Original Article

Electrophysiologic pattern of carpal tunnel syndrome among patients with and without diabetes mellitus

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ABSTRACT

Background: *Carpal tunnel syndrome (CTS) is the most common compression neuropathy in the upper limb in general population. Female gender, obesity, increase of age, diabetes mellitus (DM), hypothyroidism, pregnancy, rheumatoid arthritis, osteoarthritis and occupational factors like repetitive work are the main risk factors for CTS. The objective of this study was to determine whether the nerve conduction study measurement of the median nerve (MN) at the wrist differ between diabetic and non-diabetic CTS patients.*

Methods: *This cross-sectional study was conducted at Electrodiagnostic Lab of BIRDEM General Hospital and Popular Medical College Hospital, Dhaka during the period of October 2017 to August 2019. Five hundred and seventeen hands from 377 patients were sampled according to inclusion criteria. Participants were assigned to two groups: Group 1 (CTS with DM) and Group 2 (CTS without DM). NCS study were performed using Nihon Kohden electrodiagnostic machine. Measurements at the MN was taken under consideration for study. Severity of CTS was graded according to Canterbury electrophysiologic grading scale and parameters were compared among diabetic and non-diabetic participants. Data were analyzed using Statistical Package for the Social Sciences SPSS version 23 (SPSS Inc., Chicago, IL, USA).*

Results: *The 377 participants comprised 144 and 233 in Group 1 and Group 2, respectively. Out of 377 patients, 334 (88.59%) were females and there was no statistically significant difference between two groups. The average age was 50.66±10.2 years in diabetic participants and 43.34±10.7 years in non- diabetic participants. In the study population moderate CTS (Grade 3) was the most frequent (46.4%) followed by very severe (Grade 5) CTS. There was no statistically significant difference in incidence between diabetic and non-diabetic patients. Analysis of electrophysologic parameters of MN showed statistically significant difference in mean MN sensory nerve action potential (SNAP) amplitude (P 0.003), compound muscle action potential (CMAP) amplitude (p 0.05, right) and CMAP latency (p 0.02, right and 0.05, left) between diabetic and non –diabetic patients. Inter-group comparison revealed that impaired glycaemic status and duration of diabetes in diabetic population had a minimal influence in the electrophysiological severity of CTS in either hands.*

Conclusion: *Some nerve conduction study parameters of the MN differ significantly between diabetic and non-diabetic patients with CTS and may provide both diagnostic and predictive results across the entire spectrum of CTS.*

Key words: *Carpal tunnel syndrome, nerve conduction studies, diabetes mellitus, median nerve, electrophysiological pattern.*

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common form of entrapment neuropathy.[1] A clinical diagnosis of CTS is established by the presence of any four of the following six criteria: history of paresthesia in hands and/or marked preponderance of sensory symptoms in the hands, nocturnal hand symptoms awakening patient, symptoms precipitated by activities such as holding a newspaper or driving a car and relieved by hand shaking, predilection for radial digits, weak thenar muscles or upper limb sensory loss solely within the distribution of the median nerve.[2] Female gender, obesity, increase of age, hypothyroidism, pregnancy, rheumatoid arthritis, osteoarthritis and occupational factors like repetitive work are identified as the main risk factors for CTS.[3] In addition, previous studies stated that diabetes mellitus (DM) is also considered as a risk factor [4,5] with a higher incidence of CTS in patients with pre-diabetes.[6] A relationship between HbA1c, duration of DM, micro vascular complications and CTS had been stated.[7] Entrapment disorders are highly prevalent in patients with diabetes, the most common neuropathy being CTS.[8] However, although type 2 diabetes was more frequently diagnosed among patients with CTS, it could not be identified as an independent risk factor.[3] The high prevalence of CTS among patients with diabetes might be as a result of repeated undetected trauma, metabolic changes, accumulation of fluid or edema within the confined space of the carpal tunnel and /or diabetic cheiroarthropathy.[8]

Electro diagnostic studies are an important extension of the history and physical examination in diagnosing CTS. Nerve conduction studies (NCS) are considered to be the gold standard in the diagnosis of CTS because it is an objective test that provides information on the physiological health of the median nerve across the carpal tunnel. The test can determine the presence and the severity of median neuropathy at the wrist.[8] The needle electromyographic examination is less sensitive than NCS in diagnosis of CTS. The objective of this study was to determine whether the NCS measurement of the median nerve at the wrist differ between diabetic and non-diabetic CTS patients.

