present with muscle atrophy and weakness. (Deniz et al., 2012).

The diagnosis is fundamentally clinical and the complementary investigation is usually reserved for patients in whom the diagnosis is doubtful, but the need to carry out tests is still controversial. The complementary exams that are usually requested are Electromyography, Ultrasonography, Computed Tomography and Magnetic Resonance. (Calandrucchio e Thompson, 2018).

Anamnesis and physical examination

Obtaining a detailed history is important in the investigation of a suspected case of CTS. Asking the patient whether the symptoms are worse during the day or at night, which activities exacerbate the symptoms and which relieve the symptoms, support the formation of the hypothesis.

The symptomatology can be characterized in three evolutionary phases. At first, symptoms are more frequent at night, characterized as burning pain in the hands, which usually improves with shaking, shaking the symptomatic hand. In a second phase, the symptoms also appear during the day and can be felt during certain hand movements; in addition, the patient may complain of weakness in holding objects with the hand. In the last phase, there is hypotrophy or even atrophy of the muscles of the thenar region. (Alfonso et al., 2010).

In the physical examination, proper evaluation of the hand and wrist is the initial step to check for changes that could lead to a secondary cause. consists of motor and sensory assessment. (Gunnarsson et al., 1997).

The assessment of the musculature innervated by the median nerve should be performed carefully and may help to identify paresis or atrophy of the thenar musculature. The presence of this finding has a sensitivity of 4% to 28% and a specificity of 82% to 99%. (D'arcy e Mcgee, 2000a).

Sensitivity assessment should be performed using the Monofilament test, the two- point discrimination test and the vibration test with the 256 Hz tuning fork. These tests are commonly performed on the first three polydactyls of the symptomatic hand and compared with the asymptomatic side and have varied accuracy to aid in the diagnosis of CTS. (Macdermid e Wessel, 2004).

The test with the Semmes-Weinstein Monofilament is considered altered when the perception is only possible with a filament greater than 2.83. Sensitivity from 59% to 72% and specificity from 59% to 62%. The evaluation of two-point discrimination is positive when there is a distance greater than 4 to 6 millimeters in the digital pulps; sensitivity is from 6% to 32% and specificity from 64% to 99%. And the vibration test provides 55% sensitivity and 81% specificity. (D'arcy e Mcgee, 2000b; Macdermid e Wessel, 2004).

To complement the physical examination and corroborate the hypothesis raised, some provocative tests should be performed. The most commonly performed are: Phalen's test, Tinel's sign and Durkan's test. (Calandruccio e Thompson, 2018).

Phalen's Test

The Phalen's test consists of reproducing the symptoms with maximum wrist flexion for 60 seconds, with significant improvement after releasing the wrists. (Phalen, 1951). In an analysis of 80 wrists with a suspected diagnosis of CTS, Heller et al (1986) showed sensitivity and specificity of 67% and 59%, respectively.

Tinel's sign

Tinel's sign consists of percussion of the median nerve under the transverse carpal ligament and causes a sensation of paresthesia in the hand. Originally, it was described as a sensation of paresthesia that occurred in the proximal stump of an injured nerve, suggesting axonal regeneration. (Bruske et al., 2002).

It is not known for sure when it started to be used as a provocative test in the evaluation of carpal tunnel syndrome (Kuschner et al., 1992). Heller et al (1986) showed sensitivity and specificity for Tinel's sign, respectively 60 and 77%.

Durkan's sign

Durkan's test consists of compression of the carpal tunnel at wrist level for at least 30 seconds. In his work, Durkan (1991) evaluated 31 patients with idiopathic carpal tunnel syndrome from January 1987 to October 1990, totaling 40 hands at the end. Symptoms appeared on average 16 seconds after the start of compression.

Electrodiagnostic Study

Electrodiagnostic studies have been used for diagnostic confirmation after clinical suspicion and also to assess the severity of mononeuropathy (Sucher and Schreiber, 2014). The examination can be performed using different techniques, and there is no consensus on which would be the best approach.

The evaluations recommended by the American Academy of Neurology, American Association of Electrodiagnostic Medicine and American Academy of Physical Medicine and Rehabilitation are study of sensory conduction of the median nerve through the wrist with a conduction distance of 13 to 14 centimeters and motor conduction of the median nerve in the musculature thenar and another nerve in the symptomatic meter to measure distal latency (Jablecki et al., 2002). The analysis of latencies and waveforms obtained should be analyzed together with the findings of the clinical examination.

According to EMG findings, Carpal Tunnel Syndrome can be graded as Mild, Moderate or Severe. (El Habashy et al., 2017).

The study of sensory conduction should be performed from the wrist to the second or third polydactyls and, in the presence of abnormality, it should be carried out from the palmar region to the second or third polydactyls. (Jablecki et al., 2002). The reduction in conduction in the segment from the wrist in relation to the palmar region suggests compression of the median nerve at the level of the carpus. (Sucher and Schreiber, 2014). To corroborate the findings in the electrophysiological assessment, the needle study allows confirming the presence of denervation in cases of muscle atrophy observed in the clinical examination. This study provides subsidies to carry out the differential diagnosis with radiculopathy. (Jablecki et al., 2002; Kutlar et al., 2017).

