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ORIGINAL ARTICLE

Diagnostic Utility of the Sonographic Median to Ulnar Nerve Cross-Sectional Area Ratio in Carpal Tunnel Syndrome

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Abstract

Background: ***Carpal tunnel syndrome (CTS)is a prevalent ailment where the median nerve in the wrist is compressed, producing 90% of cases of nerve entrapment.***

Aim and objectives: ***To ascertain the diagnostic utility of the ultrasonographic (US) ratio among the cross-sectional area of the ulnar nerve (u-CSA) and the median nerve (m-CSA) at the carpal tunnel inlet's pisiform bone in CTS.***

Patients and methods: ***In the current research, 20 cases of manifestations of CTS were presented to the neurology department of Al-Hussein University Hospital. At the start of January 2023 & the conclusion of June 2023, 20 healthy controls were enlisted. Between the patients & the healthy control group, a comparison was made.***

Results: ***Contrasting the CTS group to the control group, Variation in the median/ulnar cross-sectional area ratio (m-CSA/u-CSA) and m-CSA varied significantly. We determined the cut-off points for the m-CSA and m-CSA/u-CSA ratios to be 11.25 mm2 and 3.15 mm2, respectively, based on the coefficient of variation (ROC) curve and Youden's index.***

Conclusion: ***CTS can be diagnosed by measuring the m-CSA to u-CSA ratio.***

Keywords: carpal tunnel syndrome; ulnar nerve; ultrasound; median nerve; median nerve entrapment

1. Introduction

CTS represents ninety per cent of entrapment neuropathies, a frequent compressible neuropathy affecting the midline nerve in the vicinity of the wrist. It affects roughly 3.8% of people in general. It peaks between 40 and 60 years old and is more prevalent in women.[1]

Tingling, weakness, or hyperesthesia, also called over the median nerve, which innervates the digits, are usually the first clinical signs investigated in patients. It's likely that with prolonged wrist flexion or extension, symptoms will appear or worsen at night. Provocative examinations, including the Phalen and Tinel tests, may be done to look for mildly irritable neuropathic indications. In severe cases, the appearance of transverse muscle weakness may be apparent.[2]

Conversely, individuals with mild cases could have hazy signs or less distinct clinical indicators. Consequently, a nerve conduction study (NCS) offers further, unbiased support as a diagnostic factor for CTS. Motor and Sensory NCSs of the median nerve can provide an excellent sensitivity rate (>62%) and great specificity rate (98%), corresponding to The American Association of Electrodiagnostic and Neuromuscular Medicine's summary statement of electrodiagnostic investigations of CTS.[3]

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Updated research indicated a 75% sensitivity rate may be obtained with an NCS based on onset latency and a short segment.[4]

Nonetheless, these results suggest that clinical evidence of CTS still has a significant proportion of false negatives (10-25%).[5]

So, to get a fair look at the configuration of the median nerve, imaging methods like magnetic resonance imaging (MRI) and US at the wrist level of the nerve were generated.[6]

Compared with NCSs, imaging examinations are less uncomfortable and more capable of identifying structural issues inside the carpal tunnel. Due to its mobility and affordability, the US outshines MRI. Also, the US can lead future interventional treatment options, be dynamic in its evaluation, and be faster than other methods of injections into the median nerve or carpal tunnel.[7]

The study aimed to determine the diagnostic value of the m-CSA and u-CSA ratios on an ultrasonogram of the pisiform bone at the carpal tunnel entrance to diagnose CTS.

2. Patients and methods

In our study, 20 patients presented with manifestations of CTS to the Neurology Department of Al-Hussein University Hospital, and 20 healthy controls were enlisted between the start of January 2023 and the conclusion of June 2023. A comparison was made between the patients and the healthy control group.

We included individuals with electrophysiological studies confirming the diagnosis of CTS, ages 18 to 70. We excluded cases with a history of upper extremity trauma, fractures, surgeries, or steroid injections; individuals who have undergone CTS treatment in the past, whether it was surgical or nonsurgical, such as through splints, physical therapy, or steroid injections; those with specific anatomical abnormalities, Examples of conditions that may contribute to CTS include anatomical variations involving an abnormal persistent median artery, Martin-Gruber, a bifid median nerve, or any other kind of anastomosis. Additionally, individuals with neurological disorders that can impair hand function, for example, mononeuropathies, cervical radiculopathy, polyneuropathy, or cerebrovascular events, are at risk. Those with systemic diseases associated with CTS, such as bifid joint diseases, hypothyroidism, acromegaly, type 2 diabetes, chronic renal failure, or those who have undergone certain types of surgery, are also susceptible. Lastly, pregnant women are another group that may experience CTS. Two sets of participants were created: a case group (20 participants) consisting of unexplained CTS cases and a control group (20 participants) composed of healthy individuals who match in age and sex but do not exhibit any clinical indications or symptoms of CTS.

