RESEARCH ARTICLE

Ultrasonic and Electrophysiological Evaluation of Carpal Tunnel Syndrome in Diabetic and Non-diabetic Subjects

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Received: 05th April, 2023; Revised: 10th May, 2023; Accepted: 02th June, 2023; Available Online: 25th June, 2023

ABSTRACT

Background: Carpal tunnel syndrome (CTS) is the most prevalent upper-limb entrapped neuropathy. A nerve conduction study (NCS) is the simplest method for identifying CTS when combined with a satisfactory clinical assessment and physical assessment. Ultrasound is a beneficial non-traumatic screening approach for CTS and there is a relationship between the NCS tests and the measures of CSA by ultrasound.

Objective: to assess whether or not sonographic observations of the median nerve seems to be varied amongst DM and non-DM CTS individual.

Patients and methods: The total of 50 non-DM Individuals with CTS and 50 DM individuals with CTS have been included in this study. All individuals were submitted to full medical assessment NCS testing the hands and sonogram US for assessment of cross-sectional area CSA and wrist forearm ratio (WFR).

Results: Total 100 affected wrists with CTS are classified as 30 (60.0%) wrists with mild disease, 11 (22.0%) wrists that demonstrated moderate disease and 9 (18.0%) wrists had a severe disease in diabetic CTS patients and 23 (46.0%) wrist mild disease, 20 (40.0%)wrist show moderate disease, 7 (14.0%) wrist had a severe disease in non-diabetic CTS patient. The mean of the median nerve CSA was (0.14+0.03), (0.15+0.04) in diabetic and non-diabetic CTS individuals, respectively with no significant difference between the two groups. In contrast, the wrist-forearm ratio demonstrates a significant difference between the two groups.

Conclusion: The CSA of the median nerve is greater in CTS wrists through both DM and non-DM individuals with no significant difference. The mean wrist-forearm ratio was less in diabetic patients than in non-diabetic with a significant difference. Pairing NCS with US imaging gives effective assessment methods for the CTS hands in individuals with and without diabetes.

Keywords: Carpal- tunnel syndrome, Diabetes mellitus, Wrist forearm ratio, Electrophysiological and ultrasonography.

International Journal of Drug Delivery Technology (2023); DOI: 10.25258/ijddt.13.2.09

How to cite this article: Shalal NM, Hasan AE, Hasan SMS. Ultrasonic and Electrophysiological Evaluation of Carpal Tunnel Syndrome in Diabetic and Non-diabetic Subjects. International Journal of Drug Delivery Technology. 2023;13(2):510-515.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most prevalent type of median nerve neuropathy and about 90% of neuropathies. It involves (4–5%) of people, mainly between the age range of (40–60 years.). The incidence is bigger overall for females (9.2%) than it does for males (6%) seen between the ages of 45–60 years old. And most occurrences of CTS are unexplained (idiopathic). CTS is usually attributable to a tissue thickening of the synovial flexor sheath and hand motions that are repeated. Various factors were identified to be related with CTS, including physical and occupational concerns.[1] In comparison to non–DM individuals, DM individuals had a less favorable result. Such results indicated that nerve-damaging internal factors could induce CTS in DM individuals, like increased glucose.[2]

The general manner of testing contrasts the latency and amplitude of a median nerve section that travels the CT *versus* the latency and amplitude of a nerve section that would not transit the CT like the radial or ulnar nerve accurate technique.[3] The electrophysiological grading is in compliance with the American Academy of electrophysiological medicine (AAEM) rules, following the neurophysiological evolution of CTS degree and comprises the access level:

- Negative CTS: Standard result including all studies (such as comparative as well as segmental investigations)
- Minimal CTS: Irregular results limited by comparative or segmental testing

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- Mild CTS: SCV attenuated throughout the finger-wrist region with acceptable DML. Moderate CTS: SCV delayed in the finger-wrist region with higher DML
- Severe CTS: Impairment of sensation reaction in the finger-wrist region with higher DML
- Extreme CTS: Elimination of thenar motor reaction.[4]
- Ultrasound elastography is a simple and rapid technique and characterized by its effectiveness and accessibility. It has been recommended as a supplemental technique in the diagnosis of CTS.[5] In a hyperglycemic condition, the neuron and surrounding Schwann cells accumulate intracellular sorbitol due to excess glucose metabolism. In the end, this causes axonal degeneration and segmental demyelination of the nerve, rendering it more susceptible to compaction with a minimum threshold for developing (CTS).[6]

Aim of Study

To assess whether or not sonographic observations of the median nerve seems to be varied amongst DM and non-DM CTS individual.

