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Neurophysiologic Pattern and Severity Grading Scale of Carpal Tunnel Syndrome in Sudanese Patients

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Abstract

Background: Carpal tunnel syndrome is the most frequent compression-induced neuropathy, where the median nerve is compressed at the wrist causing sensory and motor deficits. It is more common in females than males and accounts for a higher number of days off work than all other work-related musculoskeletal disorders.

Objectives: The aim of this study is to describe electrophysiological criteria for diagnosis of CTS among Sudanese patients, to classify patients with CTS according to severity based on NCS results and clinical presentation, and to determine the age group most affected beyond finding any gender difference.

Material and methods: This is a retrospective analytic electrophyisologic study performed in 671 clinically diagnosed CTS patients. NCS was performed in more than 1089 hands which included the median and ulnar nerves. Onset and peak latencies, amplitude, conduction velocity, F waves and distance were calculated.

Result and discussion: Out of 671patients with CTS; females were 81.7% and males were 18.3%. The most affected age group was (48-58) years. The classic history of CTS was reported by 484 patients, Parasethisa was reported by 339 patients (70%), Parasethisa and pain 205 patients (42.3%), diurnal day and night pain by 127 patients (26%), nocturnal pain only by 283 patients (57%), and numbness by 340 patients (70.2%). Weakness of abductor policis brevis (APB) muscle was found in 127 patients (26%), of these 78 patients showed wasting of the same muscle (16%).

Conclusion: Beside the Italian and Canterbury grading of CTS, a new modified scale was adopted in our patients rated as very mild, mild, mild to moderate, moderate, moderate to severe, severe, and very severe.

Keywords: Carpal tunnel syndrome; Compression-induced neuropathy

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Introduction

Carpal tunnel syndrome is a medical condition in which the median nerve is compressed at the wrist causing symptoms like numbness and pain. It is the most frequent compression-induced neuropathy where it is more common in women than it is in men (139 per 100,000 person-years for men and 506 per 100,000 person-years for women) [1,2]. It can occur at any age, but has a peak incidence around the age 50 [3]. It accounts for a higher number of days away from work than all other work-related musculoskeletal disorders [4,5].

Sudanese are heterogenic ethnic group of Arab and African ancestors, with different varieties in life style, culture and believes. The aim of this study is mainly to determine the neurophysiological pattern and severity grading of CTS among Sudanese patients and compare it with those in the literature.

Material and Methods

This is a retrospective analytic study conducted in El-Magzoub's, neuroscience clinic, The National Ribat University, Khartoum, Sudan, in the period from 2008 to 2013. During this period 671

patients were diagnosed with carpal tunnel syndrome according to nerve conduction study and clinical presentation.

An 8- and 4- channel Viaysis Select and Quest machines with stimulator (S403) were used. Motor and sensory studies were performed for the ulnar and median nerves. The Sensory component of each nerve was stimulated antidromically while the motor part was stimulated orthodromically and the F wave was recorded.

The action potentials was recorded as sensory nerve action potential (SNAP) and compound muscle action potential (CMAP) for sensory and the motor nerves respectively. The parameters obtained were; latency (distal or onset and peak latency for the Median nerve, onset latency for the ulnar nerve) amplitude, duration, area, distance and nerve conduction velocity.

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 20. Univariate analysis for age, gender, occupation, symptoms, unilateral and bilateral hands involvement, dominant hand, and severity was done. Master figure was done to show frequency of performing Tinel and Phalen tests. Bivariate analysis was done for both median and ulnar nerves latencies, velocities, amplitudes, and M and F wave latencies in relation to severity [6-9].

Results

This is a retrospective analytic study containing (671) patients presented with symptoms and signs of CTS, confirmed by NCS with mean age of 52.7 ± 12.7 (15-86) shown in **Table 1**.

Females were found to dominate with a female to male ratio 4:1.

The majority of patients were housewives followed by manual workers and the rest was shown in **Table 2**.