The following data were collected: Age, gender, height, and weight information for each participant's demographics. After documenting the clinical complaints, all patients in the case group had physical examinations, including motor and sensory assessments and Tinel-Phalen tests. Every participant had their ultrasound measurements taken. The pisiform bone was used as an indication to measure the m-CSA & u-CSA at the proximal intake of the carpal tunnel.

The Ethics Unit of Al-Azhar University's Faculty of Medicine granted the Board of Institutional Review permission to conduct this research by the Helsinki Declarations.

STATISTICAL ANALYSIS

To evaluate the statistical significance, we used Microsoft Office Excel 2016 in conjunction with the SPSS (Statistical Package for the Social Sciences) tool, version 25.0 (IBM Inc., Chicago, USA). The data was checked for normal distribution using the Kolmogorov-Smirnov test. Each parameter in the groups that were studied was subjected to descriptive statistics. For qualitative data, percentages and numbers were used as representation. The mean±standard deviation (SD) was used to describe quantitative parametric data. To determine the variation among the qualitative variables, the Chi-square test ($x2$) was used. If the anticipated cell count was below 5, the Fischer exact check was applied. The numerical variables were compared using the independent t-test where the data were normally distributed, and the Mann-Whitney U test when the data weren't.

Using receiver operating characteristic (ROC) curves, the diagnostic importance of the ratios m-CSA and m-CSA/u-CSA has been evaluated at the proximal entrance of the carpal tunnel. We assessed the specificity, sensitivity, negative and positive predictive values, and m-CSA/u-CSA ratios to find out how well they might diagnose CTS. We used ROC curves and Youden's index—the product of sensitivity and specificity minus one—to determine the cut-off values.

We used Spearman correlation coefficients to examine how the demographic information of the controls and people with CTS related to the CSA measurements taken by ultrasonography of the median nerve. The results were assessed at a significance level of 5%.

3. Results

Table 1. CTS demographics and comparison groupings

DEMOGRAPHIC DATA	TOTAL (N= 40)	CONTROL (N = 20)	CASE (N = 20)	STATISTICAL TEST
GENDER N (%)				Fisher's Exact Test
MALE	5 (12.5 %)	3 (15 %)	2 (10 %)	$X^2 = 0.577$ P-value =
FEMALE	35 (87.5 %)	17 (85 %)	18(90 %)	0.704 n.s.
AGE (YEARS)				t-test
(MEAN ± SD)	38.85 ± 10.16	37.4 ± 10.82	40.3 ± 9.42	t = 1.11 P-value = 0.273
MED. (MIN-MAX)	40 (18 - 59)	34.5 (19 - 59)	40 (18 - 55)	n.s.
BMI				Mann-Whitney U
(MEAN ± SD)	28.1 ± 6.61	28.43 ± 7.78	27.77 ± 5.3	Value = 410.5
MED. (MIN-MAX)	26.5 (19 - 46)	25 (19 - 45)	27 (21 - 46)	p-value = 0.557 n.s.

Regarding demographic data, no significant distinction was stated amongst the control & CTS groups concerning gender, age & BMI index (P > 0.05).

Table 2. In both the control groups and CTS, the mean measures of the u-CSA, m-CSA, and m-CSA/u-CSA

	CONTROL (N = 20)	CASE (N = 20)	STATISTICAL TEST
M-CSA (MM^2)			Mann-Whitney U
(MEAN ± SD)	9.04 ± 1.23	14.53 ± 4.04	Value = 12.0 p-value <
MED. (MIN-MAX)	9 (7.5 - 11)	13 (10 - 26)	0.001***
U-CSA (MM^2)			Mann-Whitney U
(MEAN ± SD)	3.42 ± 0.54	3.65 ± 0.52	Value = 362.0 p-value = 0.186
MED. (MIN-MAX)	3.5 (2.5 - 4.5)	3.5 (2.8 - 5)	n.s.
M-CSA/U-CSA			Mann-Whitney U Value = 23.0
(MEAN ± SD)	2.68 ± 0.36	4.02 ± 1.17	P-value < 0.001***
MED. (MIN-MAX)	2.67 (2.0 – 3.33)	3.7 (3 – 7.88)	

In comparison to the control group, the CTS group exhibited significantly larger m-CSA and m-CSA/u-CSA (P < 0.001 for both groups). The m-CSA was determined to have a cut-off point of 11.25 mm2, while the m-CSA/u-CSA ratio had a cut-off point of 3.15. These values were decided based on the analysis of the ROC curve and Youden's index.