METHODOLOGY

A case-control study conducted at Al-Shaheed Ghazi Al-Hariri teaching hospital, Baghdad, in the period from November 2021 to March 2022 included 50 individuals who had CTS with diabetes and 50 individuals who had carpal tunnel syndrome without diabetic referred from the neurosurgery and orthopedic departments. Verbal permission was collected from all patients; an electrodiagnostic study was performed for all included hands, and ultrasound was used to measure the median nerves CSA and WFR. All patients have a clinical diagnosis of CTS lasting a minimum of one month. Subjects were divided into two sets according to the status of DM (50) DM individuals (class I) (mean age 47.14+12.21 years) and (50) non-DM individuals (class II), (Mean age 45.7+11.65 years)

Inclusion Criteria

Patients with diabetic and non-diabetic referred as have the following criteria:

- Numbness, aberrant sensation, or discomfort on the three radially parts of a hand finger and half of the fourth finger (first, second and third finger, with radial half of the ring finger)
- Throughout the dominating region of the palm, the median nerve is numb. numbness throughout the night or swelling of the hand in the morning;
- increase tingling and shaking of the hands
- bunion on the palm muscle decrease
- atrophy of muscle.

Exclusion criteria

- Wrist trauma
- Cervical radiculopathy
- Connective tissue diseases
- Rheumatoid arthritis
- Thyroid disease

Pathological CTS was established. in accordance with the guidelines of the American Academy of Neurology. All patients had a complete history taking, a complete physical examination, and a neurological evaluation, including:[7]

- Paraesthesia, discomfort produced or increased by sleepiness, prolonged wrist or arms posture, or repeated activity of the hand or wrist that is lower by either a variation in attitude or by trembling of the hand
- Sensory deficiency in median nerve transmission;
- Motor deficiency of median-nerve to thenar muscle tissue; and
- Stimulating exam gets positive for (CTS) (Tinel sign, Phalen test).

Electrodiagnostic Study

NCS detected patients with CTS by assessing the sensorimotor fibers of both the median and ulnar nerves and recording abnormal median nerve conduction parameters. We examined the median sensory nerve action potential's amplitude, latency, and sensory conduction velocity. The median nerve motor amplitude, distal motor latency, and motor conduction velocity were assessed using established methods of supramaximal dermal excitation and external electrodes. The study cutoff points or normal values for our investigation would be as regards:[1] median nerve (DSL), the maximum normal value of 3.5 milliseconds;[2] (DML), over the thenar, the maximum normal value of 4.4 milliseconds; and[3] median nerve (MCV), the lower normal value of 40 m/s median nerve (SCV), the lower normal value is 40 m/s as per.[8]

Electromyography (EMG) was performed on the patients to rule out any concomitant diseases. During a patient examination, the room temperature was maintained between (25–28°C) and the temperature of the skin was monitored between (36–37°C) using a thermometer.

Ultra-sonographic Imaging Analysis

All patients were subjected to a sonographic evaluation of their carpal tunnel-affected hands. The US examination was conducted using HD11XE Philips 2009 and a US unit coupled with a linear probe (10–12 MHz frequency). The computed tomographic assessment was performed same time or within consecutive times following the electrophysiological examination. The grayscale US was used to assess the median nerve in the transverse segment through the CT. The patient was at the setting position, with his hand open and elbow simi-flexed on the coach, and the examination was performed in a transverse direction. The median nerve's upper normal CSA limit was applied at the pisiform bone level (10 mm^2).[9] To quantify the WFR, the CSA was assessed (12 cm) adjacent to the pronator quadratus muscle (PQ). The CSA was assessed by unlimited access recording of the median nerve and the hyperechoic epineurium using an on-board dimension. The WFR was then evaluated.[10]

Statistical Analysis

The Statistical Package for Social Sciences (SPSS/PC/VER 23) was used. Statistical tools: mean, standard deviation, median,

Table 1: Comparing demographic information of CTS patients between diabetic and non-diabetic