The dominant hand is more affected whether the presentation of CTS is bilateral or unilateral, as shown in **Table 3**.

The classic history of CTS was shown in **Table 4**.

Table 1 This is a retrospective analytic study containing (671) patients presented with symptoms and signs of CTS, confirmed by NCS with mean age of 52.7 ± 12.7 (15-86).

Age groups	Frequency	Percent
(15-25)	11	1.60%
(26-36)	55	8.20%
(37-47)	158	23.50%
(48-58)	232	34.60%
(59-69)	143	21.30%
(70-80)	63	9.40%
(>80)	9	1.30%
Total	671	100%

Table 2 The majority of patients were housewives followed by manual workers and the rest.

Occupation	Frequency	Percent
Housewives	481	71.6%
Manual workers	66	10.0%
Teachers	52	7.7%
Writers	21	3.1%
Retired	21	3.1%
Drivers	15	2.2%
Soldiers	11	1.6%
Students	3	0.4%
Nurses	1	0.1%
Total	671	100%

Table 3 The dominant hand is more affected whether the presentation of CTS is bilateral or unilateral.

Laterality	Frequency	Percent
Right	171	25.4%
Left	82	12.2%
Bilateral more Rt	170	25.3%
Bilateral more Lt	140	20.9%
Bilateral equal	108	16.0%
Total	671	100%

Table 4 The classical history of CTS.

Symptoms	Frequency	Percent
Parasethisa	339	70%
Pain and parasethisa	205	42.3%
Diurnal day and night Pain	127	26%
Nocturnal pain	283	57%
Numbness	340	70.2%
Hand weakness	127	26%
APB wasting	78	16%

The criteria adopted in severity grading of CTS performed in Italy by Padua and in Canterbury by Bland was based on SNAPs and CMAPs distal latency, conduction velocity, and amplitude.

In this study we showed a modified scale for grading the severity of CTS in Sudanese patients by including peak latency to the above mentioned parameters with some differences in determining the grades.

As CTS frequently affect both hands usually unequally, in this study the most affected hand with worse neurophysiological finding is included in the grading of severity. This is shown in **Tables 4 - 6**.

Tables 6-12 show the detailed electrophysiological findings of each grade of our modified new scale for assessing the severity of CTS. This includes SNAPs and CMAPs distal latency, peak latency, conduction velocity, amplitude as well as the F wave.

For comparison with other hand nerves, parameters of the Ulnar nerve were included in each grade of the new scale.

Table 5 Neurophysiological severity grading scale of CTS by recording responses from the median nerve according to our findings.

Grade	Features
(I) Very severe	No sensory responses were obtained or when recorded; distal latency is > 6.9 ms and peak latency is 9.2 ms, averaged amplitude of 1-3 μV and remarkably slowed conductive velocity
	No motor responses or enormously prolonged distal latency; latency >7.1 ms, and averaged amplitude of 0.05-0.1 μV.
(II) Severe	No sensory responses were obtained or when recorded; distal latency is >5.6 ms and <6.9 ms, and peak latency is >7.3 ms.
	Motor responses distal latency of <7.1 ms.
(III) Moderate to severe	Sensory distal latency >3.9 ms and <5.6 ms, and peak sensory latency >6.1 ms.
	Motor distal latency <4.9 ms.
(IV) Moderate	Sensory distal latency of >3.4 ms and <3.9 ms, and peak sensory latency of >4.6 ms.
	Motor distal latency ≤ 4.5 ms.
(v) Mild to moderate	Sensory distal latency of >3.4 ms and <3.9 ms, and peak sensory latency of >4.6 ms.
	Motor distal latency at the upper limit of normal
(VI) Mild	Sensory distal latency of the upper limit of normal, peak sensory latency >4.4 ms.
	Motor distal latency normal.
(VII) Very mild	Bilateral normal NCS, however the symptomatic hand showed considerable decrease in NCS parameters than the other hand