METHODS

Study design and patient population

This cross-sectional study was carried out in Electro diagnostic Lab of BIRDEM General Hospital and Popular Medical College Hospital, Dhaka from October 2017 to August 2019.Adult patients with or without DM clinically diagnosed as CTS (according to the criteria of the American Academy of Neurology practice parameters) were included. A comprehensive medical and neurological evaluation in order to exclude diabetic neuropathy, neuropathy associated with other etiologies (e.g., familial, alcoholic, nutritional, and uremic) and patients with traumatic median nerve injury, previous CTS surgery, malignancy, pregnancy, obesity, gout, hypothyroidism, rheumatoid arthritis and musculoskeletal disorders, limited joint mobility, Dupuytren’s contracture, flexor tenosynovitis as well condition that mimics CTS such as cervical radiculopathy were excluded from study. Standardized bilateral NCS were performed on these patients using Nihon Kohden electro diagnostic machine to confirm CTS and grade the severity of CTS. Verbal informed consent was taken from electro diagnostically confirmed CTS patients (both diabetic and non-diabetic) after explaining the purpose of study and use of data for research.

Demographic data including age, gender and hand involvement along with duration of CTS symptoms were recorded. If any patient had diabetes, then their HbA1c level and duration of diabetes was documented.

Electrodiagnostic testing

NCS study were performed using Nihon Kohden electro diagnostic machine and reported by consultant neurologists. Only data of the MN from the NCS were used in this study. The MN motor study was performed with stimulation at the wrist, antecubital fossa with recording at the abductor pollicis brevis. The onset latency, amplitude of the compound muscle action potential (CMAP), and conduction velocity (CV) were collected. Using the orthodromic method, sensory studies were performed for the amplitude of the sensory-nerve action potential (SNAP), peak latency and CV. If the MN sensory NCS results were normal, a comparison test was performed to compare the sensory conduction values of the MN and ulnar nerve (UN) between the wrist and ring fingers. F-response latency of median nerve was obtained to exclude proximal affection of the median nerve roots.

CTS was classified into six grades based on a Canterbury Electrophysiologic Grading Scale. According to the following scale: normal (grade 0), very mild (grade

1): CTS demonstrable only with most sensitive tests; mild (grade 2): sensory nerve conduction velocity slow on finger/wrist measurement, normal terminal motor latency; moderate (grade 3): sensory potential preserved with motor slowing, distal motor latency to abductor pollicis brevis (APB) < 6.5 ms; severe (grade 4): sensory potentials absent but motor response preserved, distal motor latency to APB < 6. 5 ms; very severe (grade 5): terminal latency to APB > 6.5 ms; extremely severe (grade 6): sensory and motor potentials effectively unrecordable (surface motor potential from APB < 0.2 mV amplitude).

Statistical analysis

Collected data was analysed using Statistical Package for Social Sciences SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics: mean, standard deviation, median, range, frequencies, percentage were calculated. Test of significances: Chi square test was used to compare the difference in distribution of frequencies among different groups. Student *t*-test was calculated to test the mean differences in continuous variables between groups. Findings were represented with tables and figures.

RESULTS

Total 377 patients with CTS were included in this study, 38% were diabetic and 88.59% were females and there was no statistically significant difference between diabetic and non-diabetic groups (Table I). Average age in non-diabetic group was 43.34±10.7 years and in diabetic group was 50.66±10.2 years and there was no statistically significant difference between two groups (Table II).