Parameter		*CTS+DM (N=50)*	*CTS (N=50)*	*p-value**
Age (yr.)	Mean ± SD	47.14+12.21	45.7+11.65	0.548
	Median (Range)	46 (30-71)	44 (24-66)	
BMI (kg/m^2)	Mean ± SD	29.8+4.84	27.82+3.46	0.021
	Median (Range)	28.33 (22.4-38.54)	27.34 (23.19-35.14)	
HbA1c %	Mean ± SD	8.4+1.62	5.15+0.38	<0.001
	Median (Range)	8.5 (6-12.5)	5.2 (4.3-5.9)	
Duration (yr.)	Mean ± SD	7.55+5.37	---	
	Median (Range)	6 (1-20)	---	
		N (%)	N (%)	*p-value***
Gender	Male	9 (18.0)	15 (30.0)	0.241
	Female	41 (82.0)	35 (70.0)	
Hand	Right	49 (98.0)	45 (90.0)	0.204
	Left	1 (2.0)	5 (10.0)	

**p-value* by unpaired T-test, ***p-value* by Fisher exact test B.M.I: Body Mass Index

and range were computed. Assessment of significances: Fisher exact test and chi-square test were applied to assess the disparity in the pattern of occurrences within the various divisions. An unpaired t-test was assessed to measure the variations in repeated measures across sets. Pearson's correlation coefficient got found for parametric elements. *p-value* was ≤.05 regarded as the level of significance.

RESULT

The mean age of the patients (47.14+12.21 years) was slightly higher than that of controls (45.7+11.65 years) with no significant difference. The distribution of gender was comparable among the two groups with no significant differences with female predominance. Likewise, patients and controls had comparable BMI with significant differences (<0.021). There were 50 CTS hands in patients with DM, of which 49 (98.0%) were right hands and 1(2.0%) were left hands. On the other hand, there were 45 right hands (90%) and 5 left hands (10%) in CTS without DM with no significant difference. The HBA1C median was (8.5 (6–12.5) in diabetic CTS and (5.2 (4.3-5.9) in CTS non-diabetic with a significant difference (Table 1).

Electrophysiological Parameters

Considering the (NCS) of the median n., there was a significant variation between the two classes in the distal sensory amplitude (DSA), although no severity variation was seen between the 2 categories (Table 2).

Ultrasound Parameters

Cross section area (CSA) of The median n. was greater in both non-DM CTS hands and DM CTS hands, but there was no statistically significant variation in between the two sets. While wrist forearm ratio showed a significant difference between the two groups, the mean was 1.8+0.3 (range = 1.5–2.8) and 2.07+0.53 (range = 1.5–3.2) in diabetic CTS and non-diabetic CTS, respectively. (Table 3)

Correlation between (CSA) of the Median N. with other Parameters

Pearson's correlation was performed to explore the Correlation of median nerve (CSA) with another parameter in patients and control. (CSA) demonstrated a significant positive correlation to age in non-diabetic (CTS) (r = 0. 505, p< 0.00 1). There is a significant positive correlation between BMI and (CTS) in DM individuals (r = 0.529, p< 0.001) each of median N. Motor distal latency in both group with a positive correlation, but median N. Motor amplitude with a significant negative correlation in the diabetic CTS individual (r = -0. 435, p = 0.00 2) and median N. motor CV with a significant negative correlation in diabetic (CTS) individuals (r= -0. 667, p= 0.00 1) and a significant positive connection with median nerve distal sensory latency in non-diabetic CTS (r = 0. 514,p < 0.00 1), and significant negative connection to amplitude, conduction velocity in a non-diabetic group(r = -0. 459,p = 0.00 2)(r = -0. 815, p = <0.00 1). The WFR is positively correlated with CSA in both groups (Table 4).