Table 6 Neurophysiologic findings in Patients with very severe CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	23	4.5	0.8	0 – 8.2	0.000**
	Lt	Onset latency sensory (ms)	37	4.8	0.6	0 – 7.5	0.000**
	Rt	Peak latency sensory (ms)	16	5.6	1.2	0 – 11.2	0.000**
Sensory	Lt	Peak latency sensory (ms)	35	5.3	0.7	0 – 8.6	0.000**
	Rt	Amplitude sensory (μV)	8	11.3	9.9	0 - 32	0.000**
	Lt	Amplitude sensory (μV)	10	11.3	6.8	0 - 23	0.000**
	Rt	Velocity sensory(m/s)	8	33.3	6.2	0 – 45	0.000**
	Lt	Velocity sensory(m/s)	10	34.7	5.5	0 - 44	0.000**
	Rt	Latency motor (ms)	14	6.3	2.1	0 – 9.4	0.000**
	Lt	Latency motor (ms)	15	5.3	1.3	3.3 – 8.4	0.000**
	Rt	Amplitude motor (μV)	14	3.1	3	0 – 10.9	0.000**
Motor	Lt	Amplitude motor (μV)	15	4	1.7	1.6 – 7.9	0.000**
	Rt	Velocity motor (m/s)	13	51.2	8.7	0 – 63.0	0.000**
	Lt	Velocity motor (m/s)	15	51.9	7.4	31.0 -58.0	0.000**
	Rt	F wave	1	30.3	0	30.3	0.000**
	Lt	F wave	1	24.9	0	24.9	0.498**
Ulnar	Rt	Onset latency sensory (ms)	15	1.9	0.2	1.6 – 2.3	0.799*
	Lt	Onset latency sensory (ms)	15	1.9	0.2	1.6 – 2.3	0.056*
	Rt	Peak latency sensory (ms)	15	2.6	0.2	2.4 – 3.0	0.000**
Sensory	Lt	Peak latency sensory (ms)	15	2.7	0.3	2.4 – 3.2	0.450*
	Rt	Amplitude sensory (μV)	15	29.9	11.6	15.0 -50.0	0.008**
	Lt	Amplitude sensory (μV)	15	31.9	11.9	16.0 -58.0	0.000**
	Rt	Velocity sensory(m/s)	15	59.6	5	52.0 -67.0	0.837*
	Lt	Velocity sensory(m/s)	15	57.6	5.5	52.0 -71.0	0.087*
	Rt	Latency motor (ms)	14	2.5	0.3	1.9 – 3.1	0.821*
	Lt	Latency motor (ms)	13	2.5	0.3	2.0 – 3.0	0.482*
Motor	Rt	Amplitude motor (μV)	14	6.5	2.2	3.7 – 11.1	0.006**
	Lt	Amplitude motor (μV)	13	6.1	1.4	3.6 – 8.3	0.048**

Table 7 Neurophysiological findings in Patients with severe CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory(ms)	281	3.9	1	0 – 5.6	0.000**
	Lt	Onset latency sensory(ms)	268	3.5	1	0 –5.2	0.000**
	Rt	Peak latency sensory (ms)	333	4.7	1.1	0 – 7.3	0.000**
Sensory	Lt	Peak latency sensory (ms)	323	4.5	1.2	0 – 6.7	0.000**
	Rt	Amplitude sensory (μV)	339	12.9	10	0 - 63	0.000**
	Lt	Amplitude sensory (μV)	347	18.3	15.2	0 - 82	0.000**