Table I. Gender distribution of study population (N=377)

Sex	Diabetic (n=144)	Non-diabetic (n=233)	p value
Male	13 (9.0)	30 (12.9)	$\chi^2 = 1.304$
Female	131 (91.0)	203 (87.1)	*p = 0.253

*p-value was reached from Chi –square (χ^2) Test . P- value is statistically significant if the value if 0.05 or less .Figure within the parenthesis indicates corresponding percentages

Table II. Age distribution of study population (N=377)

Age (in years)	Diabetic (n=144)	Non-diabetic (n=233)	p value
<=35	11 (7.6)	55 (23.6)	
36 – 45	36 (25.0)	83 (35.6)	
46 – 55	59 (41.0)	67 (28.8)	t=-6.565
56 – 65	27 (18.8)	22 (9.4)	
66 – 75	11 (7.6)	6 (2.6)	
Mean ± SD	50.66±10.2	43.34±10.7	*p <.001

* p-value was reached from unpaired t-test . P- value is statistically significant if the value if 0.05 or less. Figure within the parenthesis indicates corresponding percentages

Number of patients in different Canterbury NCS Electrophysiologic Grading Scale Grades of CTS among diabetic and non-diabetic patients is shown in Table III. It was observed that Grade 3 was the most frequent followed by very severe (Grade 5) in both groups. There was no statistically significant difference between two groups (Table III).

Table III. Comparison of CTS grade of study population (N=377)

CTS Grade	Diabetic n (%)	Non-diabetic n (%)	p value
Very Mild (Grade 1)			
Right/left	2 (1.8)/ 1 (1.2)	9 (4.6)/ 8 (6.3)	Right hand:
Mild (Grade 2)			$\chi 2 = 3.493$
Right/left	13 (11.7)/ 8 (9.8)	20 (10.2)/ 21 (16.5)	p = 0.624
Moderate (Grade 3)			Left hand:
Right/left	32 (28.8)/ 33 (40.2)	70 (35.5)/ 40 (31.5)	$\chi 2 = 7.542$
Severe (Grade 4)			p = 0.183
Right/left	21 (18.9)/ 16 (19.5)	32 (16.2)/ 16 (12.6)	
Very Severe (Grade 5)			
Right/left	39 (35.1)/ 22 (26.8)	60 (30.5)/ 39 (30.7)	
Extremely Severe (Grade 6)			
Right/left	4 (3.6)/ 2 (2.4)	6 (3.0)/ 3 (2.4)	

*p-value was reached from Chi –square ($\chi 2$) Test . P- value is statistically significant if the value if 0.05 or less .Figure within the parenthesis indicates corresponding percentages

Regarding electro diagnostic studies of the MN the amplitude SNAP was the only parameter that was significantly different among diabetic and non-diabetic participants in both hands (p = 0.03). Statistically significant difference between two groups was found in the right CMAP amplitude and Left MN CMAP latency (p .05, .05 and .03 respectively) (Table IV). The Right CMAP Amplitude was significantly low in diabetic groups. Left MN CMAP latency and SNAP CV was also significantly prolonged in diabetic group.

