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Original research article

FORENSIC IMPLICATIONS OF CARPAL TUNNEL SYNDROME IN RELATION TO RADIOLOGICAL AND ORHOPEDITION

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Abstract: *Carpal tunnel syndrome (CTS) is a common peripheral neuropathy with significant clinical and forensic implications. The condition is characterized by compression of the median nerve within the carpal tunnel, leading to pain, tingling, and functional impairment. Accurate diagnosis is crucial not only for clinical management but also for forensic evaluations, especially in cases of occupational claims and medico-legal disputes.* ***Objective:*** *The purpose of this research is to investigate the forensic consequences of carpal tunnel syndrome regarding radiographic and ophthalmic examinations.* ***Methods:*** *This prospective study included 180 individuals, aged 18 to 65 years, of both genders. This study was conducted at the Department of Forensic Medicine LUMHS from January 2023 to June 2023. Group I comprised 90 patients diagnosed with CTS, while Group II included 90 individuals without CTS, serving as controls. Demographic data, including age, sex, and BMI, were recorded. CTS was confirmed using ultrasonographic and other diagnostic modalities. The cross-sectional area of the carpal tunnel at the pisiform (CSAp) and the carpal tunnel at the hook of the hamate (CSAc) was measured. Delta CSA was calculated as the difference between CSAc and CSAp. Sensitivity and specificity for CTS diagnosis were evaluated. Statistical analysis was performed using SPSS Version 26.0.* ***Results:*** *The study found a predominance of females in both groups, with 63 (70%) females in Group I and 58 (64.4%) in Group II. The mean age in Group I was 47.34 ± 8.58 years with a mean BMI of 25.13 ± 10.49 kg/m², while Group II had a mean age of 49.53 ± 12.74 years and a BMI of 26.34 ± 11.61 kg/m². Group I demonstrated significantly higher CSAc values (18.5 ± 3.35 mm²) compared to Group II (9.8 ± 7.25 mm²; p < 0.004). The delta CSA was also higher in Group I (7.37 ± 8.32 mm²) compared to Group II (1.3 ± 2.13 mm²; p < 0.005). The CSAp values showed no significant differences between groups (Group I: 9.4 ± 3.6 mm²; Group II: 7.12 ± 9.6 mm²). A delta CSA threshold of 2 mm² demonstrated high diagnostic accuracy, yielding a sensitivity of 99.1% and specificity of 100% for Group I wrists.* ***Conclusion:*** *Delta CSA is a highly reliable parameter for diagnosing CTS, surpassing CSAc in accuracy. Advanced ultrasonographic techniques, including high-frequency probes and enhanced power Doppler imaging, represent the gold standard for CTS diagnosis, providing robust evidence for both clinical and forensic applications.*

Keywords: Ultrasonography, CSA, Wrists, Carpel Tunnel Syndrome (CTS), Specificity, Sensitivity.

Introduction

Many people suffer from common hand ailments, including carpal tunnel syndrome (CTS) (1). Some of the several potential causes of carpal tunnel syndrome include idiopathic discomfort, oral contraceptives, pregnancy, arthritis, collagen-vascular issues, diabetes, hypothyroidism, diabetes mellitus, and repetitive motion employment or hobbies. The probability of median nerve compression in the carpal tunnel is increased by the tunnel's diameter and by any surrounding factors that could cause it to be smaller. One theory is that a smaller carpal tunnel raises the risk of getting idiopathic carpal tunnel syndrome, which is more frequent in women (2). Anatomically, there are two potential sites of median nerve compression: the hook of the hamate and the proximal margin of the carpal tunnel. Because the forearm facia and the proximal section of the flexor retinaculum are thicker and more rigidly packed, the fluid pressure in the carpal tunnel varies as the wrist moves (3).

Depending on the industry, carpal tunnel syndrome can affect anywhere from one percent of the population to five percent of workers (4). It is also well-known that jobs involving heavy lifting or repetitive motion are a common cause of CTS [2]. Acromegaly, hypothyroidism, diabetes mellitus, rheumatoid arthritis, Colles fracture, amyloidosis, and hypothyroidism are some conditions that might present with CTS (5).