Nerves	Side	Test	N	Mean	S.D±	Range	P value
	Rt	Velocity sensory(m/s)	340	38.7	9.9	0 - 71	0.000**
	Lt	Velocity sensory(m/s)	344	40.5	11	0 - 76	0.000**
	Rt	Latency motor (ms)	474	4.7	1.2	2.3 – 7.0	0.000**
	Lt	Latency motor (ms)	466	4.5	1.1	2.0 – 6.9	0.000**
Motor	Rt	Amplitude motor (µV)	469	4.4	2.9	0 – 17.1	0.000**
	Lt	Amplitude motor (µV)	459	4.5	2.8	0 – 15.3	0.000**
	Rt	Velocity motor (m/s)	473	51.5	9.4	21.0 81.0	0.000**
	Lt	Velocity motor (m/s)	465	52.3	9.4	19.0 -69.0	0.000**
	Rt	F wave	195	30.1	19	14.5 -37.1	0.000**
	Lt	F wave	191	28.8	2.4	23.2- 47.3	0.498**
Ulnar	Rt	Onset latency sensory(ms)	402	2.1	0.3	1.3 – 2.9	0.799*
	Lt	Onset latency sensory(ms)	380	2.1	0.4	1.5 – 4.1	0.056*
	Rt	Peak latency sensory (ms)	458	2.8	0.6	2.1 – 10.2	0.000**
Sensory	Lt	Peak latency sensory (ms)	434	2.9	0.6	2.1 – 10.6	0.450*
	Rt	Amplitude sensory (µV)	459	30.1	13.1	3.0 – 75.0	0.008**
	Lt	Amplitude sensory (µV)	435	32.3	15.4	4.0- 102.0	0.000**
	Rt	Velocity sensory(m/s)	450	57.3	7	37.0- 81.0	0.837*
	Lt	Velocity sensory(m/s)	429	55.7	7.9	38.0- 80.0	0.087*
	Rt	Latency motor (ms)	367	2.5	0.4	1.6 – 4.2	0.821*
	Lt	Latency motor (ms)	334	2.5	0.5	1.4 – 6.8	0.482*
Motor	Rt	Amplitude motor (µV)	365	7.2	2	0.2 – 12.7	0.006**
	Lt	Amplitude motor (µV)	333	6.7	1.9	0.4 – 13.7	0.048**
	Rt	F wave	131	27.5	2.5	23.1- 31.9	0.978*
	Lt	F wave	109	27.4	2.8	14.8- 31.9	0.517*

Table 8 Neurophysiological findings in Patients with moderate to severe CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	10	2.7	0.5	0 – 4.4	0.000**
	Lt	Onset latency sensory (ms)	8	3.4	1	0 - 4.6	0.000**
	8	Peak latency sensory (ms)	14	4.4	1.1	0 – 7.1	0.000**
Sensory	Lt	Peak latency sensory (ms)	14	4.4	1.1	0 – 6.3	0.000**
	Rt	Amplitude sensory (µV)	15	20.1	14.8	0 - 39	0.000**
	Lt	Amplitude sensory (µV)	15	26.1	15.8	0 - 70	0.000**
	Rt	Velocity sensory(m/s)	15	45.5	10.7	0 - 61	0.000**
	Lt	Velocity sensory(m/s)	15	45.3	12	0 - 64	0.000**
	Rt	Latency motor (ms)	19	4	0.7	2.8 – 4.9	0.000**
	Lt	Latency motor (ms)	17	4	0.6	3.4 – 4.8	0.000**
Motor	Rt	Amplitude motor (µV)	19	6	3.7	2.1 – 18.0	0.000**
	Lt	Amplitude motor (µV)	17	6.1	3	3.3 – 13.7	0.000**
	Rt	Velocity motor (m/s)	19	55.8	4.2	49.0 –64.0	0.000**
	Lt	Velocity motor (m/s)	17	57.5	4.7	50.0 –67.0	0.000**
	Rt	F wave	17	28.3	2.2	24.2 –31.7	0.000**
	Lt	F wave	15	27.9	1.8	24.2 –30.2	0.498**
Ulnar	Rt	Onset latency sensory (ms)	10	2.1	0.2	1.9 - 2.3	0.799*
	Lt	Onset latency sensory (ms)	8	2.2	0.2	1.6 – 2.6	0.056*
	Rt	Peak latency sensory (ms)	17	2.9	0.3	2.3 – 3.8	0.000**
Sensory	Lt	Peak latency sensory (ms)	13	3	0.3	2.1 – 3.4	0.450*
	Rt	Amplitude sensory (µV)	17	28.8	14.8	14.0 –70.0	0.008**
	Lt	Amplitude sensory (µV)	13	32.2	10.2	17.0 –55.0	0.000**
	Rt	Velocity sensory(m/s)	17	57	7.7	50.0 –74.0	0.837*
	Lt	Velocity sensory(m/s)	13	53.3	4.1	49.0 –69.0	0.087*
	Rt	Latency motor (ms)	17	2.5	0.3	1.8 – 3.1	0.821*
	Lt	Latency motor (ms)	8	2.5	0.4	2.2 – 3.2	0.482*
Motor	Rt	Amplitude motor (µV)	17	8.4	1.7	5.7 – 11.8	0.006**