Table IV. Parameters of NCS of MN between diabetic and non –diabetic CTS groups

	Diabetic		Non-diabetic		p value*	
	Right n=111	Left n=82	Right n=197	Left n=127	Right	Left
Motor Nerve Conduction Study						
CMAP	6.0 ± 2.4	5.7 ± 1.9	5.4 ± 2.0	5.1 ± 2.1	0.02	0.05
Lat (ms)	(5.4)	(5.4)	(5.1)	(4.8)		
CMAP	9.2 ± 6.0	10.0 ± 5.2	10.6 ± 6.0	8.3 ± 5.2	0.05	0.07
Amp (uV)	(8.8)	(9.2)	(10.4)	(7.7)		
CMAP	46.6 ± 15.1	52.4 ± 10.2	47.2 ± 19.4	47.7 ± 21.4	0.79	0.06
CV (m/s)	(49.1)	(52.8)	(53.2)	(54.1)		
Sensory Nerve Conduction Study						
SNAP	1.9 ± 2.0	2.2 ± 1.9	2.6 ± 1.8	2.5 ± 1.7	0.00	0.27
Lat (ms)	(2.8)	(3.0)	(3.2)	(3.1)		
SNAP	11.7 ± 15.3	12.6 ± 13.7	14.4 ± 14.6	17.5 ± 17.6	0.03	0.03
Amp (uV)	(6.0)	(9.5)	(11.0)	(14.9)		
SNAP	19.1 ± 19.3	22.6 ± 19.7	27.3 ± 19.1	29.0 ± 20.3	0.00	0.03
CV (m/s)	(23.3)	(28.9)	(33.3)	(35.1)		

Data are mean ± standard deviation (median) values.* p-value was reached from unpaired t-test . P- value is statistically significant if the value if 0.05 or less. Figure within the parenthesis indicates corresponding percentages AMP.: amplitude, CMAP: compound muscle action potential, CTS: carpal tunnel syndrome, CV: conduction velocity, DM: diabetes mellitus, lat.: latency, MN: median nerve, SNAP: sensory-nerve action potential

Most diabetic patients had uncontrolled blood glucose (Diabetes for more than 6 years (Figure 2). Only 47% of the diabetic patients had symptom of CTS (night pain, paraesthesia etc.) for less than 1 year before diagnosis (Figure 3).

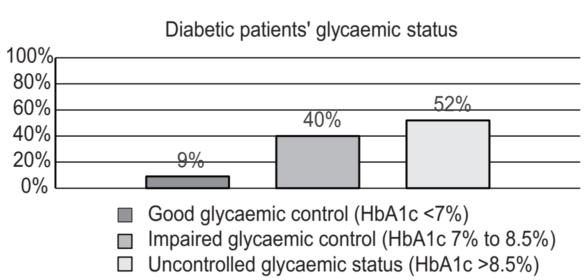

Figure 1. Glycaemic status of diabetic participants

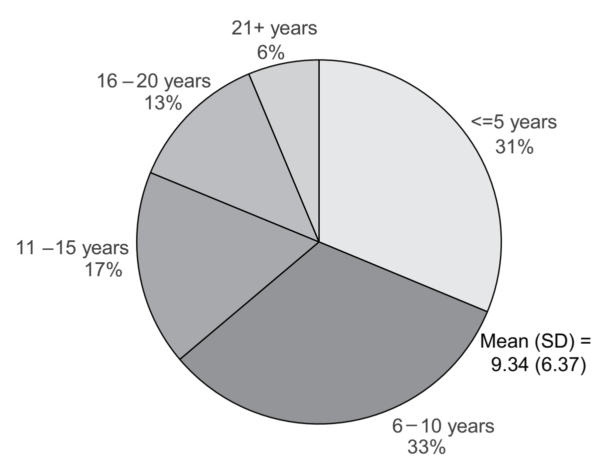

Figure 2. Duration of diabetes of diabetic participants

Glycaemic status of different grades of CTS in diabetic patients (right and left hand) is demonstrated in Figure 4. Inter-group comparison between diabetic participants using one-way ANOVA revealed that impaired glycaemic status made a statistically significant difference in the electrophysiological severity of CTS in right and left hand at 10% level of significance ($F= 2.465$ $p = 0.089$).