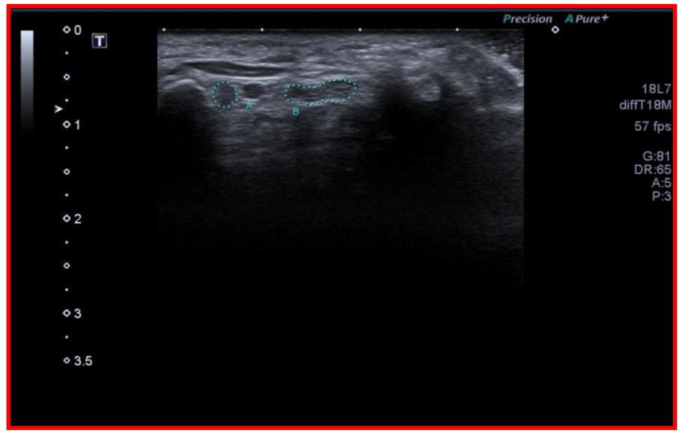

Figure 1. A picture taken of the ulnar and median nerves near the pisiform bone using ultrasound technology. Median nerve (B) and ulnar nerve (A).

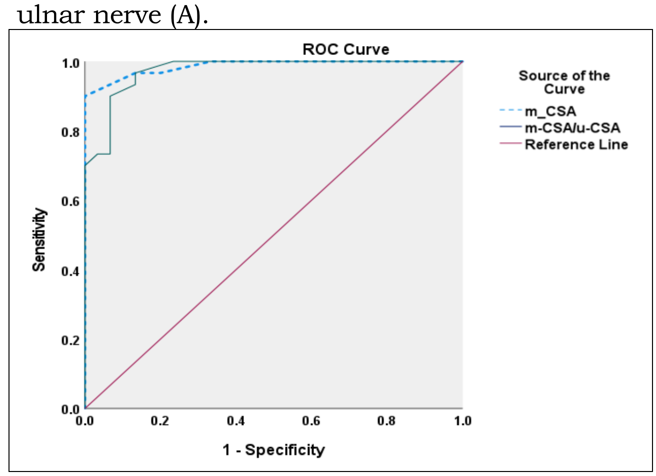

Figure 2. The m-CSA Roc curves

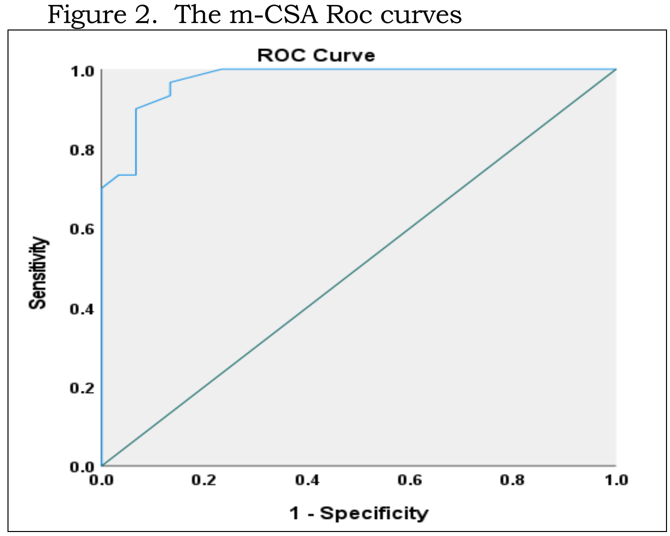

Figure 3. The m-CSA Roc curves.

Between m-CSA and age and BMI, significant correlations were observed in all subjects (CI were 0.277 and 0.439, respectively; P = 0.032 and P < 0.001). In control subjects, m-CSA exhibited a significant association with age and BMI (correlation values of 0.909 and 0.399, correspondingly; P = 0.029 and P < 0.001, correspondingly).

The m-CSA/u-CSA and u-CSA displayed significant high correlations (correlation values of 0.363 and 0.675, correspondingly; P = 0.049 and P < 0.001, correspondingly).

4. Discussion

Signs and symptoms, a physical exam, and an electrodiagnostic evaluation are utilized to diagnose CTS. Nerve conduction and Electromyography investigations are essential for confirming the CTS diagnosis, assessing the illness's severity, and ruling out other anomalies. Nevertheless, this evaluation is costly, time-consuming, and somewhat intrusive. Furthermore, it omits details regarding the structure of the carpal tunnel and the development of CTS.[8]

The assessment of the CSA of the median nerve at various carpal tunnel levels is the most widely utilized ultrasonographic examination for the purpose of diagnosing CTS. Recently, the assessment of peripheral nerves has included quantitative measures, including fascicular ratio and nerve density.[9]

The current study used ultrasound on the surface of the pisiform bone at the opening of the carpal tunnel to find the ratio of the m-CSA to the u-CSA to diagnose CTS.