Classical symptoms and indicators such as the Phalen sign (dysesthesia following wrist flexion) and clinical Tinel sign (percussion across the median nerve provokes dysesthesia) are often used in the diagnosis of carpal tunnel syndrome (CTS), along with imaging scans and nerve conduction studies (NCS). The gold standard for diagnosing CTS at this time is a battery of neuropsychological tests that look for abnormalities in median nerve function in addition to the patient's reported symptoms. Despite this, there is strong evidence that NCS can produce both false-negative and false-positive results, and the clinical symptoms only have modest sensitivity and specificity (6).

Several imaging modalities have been studied for the aim of diagnosing CTS, including sonography and magnetic resonance imaging (MRI). Although both imaging

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techniques may assess structures around the MN, their specificity and sensitivity have been shown to vary greatly among studies (7). The equipment needed for magnetic resonance imaging (MRI) is also not universally accessible, and the exam itself can be somewhat expensive. Therefore, magnetic resonance imaging (MRI) might not be the best initial assessment for suspected CTS.

When symptoms manifest, the American Academy of Orthopedic Surgeons (AAOS) reports seeing compressive neuropathy of the medial nerve at the wrist. For some, crushing MN causes a tingling or numbness in the tips of their fingers. On the other hand, CTS has no effect on the palm since it does not impact the sensitive cutaneous branch of the median nerve (PCBMN). The TCL branch is untouched by these changes in CT internal pressure as it exits approximately 6 cm before the TCL. (8) Additionally, the most prevalent diagnosis in patients suffering pain and numbness is idiopathic CTS, which appears as a tingling sensation along the MN distribution in the hands. (9) The actual etiology of this ailment is still unknown, even though it is well known. The latest findings in biomechanics, magnetic resonance imaging (MRI), and histology point to the neural vasculature, flexor tendons, and synovial tissue as the root causes of chronic traumatic stress syndrome (CTS). Work cited (10, 11) Bony arches formed by the carpal bones resemble tunnels in shape; these arches are concave on the palmar side and reverse convex on the dorsal side. The carpal tunnel is generated when the arched flexor retinaculum (FR) attaches to the osseous groove known as the sulcus carpi. (12)

Patients diagnosed with scaphoid-pisiform CTS have CSAs. We aimed to improve CTS diagnostic accuracy by adding a second cross-sectional measurement of the median nerve that was placed closer to the pronator quadratus muscle.

Methodology

This prospective study was conducted at the Department of Forensic Medicine LUMHS from January 2023 to June 2023 and comprised 180 cases with 210 wrists. Following the receipt of the patient's written consent that was informed, the patient's demographic information, which included the patient's age, gender, and body mass index, was gathered. Patients who were excluded from the study were those who were suffering from a serious medical condition and those who did not provide any verbal or written consent. A wide range of ages, from 18 to 65 years old, were represented among the patients. Two distinct groups of patients were separated from one another. In group I, 90 people were diagnosed with cerebral palsy, and in group II, 90 individuals were not diagnosed with CTS. Patients were required to undergo ultrasonography as well as ultradiagnostic testing to arrive at a diagnosis of CTS. Every wrist's delta CSA was calculated by subtracting the CSAc from the CSAp after the carpal tunnel and proximal regions of the median nerve's CSA had been evaluated. After comparing the two groups' wrists' sensitivity and specificity, a choice was made based on the findings. It was determined that SPSS version 26 was used to analyze the whole data set.