Nerves	Side	Test	N	Mean	S.D±	Range	P value
	Lt	Amplitude motor (µV)	8	7.1	0.8	3.4 – 7.9	0.048**
	Rt	F wave	12	27.8	1.7	25.9 –31.0	0.978*
	Lt	F wave	5	27.6	1.8	26.0 –30.5	0.517*

Table 9 Neurophysiological findings in Patients with moderate CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	49	3	0.6	0 – 3.7	0.000**
	Lt	Onset latency sensory (ms)	49	2.9	0.5	0 – 3.9	0.000**
	Rt	Peak latency sensory (ms)	60	3.9	0.7	0 – 5.2	0.000**
Sensory	Lt	Peak latency sensory (ms)	57	3.7	0.6	0 – 5.2	0.000**
	Rt	Amplitude sensory (µV)	60	22	13.9	0 - 60	0.000**
	Lt	Amplitude sensory (µV)	57	31.5	15.9	0 - 63	0.000**
	Rt	Velocity sensory(m/s)	60	46.8	8.4	0 - 66	0.000**
	Lt	Velocity sensory(m/s)	56	50.1	8.4	0 - 68	0.000**
	Rt	Latency motor (ms)	60	3.9	0.6	2.7 – 4.6	0.000**
	Lt	Latency motor (ms)	57	3.7	0.5	2.9 – 4.5	0.000**
Motor	Rt	Amplitude motor (µV)	60	6.7	3.3	0.7 – 14.3	0.000**
	Lt	Amplitude motor (µV)	57	7.1	2.7	2.8 - 15	0.000**
	Rt	Velocity motor (m/s)	59	56.1	6.1	37.0 –67.0	0.000**
	Lt	Velocity motor (m/s)	57	57.5	5.3	50.0 –68.0	0.000**
	Rt	F wave	29	28.1	1.6	25.1 –31.0	0.000**
	Lt	F wave	26	27.9	1.7	24.5 –30.8	0.498**
Ulnar	Rt	Onset latency sensory (ms)	52	2	0.3	1.7 - 2.3	0.799*
	Lt	Onset latency sensory (ms)	44	2	0.2	1.5 – 2.5	0.056*
	Rt	Peak latency sensory (ms)	59	2.8	0.3	2.1 – 3.6	0.000**
Sensory	Lt	Peak latency sensory (ms)	51	2.7	0.4	2.1 – 3.7	0.450*
	Rt	Amplitude sensory (µV)	59	35.5	15.6	2.0 – 73.0	0.008**
	Lt	Amplitude sensory (µV)	50	39.8	17	13.0 –80.0	0.000**
	Rt	Velocity sensory(m/s)	56	57.1	6.5	47.0 –77.0	0.837*
	Lt	Velocity sensory(m/s)	50	57.8	6.2	42.0 –74.0	0.087*
	Rt	Latency motor (ms)	46	2.4	0.4	1.8 – 3.7	0.821*
	Lt	Latency motor (ms)	40	2.4	0.3	1.8 – 3.5	0.482*
Motor	Rt	Amplitude motor (µV)	46	7.3	2	1.7 – 10.9	0.006**
	Lt	Amplitude motor (µV)	40	7.4	1.8	3.4 – 11.0	0.048**
	Rt	F wave	18	27.1	4	23.1-31.1	0.978*
	Lt	F wave	14	27.5	2.4	23.7 –31.4	0.517*