DISCUSSION

CTS is somewhat more prevalent in those with DM for mysterious reasons, and early recognition is needed to avoid irreversible injury and responsive sequel.[11] In diabetic individuals when NCS is utilized, it is harder to identify CTS from other neurological disorders. US is already utilized in the medical investigation of DM complications in peripheral nerve, yet its assessment of CTS in individuals with DM still hasn't been described. The demographic characteristics of the sample respondents described a substantial female CTS prevalence, which again is analogous to the preceding researchers[12] the right hand 49(98.0) and 45(90.0) dominance in diabetic and non-diabetic CTS respectively, as confirmed by other Western research[13] overweight and diabetes is an Impartial potential cause for (CTS).[14]

Table 2: Comparison of electrophysiological parameters of CTS patients between diabetic and non-diabetic

Parameter		*DM+CTS (N=50)*	*CTS (N=50)*	*p-value**
DML Median	Mean ± SD	4.6 ± 1.87	5.11 ± 1.71	0.161
	Median (Range)	4 (2.08-9.62)	4.85 (2.8-9.8)	
DMA Median	Mean ± SD	7.63 ± 3.02	6.57 ± 2.82	0.073
	Median (Range)	6.9 (3.1-13.4)	6.3 (2-14)	
CVM Median	Mean ± SD	49.33 ± 11.44	49.72 ± 12.76	0.872
	Median (Range)	50 (22-69.6)	48.75 (22-67)	
DSL Median	Mean ± SD	4.41 ± 0.59	4.48 ± 0.75	0.640
	Median (Range)	4.2 (3.7-6.2)	4.35 (3.6-6.6)	
DSA Median	Mean ± SD	13.9 ± 8.94	21.09 ± 8.94	<0.001
	Median (Range)	11.9 (1.06-37.8)	19.65 (8.1-41.8)	
CVS Median	Mean ± SD	42.27 ± 9.87	40.07 ± 9.19	0.290
	Median (Range)	44 (20.9-57.6)	41 (22.9-56)	
DSL Ulnar	Mean ± SD	3.44 ± 1.75	3.05 ± 1.49	0.227
	Median (Range)	3.1 (2.2-11.6)	2.8 (2.1-9.9)	
DSA Ulnar	Mean ± SD	24.59 ± 13.33	31.07 ± 10.42	0.008
	Median (Range)	20.1 (2.9-52.1)	31.1 (14.7-50)	
		N (%)	N (%)	*p-value* ***
Severity	Mild	30 (60.0)	23 (46.0)	0.151
	Moderate	11 (22.0)	20 (40.0)	
	Severe	9 (18.0)	7 (14.0)	

**p-value* by unpaired test, ***p-value* by Chi-square test, 9 cases of DM patients and 6 patients with CTS had no response in sensory parameters of median nerve

Table 3: Comparison of ultrasound parameters of CTS patients between diabetic and non-diabetic

Parameter		DM+CTS (N=50)	CTS (N=50)	P value*
CSA	Mean±SD	0.14+0.03	0.15+0.04	0.189
	Median (Range)	0.13 (0.11-0.2)	0.14 (0.11-0.23)	
WFR	Mean±SD	1.8+0.3	2.07+0.53	**0.002**
	Median (Range)	1.7 (1.5-2.8)	2 (1.5-3.2)	

MNSA was lower among electrophysiological parameters in diabetes subjects ($p < 0.001$). Similar results were seen in other studies, where multi-variate reports showed that the median n. SNAP amplitude in NCSs is still the only variable substantially linked with DM[15] patient group with DM was observed to get a prolonged latency, a lesser amplitude, and a slower CV than those without DM. Nazish S *et al.*16 found a similar finding in the existing study. Our findings are in agreement with past studies of ultrasonography in CTS in demonstrating expansion of median nerve in CT hands.[17] We observed a larger measurement of median n. CSA in subjects with affected hands. CSA measurements revealed no difference in changes comparing diabetes and non-diabetic subjects. This might be due to the fact that the biologic reaction to compaction seems to be a more substantial component than DM peripheral nerve damage and the limited sample size of DM CTS patients in the current study. Our findings are in agreement with,[18] who found the CSA of the median n. was greater in both DM CTS and non-DM CTS patients in comparison to those with no CTS[19] showed considerably greater median N. CSA in DM individuals with CTS at wrist rates comparable with those of the healthy individual[6] and[20] CSA of the median nerve (at the wrist) and tibial nerve (at the ankle) were greater in DM individual than in the control group. These results were also discovered by[18] researchers discovered a significantly greater median N. CSA measurement in both diabetes and non-diabetic patients.[21] reported that, in contrast to our findings, the measured CSA in both the DM and DPN categories were greater than those obtained in the idiopathic, non-DM, and control conditions.[21]