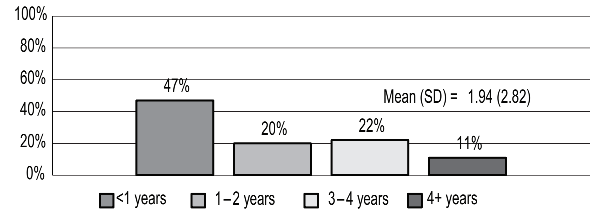

Figure 3. Duration of CTS symptoms (in years) in diabetic patients before diagnosis

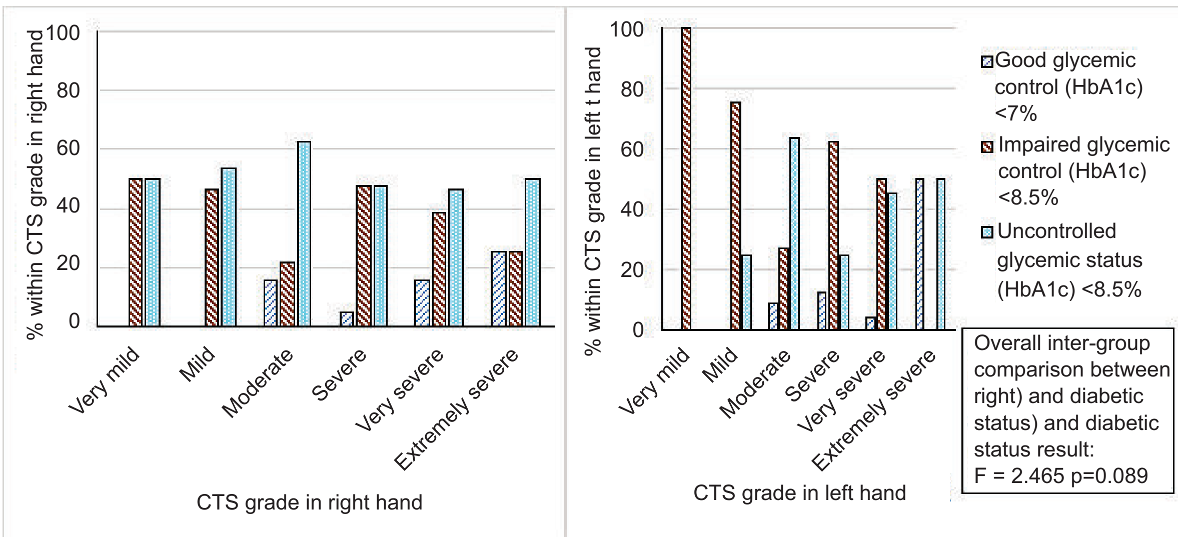

Figure 4. Glycemic state of the patients and CTS severity

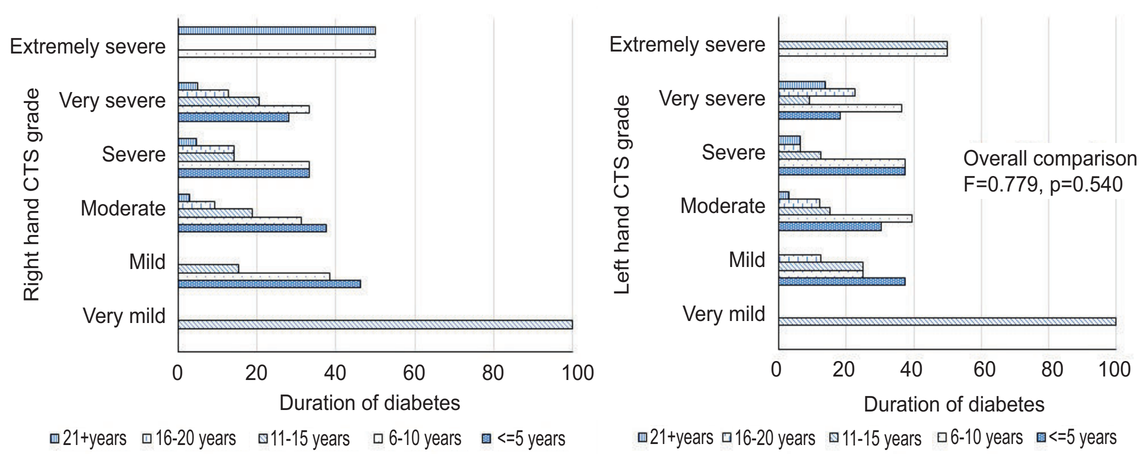

Figure 5. Duration of diabetes among CTS patients with different grades of CTS

Figure 5 shows the association between duration of diabetic and severity of CTS in right and left hand. Inter-group comparison using one-way ANOVA demonstrates that there is no significant relationship between the mean score of CTS grade in left and right hand and duration of having diabetes. ($F= 0.779$ $p = 0.540$).

DISCUSSION

CTS is the most frequent entrapment neuropathy causing numbness, tingling, discomfort, pain and weakness in hands ranging from mild to debilitating extent, especially for those whose work or recreational activities require extensive use of hands. DM has been proposed as a risk factor for CTS but this remains controversial. In every case an early diagnosis is essential to prevent permanent nerve damage and functional squeals. Confirmation of CTS is usually based on electrophysiological studies. The demographic data of the present study participants showed a marked female CTS preponderance, with male to female ratio of (1:7.7), which was similar to the previous studies conducted worldwide .[10-12] The mean age of participants was 46.14 ±11.0, which was similar to many local[11,12] and Western studies. This result differed from study sampled from general population which included pregnant patients and post-traumatic CTS.[13]

In the current study, it was observed that moderate CTS (Grade 3) was the most frequent one (46.4%) followed by very severe (Grade 5) in both groups. This observation was similar to a previous one report.[11] The high frequency of moderate and severe grade CTS might be due to the fact that we enrolled patients who were referred to the electrodiagnostic lab for their symptoms, while in another study, 73.6% had mild, 20.8% had moderate and 5.6% had severe CTS.[13]