Table 10 Neurophysiological findings in Patients with mild to moderate CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	24	2.6	0.5	1.6 – 3.4	0.000**
	Lt	Onset latency sensory (ms)	22	2.5	0.3	1.8 – 3.5	0.000**
	Rt	Peak latency sensory (ms)	24	3.5	0.5	2.7 - 4.7	0.000**
Sensory	Lt	Peak latency sensory (ms)	28	3.3	0.4	2.5 – 4.6	0.000**
	Rt	Amplitude sensory (µV)	24	31.7	13.9	8 – 81	0.000**
	Lt	Amplitude sensory (µV)	22	44.3	20.5	18 – 93	0.000**
	Rt	Velocity sensory(m/s)	24	54.8	10.4	41 – 81	0.000**
	Lt	Velocity sensory(m/s)	22	57.1	8.5	47 – 78	0.000**
	Rt	Latency motor (ms)	25	3.7	0.6	2.8 – 4.4	0.000**
	Lt	Latency motor (ms)	22	3.4	0.5	2.4 – 4.4	0.000**
Motor	Rt	Amplitude motor (µV)	25	6.9	2.2	3.0 – 11.5	0.000**
	Lt	Amplitude motor (µV)	22	6.8	3.1	3.3 – 15.8	0.000**
	Rt	Velocity motor (m/s)	25	55.4	4.1	51.0 –63.0	0.000**
	Lt	Velocity motor (m/s)	22	57.2	5.4	44.0 –67.0	0.000**
	Rt	F wave	16	27.3	1.8	24.0 –30.1	0.000**
	Lt	F wave	15	26.5	3.6	14.8 -29.4	0.498**

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Ulnar	Rt	Onset latency sensory (ms)	21	2	0.2	1.7 – 2.4	0.799*
	Lt	Onset latency sensory (ms)	19	1.9	0.2	1.5 – 2.3	0.056*
Sensory	Rt	Peak latency sensory (ms)	24	2.9	0.5	2.4 – 4.5	0.000**
	Lt	Peak latency sensory (ms)	22	2.9	0.8	2.3 – 6.0	0.450*
	Rt	Amplitude sensory (µV)	24	38.5	18.9	12.0 –78.0	0.008**
	Lt	Amplitude sensory (µV)	22	46.5	17.1	27.0 –84.0	0.000**
	Rt	Velocity sensory(m/s)	24	57.5	6.5	44.0 –71.0	0.837*
	Lt	Velocity sensory(m/s)	22	58.9	5.6	48.0 –67.0	0.087*
	Rt	Latency motor (ms)	23	2.4	0.4	1.9 – 3.5	0.821*
	Lt	Latency motor (ms)	13	2.4	0.4	1.8 – 3.3	0.482*
Motor	Rt	Amplitude motor (µV)	23	7.3	2.1	2.3 – 11.2	0.006**
	Lt	Amplitude motor (µV)	13	7	1.7	4.8 – 11.1	0.048**
	Rt	F wave	9	2.7	0.5	2.2 – 3.7	0.978*
	Lt	F wave	8	26.2	1.3	23.5 –28.0	0.517*

