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The Role of Ultrasonography Compared to Nerve Conduction Velocity in Diagnosis of Median Nerve Entrapment: Review Article

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ABSTRACT

Background: A lot of studies investigated the role of sonography and nerve conduction velocity for diagnosis of median nerve pathology. The data were examined to draw conclusions on the clinical performance of ultrasound as a screening tool to replace electrophysiological studies and to propose further and future study. There is a lot of opportunity for clinical screening in the region of the carpal tunnel where the median nerve has its largest cross-section. Further analysis is required to determine whether nerve swelling can be detected using comparison measures and doppler methods. **Objective:** To assess the accuracy of ultrasonography and nerve conduction velocity in diagnosing median nerve entrapment. **Data Sources:** Medline databases (PubMed, Medscape, ScienceDirect. EMF-Portal) and all materials available in the Internet till 2023. **Conclusion:** In confirming a diagnosis of carpal tunnel syndrome (CTS), nerve conduction studies (NCS) is more sensitive than US. Due to US's strong positive predictive value, one can think of utilizing it as a screening test instead of NCS in the majority of cases when there is clinical suspicion of CTS. NCS would then only be used in cases where US is negative.

Keywords: Median nerve mononeuropathy, Carpal tunnel syndrome, Ultrasound, Nerve conduction velocity.

INTRODUCTION

Carpal tunnel syndrome (CTS) is one of the commonest entrapment neuropathies estimating for 90% of all compressive, manifests with sensory symptoms in the hands, such as pain, tingling or paralysis, where the median nerve is distributed. When compared to men, women are more likely to experience it, and the peak occurrence occurs between the ages of 40 and 60 years. Despite the fact that carpal tunnel syndrome is mostly idiopathic, a number of variables have been linked to it, including smoking, skeletal deformity, hypo functioning thyroid, metabolic disorders, inflammatory arthritis, diabetes mellitus, pregnancy, using corticosteroids, oestrogen administration and amyloidosis **(1)**.

The diagnosis of median nerve entrapment is built on clinical demonstration and imaging method like ultrasound. Ultrasound is becoming more popular for determining the anatomical characteristics of the median nerve, such as its echogenic nature and size, because it is a non-invasive and easily accessible technology with several benefits **(2)**.

The majority of the time, nerve conduction velocity is used to confirm the diagnosis, even though there is no one set method for diagnosing CTS. We are aware that using NCS has some limitations. Nonetheless, given the importance of NCS in detecting coexisting neurologic illnesses, providing unbiased support for the diagnosis of CTS, and helping to disprove negligence claims in situations of unsuccessful surgery, we feel it to be a credible reference standard. The median nerve and local compressive causes are not morphologically covered by nerve conduction study, despite the fact that it gives significant information on median nerve function **(3)**.

Ultrasound Assessment of CTS:

Currently, fascicles, the epineurium, and the perineurium of nerves, as well as their surrounding components, may be accurately reproduced by ultrasound **(4)**.

The median nerve's cross-sectional area in the proximal carpal tunnel is the most frequently reported ultrasonography measure used to diagnose carpal tunnel syndrome because it is the most easily observable. An evidence-based guideline determined that there was strong evidence to support a diagnosis of CTS when the median nerve cross-sectional area at the wrist was measured. Also, it was proposed in this recommendation that ultrasound, which can identify structural irregularities, is valuable in complementing electrophysiological testing in the assessment of carpal tunnel syndrome **(5)**. In addition to the severity of the condition, other factors influencing diagnosis accuracy and cutoff values include the size of the nerves in relation to a person's height, sex, weight, age, race, and visual acuity. Contrary to popular belief, there hasn't been enough research done on how age, sex, and race affect nerve size **(6)**.

Ultrasound parameters for CTS diagnosis:

Differences in calibre, including hourglass-shaped constrictions of the nerve under the flexor retinaculum related to distal thinning and proximal expansion of the median nerve **(7)**. Considering that the cross-sectional range of the typical median nerve is between 6.1 and 10.4 mm^2, nerve measure of 12 mm^2 provides 99% sensitivity in detecting carpal tunnel syndrome **(8)**.

The ideal threshold for those who have bifid median nerves is 12 mm^2, which is calculated by adding the cross-sectional areas of both branches of the bifid

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median nerve. Increased nerve size and decreased conduction velocity are correlated linearly. Between two and eighteen months following surgical discharge, the cross-sectional area returns to normal [9].

Doppler can assess intraneural hyperemia brought on by squeezed median nerve together with clogged epineural and endoneural veins, inflammation and vascular problems [10].