It has been found that wrist forearm ratio in patients with DM is less than in patients without DM with a significant difference between the two groups. The WFR is a ratio of the CSA evaluated at the carpal tunnel even at the forearm, i.e., the nerve will be its own supervision about a potential rise in CSA at CT This expansion is reported to happen in non-DM individuals with CTS.[22] We suggest that the overall procedure accounts for these results: The nerve is reported to be unevenly expanded in the forearms of diabetic patients.[6] However, the CSA at the forearms is initially greater in diabetes compared to healthy individuals. Amplification of the median nerve in the CT, the location of entrapped in CTS, possibly restricted (e.g., by the epineurium or adjacent anatomical features such as that of the subcutaneous fascia or possibly as the transverse carpal ligament.[23] Whereas the discrepancy in between CSA at the forearm and the CT keep

Table 4: Correlation of CSA with other parameters in CTS patients between diabetic and non-diabetic group

Parameter		*CSA*	
		DM + CTS	*CTS*
Age (yr)	r	-0.166	0.505
	p	0.248	<0.001
BMI (kg/m_2)	r	0.529	-0.051
	p	<0.001	0.725
Hba1c %	r	-0.142	-0.022
	p	0.326	0.882
DML Median	r	0.552	0.588
	p	<0.001	<0.001
DMA Median	r	-0.435	-0.360
	p	0.002	0.010
CVM Median	r	-0.667	-0.374
	p	<0.001	0.007
DSL Median	r	0.416	0.514
	p	0.007	<0.001
DSA Median	r	-0.072	-0.459
	p	0.653	0.002
CVS Median	r	-0.217	-0.815
	p	0.174	<0.001
DSL Ulnar	r	0.364	-0.254
	p	0.009	0.075
DSA Ulnar	r	-0.173	0.079
	p	0.230	0.584
CVS Ulnar	r	-0.219	0.059
	p	0.126	0.685
WFR	r	0.693	0.995
	p	<0.001	<0.001
DM duration (yr)	r	-0.121	
	p	0.403	

lower, i.e. the WFR stays low, the above individuals may experience otherwise (diagnostically) apparent CTS without an abnormal ratio of the median nerve CSA through the forearm. Pathologic WFR utilized in non-diabetic individuals will therefore underestimate the risk of CTS in DM patients.[23] In contrast to our result[24] demonstrated greater CSA and WFR levels in individuals with DM than in non-D.M individuals. The difference in CSA and WFR between the two categories might be attributable to the greater sensitivity of the nerves of DM individuals to exterior tension. An association was identified between DML and median nerve CSA at the wrists band between DML and WFR, demonstrating This had usually been proven in polyneuropathy.[25)] Regarding the association of CSA with other variables, our results indicated no significant link with age, hba1c, or diabetes length. This discovery is compatible with an additional finding[26] who observed that the length of DM above 5 years had no influence on the MN CSA. This estimate is conservative, as individuals would have had the condition before admission. This could account for the lack of significance in between MN. (CSA) and length of DM shown in our investigation. Since chronic hyperglycemia has been linked to the development of DPN[27] In this investigation, MN CSA expanded more in DM with PN, it was predicted that a poor glycemic status would be related in a further widening of the MN. CSA in DM with PN and reveal a true association with Hb.A1c.Unexplored variables, such as poor insulin signaling and insulin growth factor, may have led to the different results of our study. A similar non-significant association.[26] Our findings are supported by the results of research[28] who reported that CTS progression risk is associated with BMI and body weight gain.[28] Initially, the association between BMI and CTS was attributed to the greater fats accumulation in the CT and greater pressure gradients in the carpal tunnel of overweight persons.[29] The CSA of the median nerve correlates positively with the distal motor and sensory latencies of the median CMAP, and SNAP, respectively. In contrast, the CSA of the median nerve correlates negatively with the amplitude of the median CMAP, the amplitude of the median SNAP, and the median nerve's SNCV. Indicating that median nerve enlargement leads to median nerve axonal degeneration in CTS. Thus, greater CSA indicates more median nerve injury.[18] Compared to the WFR protocol, WFR demonstrated a greater connection with the symptom severity of CTS patients.[30,31]

CONCLUSION

The CSA of the median nerve is greater in CTS wrists through both DM and non-DM individuals with no significant difference. The mean wrist-forearm ratio was less in diabetic patients than in non-diabetic with a significant difference. Pairing NCS with US imaging gives effective assessment methods for the CTS hands in individuals with and without diabetes.

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