Table 11 Neurophysiological findings in Patients with mild CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	27	2.8	0.4	2.0 - 3.4	0.000**
	Lt	Onset latency sensory (ms)	26	2.7	0.4	2.0 – 3.3	0.000**
	Rt	Peak latency sensory (ms)	33	3.5	0.5	2.6 – 4.5	0.000**
Sensory	Lt	Peak latency sensory (ms)	26	3.5	0.5	2.4 – 4.5	0.000**
	Rt	Amplitude sensory (µV)	33	26.7	13.6	Aug-64	0.000**
	Lt	Amplitude sensory (µV)	32	37	17.1	14 - 93	0.000**
	Rt	Velocity sensory(m/s)	33	51.6	7.2	40 - 67	0.000**
	Lt	Velocity sensory(m/s)	32	53.1	7.6	41 - 68	0.000**
	Rt	Latency motor (ms)	35	3.8	0.5	2.9 – 4.2	0.000**
	Lt	Latency motor (ms)	31	3.6	0.5	1.9 – 4.3	0.000**
Motor	Rt	Amplitude motor (µV)	35	7.1	3.4	3.4 – 16.0	0.000**
	Lt	Amplitude motor (µV)	31	7.2	2.3	3.6 – 12.4	0.000**
	Rt	Velocity motor (m/s)	35	56.9	4.4	51.0 –65.0	0.000**
	Lt	Velocity motor (m/s)	30	57	5.9	43.0 –68.0	0.000**
	Rt	F wave	20	27.8	2.5	20.2 –31.5	0.000**
	Lt	F wave	20	27.6	1.9	24.7 –30.7	0.498**
Ulnar	Rt	Onset latency sensory (ms)	29	2.1	0.3	1.5 – 2.5	0.799*
	Lt	Onset latency sensory (ms)	27	2.2	0.3	1.6 – 2.7	0.056*
	Rt	Peak latency sensory (ms)	32	2.8	0.3	2.3 – 3.8	0.000**
Sensory	Lt	Peak latency sensory (ms)	30	3	0.4	2.2 – 3.7	0.450*
	Rt	Amplitude sensory (µV)	32	33.4	12.4	16.0 –68.0	0.008**
	Lt	Amplitude sensory (µV)	30	35.9	13.3	20.0 –73.0	0.000**
	Rt	Velocity sensory(m/s)	32	56.9	5.3	47.0 –71.0	0.837*
	Lt	Velocity sensory(m/s)	30	54.3	6.1	48.0 –76.0	0.087*
	Rt	Latency motor (ms)	29	2.6	0.4	1.8 – 3.5	0.821*
	Lt	Latency motor (ms)	21	2.5	0.4	1.9 – 3.0	0.482*
Motor	Rt	Amplitude motor (µV)	29	8.3	2	5.3 – 12.7	0.006**
	Lt	Amplitude motor (µV)	21	7.7	1.3	6.3 – 10.7	0.048**
	Rt	F wave	17	27.2	2.5	21.9 –31.2	0.978*
	Lt	F wave	10	28.4	2	24.3 –31.5	0.517*

Table 12 Neurophysiological findings in Patients with very mild CTS.