Regrettably, 20% of patients with early-stage illness have normal ultrasound results. If the median nerve exhibits a substantial expansion, measurement of the maximum cross-sectional area acquired merely at level of carpal tunnel may be enough. The accuracy of the diagnosis is increased when a variety of ultrasound findings are combined with substantial nerve hypertrophy. A perineural scarring (an uneven hypo echogenicity surrounding the nerve) or even an incomplete release of the flexor retinaculum can be found with ultrasound in cases of clinical recurrence following surgery. Moreover, dynamic testing may reveal a restricted range of nerve mobility due to granulation tissue formation between the nerve and other tissues [7, 11].

Nerve Conduction Studies (NCS):

Due to its ability to reveal physiological data regarding the median nerve over the carpal tunnel, NCS is regarded as the gold standard in the diagnosis of CTS. The fundamental approach involves comparing latency and amplitude of the median nerve segment passing via the carpal tunnel to various nerves, like the radial and ulnar nerves, which pass outside the carpal tunnel. An action potential is produced in the nerve by a transcutaneous electrical pulse that activates it. A recording electrode is positioned to capture the depolarization wave that passes by the electrode surface. This method is the most sensitive and accurate, with high specificity and sensitivity [12].

Many variables affect a diagnostic test's sensitivity and specificity. The patient population can have a significant impact on a diagnostic test's accuracy, with high prevalence groups artificially inflating the test's sensitivity and specificity. A stringent definition, such as thenar eminence atrophy, will reduce sensitivity, whereas a loose definition, such as hand pain or numbness, will increase sensitivity [13].

Last but not least, the cut-off values for a positive diagnosis might differ significantly and have a significant impact on sensitivity and specificity. One can improve the sensitivity of the exam by setting the distal motor and/or sensory latency cut-offs lower. One can improve the specificity of the exam by selecting a greater value [13].

Common elements impacting nerve conduction studies:

In routine practice, a variety of technological and physiological factors may influence waveforms and produce false results. To guarantee the best outcomes, constant attention to detail and a systematic technique are required. **The NCS may be affected by the following elements [14-15]:**

Temperature:

The cold limb is one of the most frequent issues encountered in the electrodiagnostic lab and can impact both the nerve conduction study and needle electrode assessment. At lower limb temperatures, changes such as larger amplitudes, longer durations, lengthened latencies, and decreased conduction velocities are observed. Cold temperatures physiologically cause sodium channels to open more slowly and to take longer to deactivate. The first influences the speed of nerve conduction, whereas the second causes higher amplitudes [14, 15].

Age:

There is a decline in amplitude that is documented with each decade, notably beyond age of 60 years. For sensory responses in the distal lower extremities, this is very clear [16].

Height:

Taller people exhibits slower conduction velocities and longer latencies, which is probably due to their longer limbs and their more distal limbs being colder [15].

Body habitus:

Higher BMI individuals had reduced sensory nerve action potentials (SNAP) in the nerves of the upper limbs but not the lower limbs [17].

Sex:

Compared to men, women have larger amplitudes and faster conduction speeds. The former can be explained by height, but it is not evident why the amplitude is higher [18].

The following parameters were used to classify the intensity of CTS as minor, intermediate or severe [19]:

- **Minor:** longer than average sensory distal delay. Axon loss is not demonstrated.
- **Intermediate:** motor and sensory distal delay that is protracted. There is no sign of axon loss.
- **Severe:** Any of the abovementioned NCS anomalies that show signs of axonal loss, as indicated via one of the following: a missing or low-amplitude SNAP or a low-amplitude or deficient thenar CMAP.

The following parameters were used to identify carpal tunnel syndrome in patients with diabetic neuropathy [20]:

1. The median nerve's distal motor delay was longer than the ulnar nerve's by a ratio larger than 1.5.
2. The median nerve's distal sensory delay was more than 1.2 times longer than the ulnar nerve.
3. The median SNAP to ulnar SNAP amplitude ratio was less than 0.6.
4. The median sensory nerve showed a difference in latency from wrist to palm that was higher than the delay from palm-to-finger.

Individuals were identified as having diabetic neuropathy and carpal tunnel syndrome if the NCS findings met two out of the four aforementioned requirements [20].

Lowering the likelihood of a false positive or false negative by using two comparison procedures that are in agreement (either pathological or normal) [21].