The included patients were split into two groups to test our hypothesis: the case group consisted of idiopathic CTS patients, and the control group comprised individuals in good health who were age- and sex-matched. Still, it did not exhibit any clinical indications or symptoms of CTS. At the Al-Azhar University Hospital's ENMG Laboratory, patients underwent electrophysiological evaluations. The median and ulnar nerves' CSA measurements were taken utilizing the US device's manual trace program within the hyperechogenic annulus surrounding the wrist's nerve.

The current study's results showed that there was no discernible variance in gender, age, or BMI index amongst the CTS groups and control (P > 0.05).

Consistent with our findings, Atan et al. found that the two groups' body mass index (BMI), height, weight, sex, and age did not significantly differ from one another (The values of P were 0.637, 0.646, 0.504, 0.944, and 0.785, correspondingly.).[10]

Although Chang et al. revealed that while gender, marital status, age, smoking habit, dominant hand, and educational attainment did not substantially differ amongst the CTS cases and the healthy volunteers, the BMI of the CTS patients was considerably higher (P = 0.01) than that of the healthy volunteers. [11]

In line with our results, El-Bahnasawy et al. showed statistically insignificant changes in BMI, gender, and age.[8]

The present research findings revealed that the CTS group exhibited significantly advanced m-CSA and u-CSA levels compared to the control group (both P values < 0.001).

The research carried out by El-Bahnasawy et al. shown that, in comparison to both the CTS group that had been diagnosed and the control group of healthy volunteers, the ICTS group had noticeably bigger m-CSA (p < 0.001) and a higher m-CSA:u-CSA ratio (p < 0.001). [8]

In addition, Atan et al. found that the CTS group had significantly increased CSA assessments of The median nerve had an increased CSA a larger ratio of m-CSA to u-CSA at the level of the pisiform bone, in comparison to the control group. The p-value was less than 0.001 for both comparisons.[10] According to Jiwa et al. [9]

According to the findings, persons with ICTS exhibited a significantly larger m-CSA pisiform than the control group (Yurdakul et al., 2016).12

The m-CSA:u-CSA ratio was significantly greater in CTS individuals than in controls. This outcome is consistent with the discoveries made by Yurdakul et al. .[12]

To evaluate the accuracy of the m-CSA and m-CSA/u-CSA ratios at the entrance of the carpal tunnel, the study used ROC curves. The m-CSA/u-CSA ratio (100% CI: 0.94-1.0) and the m-CSA (95% CI: 0.965-1.0) both had UAC (area under the curve) values of 0.987 and 0.974, respectively. Those are two figures that indicate outstanding curve performance. A value of 11.25 mm2 was shown to be the optimal m-CSA threshold using the ROC curve. An m-CSA/u-CSA ratio of 3.15 was determined to be the cutoff.

The results are in agreement with those of El-Bahnasawy et al., who used ROC curves to assess the diagnostic utility of m-CSA and the m-CSA/u-CSA ratio for CTS case detection. The area under the curve (AUC) for the m-CSA was 0.897 (95% CI 0.862-0.939) and for the m-CSA/u-CSA ratio, it was 0.792 (95% CI 0.716-0.868).[8]

Furthermore, Atan et al. found that the area under the curve (AUC) for the m-CSA ratio was 0.83 (95% CI: 0.75-0.91) and for the m-CSA/u-CSA ratio was 0.89 (95% CI: 0.83-0.95). The m-CSA/u-CSA ratio was set at 2.95, and the m-CSA cut-off point was 11.95 mm.[10]

Jiwa et al. investigated using a sonographic m-CSA/u-CSA ratio to diagnose CTS. They discovered that when the cut-point was set at a value higher than 2.09, the sensitivity and specificity of the test were 86% and 84%, respectively. [9]

The findings of the present investigation revealed substantial correlations (with correlation values of 0.277 and 0.439, respectively; P = 0.032 and P < 0.001) among m-CSA, age, and BMI in all subjects.

To conclude, CTS can be confirmed by evaluating m-CSA at the pisiform bone level and using the m-CSA/u-CSA ratio. When comparing the CTS group to the control group, the m-CSA, u-CSA, and m-CSA/u-CSA measurements demonstrated significantly higher specificity and sensitivity for CTS diagnosis. You can also use the US to find the (m-CSA) to (u-CSA) ratio, which is another way to diagnose CTS.

5. *Conclusion*

The ratio of m-CSA to u-CSA can be used to diagnose CTS. When compared to the control group, the CTS group's m-CSA and m-CSA/u-CSA showed much better specificity and sensitivity for CTS diagnosis. There is an other approach for diagnosing CTS that may be used, which is US.

Disclosure

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Conflicts of interest

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