Regarding the parameters of electrodiagnostic test of MN the amplitude SNAP was the only parameter that was significantly different among diabetic and non-diabetic participants in both hands. The Right CMAP Amplitude was significantly low in diabetic group. Left MN CMAP latency and SNAP CV was also significantly prolonged in diabetic group. Similar findings were observed in comparison of parameters of electrodiagnostic tests between CTS and DM-CTS groups another study.[14-16]

Comparison between diabetic participants using one-way ANOVA revealed that impaired glycaemic status made a statistically significant difference in the electrophysiological severity of CTS in right and left hand at only 10% level of significance ($F= 2.465$ $p = 0.089$). No significant association was found between duration of diabetes and severity of CTS. This result was not supported by previous study.[17]

Limitation of the current study included lack of generalizability of our results as both centres are regarded as tertiary care facilities. Again CTS and diabetic polyneuropathy (DPN) are common conditions in patients with diabetes and therefore frequently occur concomitantly which can affect the electrodiagnostic findings of CTS. This issue was addressed and only diabetic patients with completely normal NCS (other than for CTS) were enrolled.

Conclusion

From the findings of this current study, it can be concluded that mean electro-diagnostic parameters may provide both diagnostic and predictive results across the entire spectrum of CTS in diabetic and non-diabetic patients. Analysis of electrophysologic parameters of MN showed statistically significant difference in mean MN sensory nerve action potential (SNAP) amplitude, compound muscle action potential (CMAP) amplitude and CMAP latency between diabetic and non –diabetic patients. Inter-group comparison revealed that impaired glycaemic status and duration of diabetes in diabetic population had a minimal influence in the electrophysiological severity of CTS in either hands. Further large-scale prospective studies with strictly controlled group compositions and application of rigorous statistical analyses is recommended.

Authors' contribution: RH, DA, SSI planned the research. RH, DA collected the data. Habib R drafted the manuscript and supervised the whole process. All authors read and approved the final version for publication.

Conflicts of interest: Nothing to declare.

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