It is uncommon to require additional nerve conduction studies if the initial comparative nerve conduction studies on the affected side are normal. Despite not being necessary to identify carpal tunnel syndrome, nerve conduction studies in the limb with no or minor symptoms are predicated on clinical value. Further testing on a larger scale is likely to be beneficial if a systemic issue like polyneuropathy is suspected. Electrodiagnostic studies have some limitations. The most prevalent unfavorable limitation is that patients will experience pain and discomfort. It happens as a result of the test's electric stimulation. It is, however, just temporary and only for the duration of the study. Some individuals, especially those who had a past experience with the test, are unable to withstand the electric stimulation [22].

Case 1

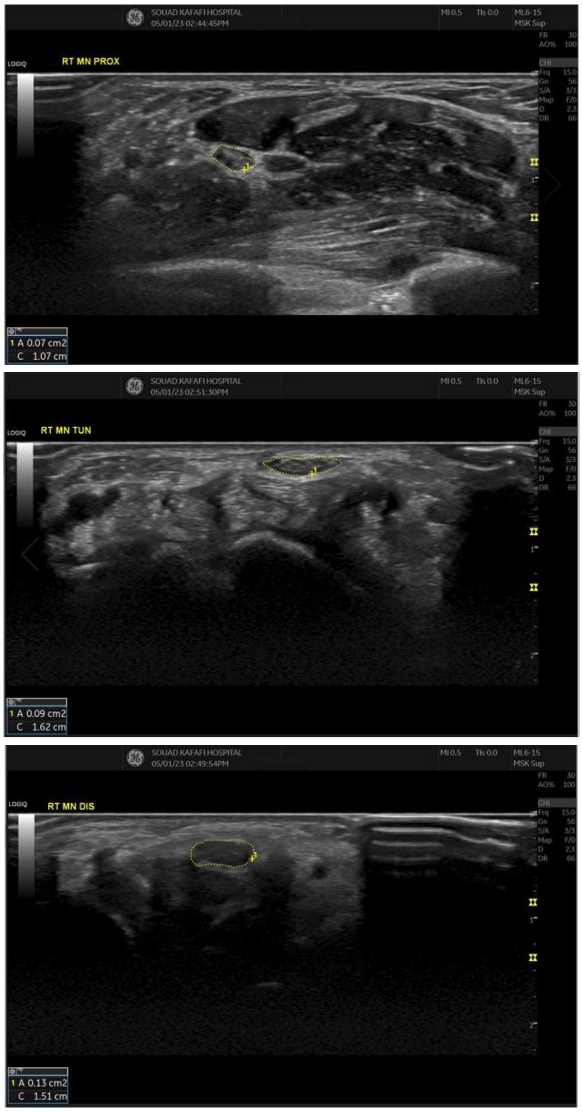

Figure (1): A case of 45 years old female patient complaining of severe numbness and pain (awakening patient from sleep), aggravated by effort diagnosed with moderate median nerve entrapment at wrist by nerve conduction study. There was increased cross sectional area at the tunnel region reaching up to 13 mm² on ultrasound assessment.