In addition, the identification of fibrillations and positive sharp waves makes it possible to determine the evolution of CTS over time. These alterations express axonal damage and corroborate the chronicity of the condition. (Sucher and Schreiber, 2014).

Ultrasonography

Ultrasound for the diagnosis of Carpal Tunnel Syndrome allows the evaluation of the median nerve, structures in the carpal tunnel, the behavior of the nerve during finger and wrist movement as well as neural and perineural changes due to changes in echogenicity (Wilson and Allen, 2012).

The evaluation can be divided into static and dynamic. In the first, measurements of the sectional area of the median nerve (in the transverse plane) are performed at the level of the wrist and distal forearm. At the wrist level, the measurement can be performed at the entrance to the median nerve in the carpal tunnel (pisiform bone level) or at its exit (hamate hamulus level) with better accuracy in the first case. And, in the dynamic study, the movement of the median nerve in the carpal tunnel and its relationship with neighboring structures during movement is observed (Torres-Costoso et al., 2018).

Normal values for the cross-sectional area of the nerve at the level of the pisiform bone vary in the literature. Ziswiler et al. (2005) propose the value of 10 mm² as a cut-off point for the diagnosis of carpal tunnel syndrome, with sensitivity and specificity of 82% and 87%, respectively.

Another measurement performed is the cross-sectional area of the median nerve between the flexor digitorum superficialis and flexor digitorum profundus muscles, approximately 4 to 12 cm distally in the forearm. This measurement can be used to verify the relationship between the median nerve cross-sectional area in the wrist and forearm or the difference between the value of this area in the forearm and in the carpus. Values for the ratio between the areas greater than 1.5 and the difference greater than 2 mm² corroborate the diagnosis of carpal tunnel syndrome (Ulasli et al., 2013).

Majid et al (2017) in a case-control study with 124 patients without carpal tunnel syndrome and 77 with the pathology, confirmed by an alteration in the electromyography exam, obtained a sensitivity of 83.12% and specificity of 100% with cross-sectional area of the median nerve at wrist level of 10 mm².

In the dynamic evaluation, it is possible to observe the behavior of the median nerve with the tunnel structures. Normally, the nerve moves freely in this region (Deniz et al., 2012). Nanno et al. (2017) found that, in patients with carpal tunnel syndrome, this movement is reduced and, after a decompression surgical procedure, nerve mobility improves in a statistically significant way, in relation to preoperative measures.

Due to its high specificity, some authors propose it as a first-line test in the diagnosis of carpal tunnel syndrome (Torres-Costoso et al., 2018).

Simple Radiography and Computed Tomography

The simple radiography has a limited role in the evaluation of carpal tunnel syndrome. It does not show muscle, ligament and nerve structures, but it can be useful in cases where there has been a fracture of the hand bones, bone stenosis or soft tissue calcification (Wilson and Allen, 2012; Calandruccio and Thompson, 2018).

In these situations, Computed Tomography (CT) is positioned as a better alternative. May demonstrate bony structures taking up space in the carpal tunnel. However, visualization of median nerve compression is clear in cases where some bony structure compresses the nerve. In idiopathic cases, for example, this phenomenon is not so evident (Ghasemi-Rad et al., 2014).

To perform the CT, the patient can lie down with the hand positioned over the head or sit with the fist close to the end of the device (Wilson and Allen, 2012). In this exam, the cross-sectional area of the median nerve is evaluated and the density measured in Hounsfield is analyzed. The normal density of the median nerve can range from 40 to 50 Hounsfield (John et al., 1983).

Nerve cross-sectional area varies, whether measured at the entrance or exit of the carpal tunnel, with the most distal measurement being the most accurate. The average value is 0.12mm². The sensitivity and specificity of the method are 67.6% and 86.7% respectively (Deniz et al., 2012).

Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) allows a good assessment of soft tissues as well as bone structures. Three Tesla devices with a specific coil for the wrist make it possible to obtain better quality images. Images must be obtained in coronal, axial and sagittal planes, and volumetric reconstructions, in T1 and T2 weights. Normally, paramagnetic contrast medium is not injected (Wilson and Allen, 2012).

The median nerve is typically isointense on axial T1-weighted images and isointense or slightly hyperintense to adjacent musculature on axial T2-weighted images with Short Tau Inversion Recovery and fat suppressed spin echo. In the case of carpal tunnel syndrome, the nerve has an abnormal increase in T2 hypersignal. In addition, there may be signs of denervation of the regional musculature, supporting the hypothesis of neuropathy (Thawait et al., 2012).

MRI helps to identify secondary causes, even in patients initially diagnosed as idiopathic. In an evaluation of 69 wrists of 55 patients diagnosed with carpal tunnel syndrome, magnetic resonance imaging detected a secondary cause in 63.3% of patients with CTS graded as moderate by EMG and in 36.7% of patients with severe CTS (Onen et al., 2015). Deniz et al. (2012) obtained sensitivity and specificity of 65% and 80%, respectively.