Results

There were majority females 63 (70%) in group I with 110 wrists and 58 (64.4%) females in group II with 100 wrists among all cases. The mean age of the cases in group I was 47.34±8.58 years with a mean BMI of 25.13±10.49 kg/m2 and in group II age was 49.53±12.74 years with a mean BMI of 26.34±11.61 kg/m2. (table 1)

Table 1: Demographics of the enrolled cases

Variables	Group I (90)	Group II (90)
Gender		
Male	27 (30%)	32 (35.6%)
Female	63 (70%)	58 (64.4%)
Wrists		
Left	60	58
Right	50	42
Mean age (years)	47.34±8.58	49.53±12.74
Mean BMI (kg/m^2)	25.13±10.49	26.34±11.61

We found higher CSAc in patients of group I 18.5±3.35 mm2 as compared to group II 9.8±7.25 mm2 with p-value <0.004. There was lower delta CSA among patients of group II 1.3±2.13 mm2 as compared to group I 7.37±8.32 mm2 with p-value <0.005. The difference in CSAp was insignificant among wrists of both groups I&II 9.4±3.6 and 7.12±9.6 mm2.(table 2)

Table 2: Statistical analysis of nerve parameters in the two sets

Variables	Group I	Group II	P Value
CSAc	18.5±3.35	9.8±7.25	<0.004
delta CSA	7.37±8.32	1.3±2.13	<0.005
CSAp	9.4±3.6	7.12±9.6	0.000

For group I wrists, a delta-CSA threshold of 2 mm2 yielded a sensitivity of 99.1% and a specificity of 100%; for group II, the corresponding figures were 94.1% and 97%, respectively.(figure-1)

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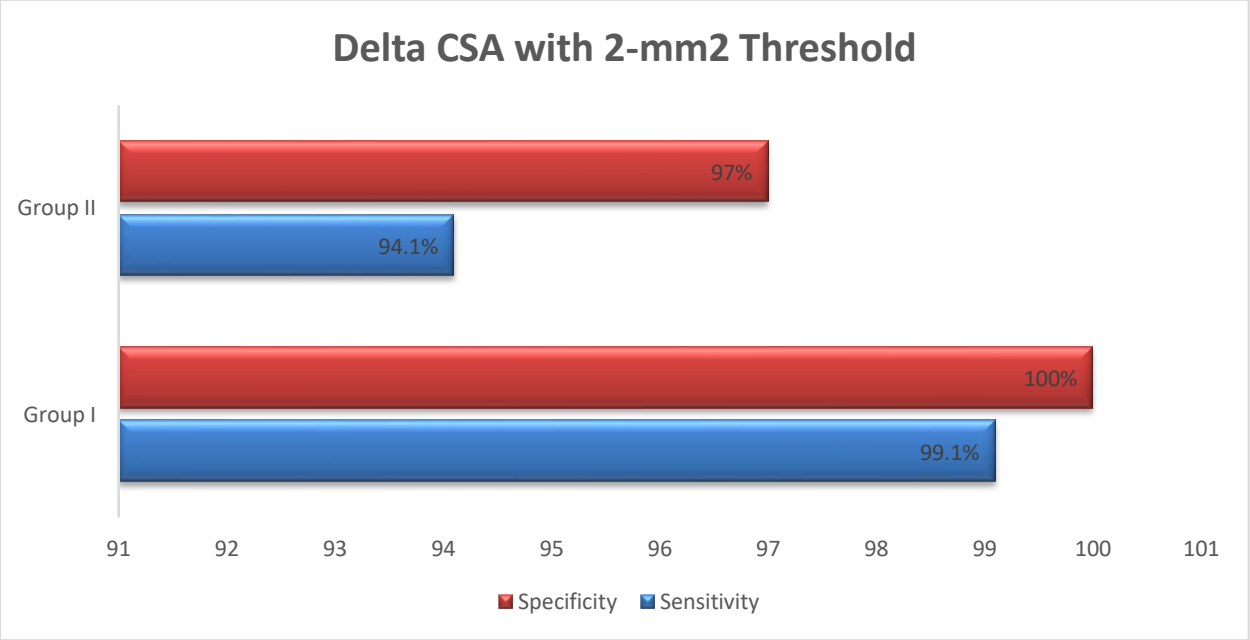

Figure 1: Sensitivity and specificity of nerve assessments in the detection of CTS in the two datasets

Discussion

Based on common clinical signs and symptoms, electrodiagnostic testing may usually confirm a diagnosis of CTS. (13) The development of idiopathic CTS is influenced by many variables. The flexion-extension motion of the fingers or wrist causes mechanical stress on the sub-synovial connective tissue, which is thought to be a major contributor to carpal tunnel syndrome (14). Presumptive narrowing of the carpal tunnels due to natural causes is another potential risk factor. Other studies (15, 16) found no statistically significant changes in carpal tunnel cross-sectional area between healthy controls and patients with idiopathic CTS.