Case 2

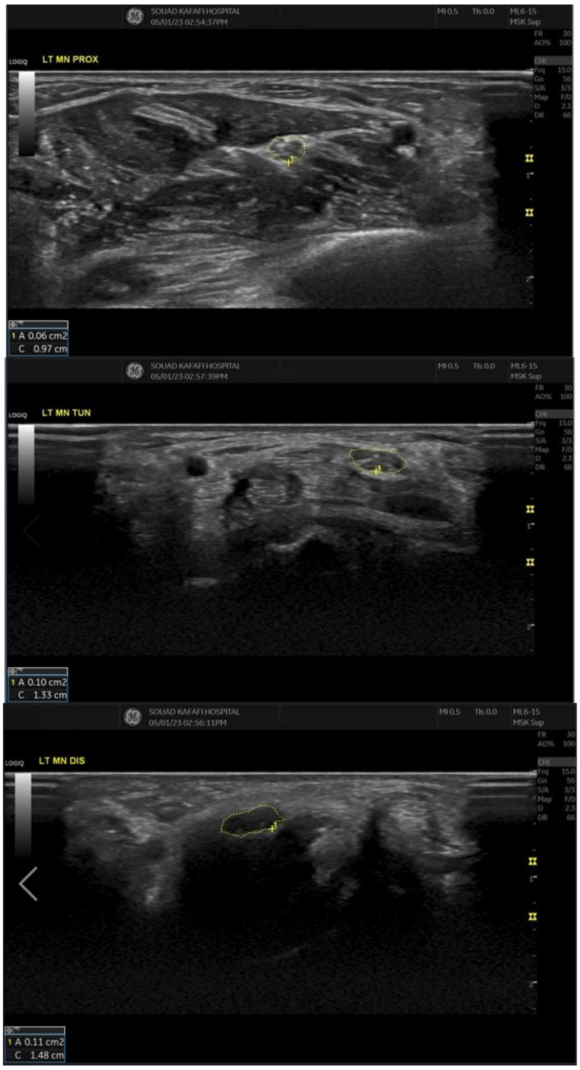

Figure (2): A case of 47years old female patient complaining of numbness, inability to move hand especially at night diagnosed with mild median nerve entrapment at wrist by nerve conduction study. There was increased cross sectional area at the tunnel region reaching up to 11 mm² on ultrasound assessment.

SUMMARY

A successful approach for diagnosing and classifying carpal tunnel syndrome is ultrasound because it is widely accessible, affordable, and real-time. Higher cross sectional area (CSA) of the median nerve on ultrasonography has been related to CTS in the majority of investigations. Unlike NCS, ultrasound can detect thickening and flattening of the median nerve but cannot assess the physiological state of the nerve [23].

According to several research, the spectrum of standard levels may be influenced by many biological and demographic characteristics, such as handedness, body mass index, and male gender. The issue is still up for debate, however, as a study of well-matched case controls revealed no connection between the biometric modalities of the participants and medial nerve CSA at the forearm and wrist [24].

CSA is the primary ultrasonographic parameter utilized in the identification of CTS, according to a new survey by **El-Shintenawy and colleagues** [25].

From the pathophysiological perspective, MN entrapment in the wrist results in impaired nerve perfusion, which leads to nerve edema. With disease progression, this edema may result in fibrosis, MN swelling, and increase CSA, essentially at the proximal distal radio-ulnar joint or tunnel inlet [26].

The relationship between skin pressure and median nerve strain was examined. Despite the fact that ultrasonic strain monitoring is now commonplace and confirmed, it is still unknown how much pressure should be applied to the skin's surface. Although manual compression was employed in many earlier research, there may have been variations in the displacement due to various pressure levels and tissue depths [27].

According to research by **Kantarci *et al.*** [28] **and Orman *et al.*** [29], CTS patients have a tougher median nerve than people without the disorder. The nerve trunk becomes edematous or fibrotic as a result of chronic nerve compression, therefore the median nerve's hardness may be a reflection of these pathologic alterations [27].

Similar to ultrasonography, nerve conduction study and electromyography use a variety of parameters to determine whether a patient has CTS. The NCS measuring criteria include sensory amplitude, distal motor latency (DML), sensory conduction velocity (SCV), and distal sensory latency (DSL) [30].

El-Shintenawy *et al.* [25] reported that high sensitivity and accuracy were seen while utilizing SCV as the diagnostic marker, with a cut-off of ≤50. (94.6% and 89.5%, respectively).

According to reported data, ultrasonography diagnoses CTS more quickly than nerve conduction studies. The ability of ultrasound to complete CTS assessments for each patient in under 90 seconds was demonstrated through a learning curve for roughly 20 patients. Yet, even when carried out by skilled specialists, electrodiagnostic tests are anticipated to take around 30 minutes [31].

Electrodiagnostic procedures, including electromyography, are uncomfortable and painful for the patient. Nonetheless, the discomforts associated with electrodiagnostic testing are frequently disregarded [30].

Some studies, particularly those involving individuals with typical CTS, have advised ultrasonography as the initial diagnostic technique. The CSA of the median nerve is crucial because, as was previously mentioned, there is a connection between CTS and an increase in its CSA. Nevertheless, electrodiagnostic testing may be employed for individuals with unusual symptoms associated with illnesses including cervical radiculopathies [32].

CONCLUSION

When diagnosing median nerve entrapment syndrome in the carpal tunnel, high-resolution ultrasound testing is a successful, satisfying method. Its accessibility, low cost, and lack of time commitment make it an excellent choice for the first investigation in determining the cause of median nerve entrapment syndrome. Moreover, sonography is a dynamic study, which is a benefit. Operator dependence persists, though.

In clinical practice, nerve conduction investigations continue to be the gold standard modality for the identification of CTS, particularly when switching from conservative treatment to surgical release is required. Its utility as a method to track the evolution of median nerve neuropathy through follow-up investigations and its role in screening individuals suspected of having CTS, may be constrained by its somewhat invasive nature and lack of anatomical and etiological information.

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