Another possibility allowed by MRI is the microstructure analysis using the Diffusion Tensor Imaging technique, acronym in English DTI. A study carried out at the University of Rome used this modality to compare the degree of impairment of patients with carpal tunnel syndrome with EMG findings. (Brienza et al., 2014)

Despite the image quality, there are some important considerations to note. Not all services have the device; the examination is time-consuming and must rely on the patient's cooperation. Some patients cannot tolerate the study due to claustrophobia and others simply cannot undergo the exam because they have devices that are incompatible with MRI (Martins et al., 2008; Deniz et al., 2012; Ghasemi-Rad et al., 2014).

Discussion

The diagnosis of idiopathic carpal tunnel syndrome is essentially clinical. Gunnarsson et al (1997) followed 100 patients with suspected carpal tunnel syndrome for 16 months; each patient was evaluated by two independent experienced hand surgeons and they came to the conclusion that only the clinical examination (history and physical examination) had a specificity of 80%.

A well performed anamnesis, together with a detailed physical examination, with evaluation of the thenar muscles, together with provocative tests and a detailed sensory evaluation with the monofilament test, tuning fork and two-point discrimination. Studies have analyzed the combination of accuracy of all tests performed together, however, they have not been able to demonstrate superiority in relation to each performed separately. (Durkan, 1991; D'arcy and Mcgee, 2000b; Macdermid and Wessel, 2004).

Phalen's test, Tinel's sign, and Durkan's test all vary in sensitivity and specificity for diagnosing carpal tunnel syndrome. Regarding the Phalen test, Bruske et al (2002) evaluated 147 wrists and obtained sensitivity and specificity of 85% and 89%. In the same study, evaluating Tinel's sign, the respective sensitivity and specificity values are lower: 67% and 68%. In the Durkan test, the scenario improves, the sensitivity and specificity obtained by Durkan (1991) were 87% and 90%, respectively. Even so, none of them, in isolation, has all the qualities necessary to close the diagnosis and dictate the conduct. (Wiesman et al., 2003).

In addition, the differences found in the values may be related to the difference between the groups of patients evaluated, different stages of the disease at the time of the examination, as well as other confounding factors. (Sears et al., 2017).

In this context, complementary exams play a relevant role in cases where the diagnosis is not very clear, and also allow the grading of the condition and assist in the conduct, whether conservative or surgical, as in the case of the electromyographic study. (Deniz et al., 2012; Wilson and Allen, 2012; Sucher and Schreiber, 2014; Calandruccio and Thompson, 2018).

The most commonly requested test is EMG. In a survey conducted by the American Society for Surgery of the Hand, about 70% of the members of this society request the exam before performing the surgical procedure (Munns and Awan, 2015). The method has variable sensitivity and specificity from 49 to 84% and 95 to 99%, respectively. (Graham et al., 2016). Despite high specificity, if there are some fast conducting fibers, nerve function remains intact and this generates a significant false negative value, as raised by Gunnarsson et al. (1997) of 13%.

Electrodiagnostic study showed good accuracy when compared to other methods such as Ultrasonography (Visser et al., 2008), Computed Tomography (Deniz et al., 2012) and Magnetic Resonance Imaging (Martins et al., 2008) for the diagnosis of carpal tunnel syndrome.

The complementary exams present some advantages or disadvantages between them. The Electrodiagnostic study is the most invasive method among them. Many patients complain of discomfort during the examination. (Jablecki et al., 2002), and the exam time and intensity influence the greater discomfort and pain during the exam. Ultrasound is examiner and device quality dependent. In the case of CT, its main disadvantage is radiation. MRI, on the other hand, is a test that is not widely available and is the most expensive test for diagnosing carpal tunnel syndrome. (Deniz et al., 2012; Calandruccio and Thompson, 2018).

Bearing in mind that most cases of carpal tunnel syndrome are idiopathic and that performing a detailed anamnesis with a detailed physical examination allows the diagnosis, the choice of the complementary exam must take into account the availability of the method and what is the purpose for performing the test. Electrodiagnostic shows good specificity in the studies, in addition to allowing the grading of the clinical picture. Its use together with the concomitant performance of Ultrasound - if available - may help in doubtful cases. Pelossi et al. 2021, suggests the combination of these two complementary exams for the best diagnosis of carpal tunnel syndrome. In situations where a better assessment of bone structures is necessary, CT can be performed. MRI, in turn, can be used for more challenging cases or when a more detailed assessment of the soft tissues adjacent to the tunnel is desired.

Conclusion

The combination of a good anamnesis, with a very detailed history of the symptoms, and a detailed physical examination, with a detailed assessment of sensitivity, motricity and added to provocative tests, present good accuracy in the diagnosis of Carpal Tunnel Syndrome. Complementary tests help in the diagnosis, especially in doubtful cases and should be chosen depending on the purpose.

Conflict of Interest

We have no conflict of interest.

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