In the current study, there were majority females 63 (70%) in group I with 110 wrists and 58 (64.4%) females in group II with 100 wrists among all cases. Results were comparable to the previous studies. (17, 18) The bones of the wrist and the ligaments that run across the palms of the hand form the carpal tunnel. (19) For patients suspected of having CTS, Yoshi Y et al. (20) proposed a methodology that would involve an initial US examination and further electrodiagnostic testing only in cases where the results of the US examination were negative. The use of ultrasonography allows for the detection of ganglia and fibromatous lesions, which are space-occupying and cause CTS symptoms, as well as an increased median nerve circumferential region in individuals with CTS. (21) We found higher CSAc in patients of group I 18.5±3.35 mm2 as compared to group II 9.8±7.25 mm2 with p-value <0.004. There was lower delta CSA among patients of group II 1.3±2.13 mm2 as compared to group I 7.37±8.32 mm2 with p-value <0.005. The difference in CSAp was insignificant among wrists of both groups I&II 9.4±3.6 and 7.12±9.6 mm2. These were similar to what was found in the earlier research. (12) The US diagnosis of CTS was shown to be quite accurate based on our study. Future strategies should incorporate clinical examinations with ultrasonography since it is less intrusive than electrodiagnostic testing.

The optimal test threshold for diagnosing CTS is a delta CSA of 2 mm2 or above. Our CSA metric performs far better than the CSAc when it comes to CTS. Wrists in Group I were 99.1% sensitive and 100% specific at a delta-CSA threshold of 2 mm2, while wrists in Group II were 94.1% and 97%, respectively. Potentially helpful metrics include the transverse carpal ligament bulge, median nerve flattening ratio, median nerve mobility, and median nerve echogenicity. This study aimed to analyze a newly published American approach for measuring median nerve size rather than concentrating on these traits, which offer important information for CTS diagnosis. This method has garnered a lot of interest in the research literature. In addition to this, we were unable to demonstrate a connection between the thickness of the median nerve and either body mass index (BMI) or hand physiognomies, both of which can be associated with small or big wrists, respectively. (22) "The" In conclusion, but certainly not least, the operator is responsible for ensuring that the US test is reliable and can be replicated. Within the scope of this study, neither the inter-observer nor the intra-observer variability was explored. The fact that we included a wide range of sickness severity levels in the design of our study contributed to the fact that it was more robust. According to the findings of the research, patients with moderate to severe chronic shortness of breath showed signs of improvement after receiving delta CSA. Carpal tunnel syndrome (CTS) is characterized by a painful, numb, or tingling feeling in the hand as well as other symptoms, including compression of the median nerve (MNS), one of the most common forms of compression injuries. CTS occurs when the median nerve is pinched or compressed as it travels through the wrist.

Through this literature review, a comprehensive overview of chronic traumatic stress disorder (CTS) has been

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provided, covering topics such as its stages, diagnostic criteria, prospective therapy, epidemiology, and risk factors. The median nerve can cause complete or partial paralysis of the muscles that it supplies with its supply of blood when the wrist joint is injured and the lesion heals, therefore entrapping and squeezing the nerve. As a consequence of this, the range of motion of the fingers is restricted, which results in an unexpectedly high degree of variance.

Conclusion

The CSA is superior to the CSAc in terms of accuracy in diagnosing CTS. Diagnostic ultrasound using high-frequency probes and enhanced power Doppler technology seems to be the gold standard for CTS.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate.
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The authors declared an absence of conflict of interest.

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Concept & Design of Study

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