Nerves	Side	Test	N	Mean	S.D±	Range	P value
Median	Rt	Onset latency sensory (ms)	5	2.7	0.2	2.3 - 2.9	0.000**
	Lt	Onset latency sensory (ms)	5	2.5	0.3	2.2- 3.0	0.000**
	Rt	Peak latency sensory (ms)	5	3.4	0.3	3.0 - 3.7	0.000**
Sensory	Lt	Peak latency sensory (ms)	5	3.3	0.4	2.9 – 3.8	0.000**
	Rt	Amplitude sensory (µV)	5	23.8	13.6	20 - 39	0.000**
	Lt	Amplitude sensory (µV)	5	34.6	15.9	16 - 32	0.000**
	Rt	Velocity sensory(m/s)	5	53.2	4.7	48 - 59	0.000**
	Lt	Velocity sensory(m/s)	5	57.4	7.9	48 - 65	0.000**
	Rt	Latency motor (ms)	5	3.8	0.6	3.2 – 3.6	0.000**
	Lt	Latency motor (ms)	5	3	0.6	2.2 – 4.1	0.000**
Motor	Rt	Amplitude motor (µV)	5	5.9	2.5	3.7 – 10.0	0.000**
	Lt	Amplitude motor (µV)	5	6.2	3.6	3.9 – 12.6	0.000**
	Rt	Velocity motor (m/s)	5	59	1.4	57.0 - 61.0	0.000**
	Lt	Velocity motor (m/s)	5	56.2	6.1	49.0 - 62.0	0.000**
	Rt	F wave	1	27.7	0	27.7	0.000**
	Lt	F wave	1	26.5	0	26.5	0.498**
Ulnar	Rt	Onset latency sensory (ms)	4	2.1	0.2	1.9 - 2.4	0.799*
	Lt	Onset latency sensory (ms)	5	1.9	0.2	1.7 - 2.3	0.056*
	Rt	Peak latency sensory (ms)	4	2.8	0.4	2.5 - 3.2	0.000**
Sensory	Lt	Peak latency sensory (ms)	5	2.7	0.3	2.3 – 3.0	0.450*
	Rt	Amplitude sensory (µV)	4	32.8	11.8	24.0 –50.0	0.008**
	Lt	Amplitude sensory (µV)	5	44.6	17.5	26.0 –67.0	0.000**
	Rt	Velocity sensory(m/s)	5	54.3	3	51.0 –58.0	0.837*
	Lt	Velocity sensory(m/s)	5	57.8	5.5	48.0 –61.0	0.087*
	Rt	Latency motor (ms)	5	2.6	0.1	2.5 – 2.7	0.821*
	Lt	Latency motor (ms)	5	2.2	0.2	1.9 – 3.0	0.482*
Motor	Rt	Amplitude motor (µV)	5	8.5	2.7	5.6 – 12.1	0.006**
	Lt	Amplitude motor (µV)	5	7.3	1.8	6.1 – 10.1	0.048**
	Rt	F wave	1	27.1	0	27.1	0.978*
	Lt	F wave	0	-	-	-	0.517*
One way ANOVA p value more than 0.05 that is considered as statistically insignificant.							
*Insignificant.							
One way ANOVA p value less than 0.05 that is considered as statistically significant.							
**Significant.							

Discussion

Many combined clinical and neurophysiological approaches exist for assessing median nerve entrapment at the wrist [10-13]. The majority of studies used different SNAP and CMAP parameters to provide a scale for grading the severity of CTS. Some used the conduction velocity, other used onset (distal) latency, peak latency and some used only the amplitude for grading the severity of CTS [14,15].

In this study we used a modified neurophysiologic grading scale to assess CTS severity.

This is modified from the Italian and Canterbury scales. We utilized the SNAP and CAMAP distal latency as well as peak latency in the median sensory fibers. As in very severe cases distal latency might be obliterated because of its enormously low amplitude and possibly the base line noise induced by the machine might cause difficulty in determining the onset latency.

According to this scale, the 671 patients with CTS included in this study, were grouped into seven categories; patients with very severe CTS showed absent SNAPs; or when recorded their distal latency was more than 6.9 ms and peak latency was more than 9.2 ms, and their CMAPs were either absent or showed enormously prolonged distal latency of more than 7.1 ms. The second group is those of severe CTS, identified by their absent SNAPs or distal latency when obtained is more than 5.6ms and peak latency is more than 7.3 ms, and their CMAPs distal latency is less than 7.1 ms. The third group is those of moderate to severe CTS, their distal latency is more than 3.9 ms and peak sensory latency is more than 6.1 ms, and their motor distal latency is less than 4.9 ms. The fourth group is those of moderate CTS, their

sensory distal latency is more than 3.4 ms and peak sensory latency is more than 4.6 ms, and their motor distal latency is less than 4.5ms. The fifth group is those of mild to moderate CTS, their sensory distal latency is more than 3.4 ms and peak sensory latency is more than 4.6 ms, and their motor distal latency is at the upper limit of normal. The sixth group is those of mild CTS, their sensory distal latency at the upper limit of normal and the peak sensory latency is more than 4.4 ms, and their motor distal latency is normal. The seventh group is those of very mild CTS, shows bilateral normal NCS, however the symptomatic hand shows considerable decrease in NCS parameters than the other hand.

Our results were in agreement with the Italian [10] scale with some difference. Most of our very severe grade showed absent sensory and motor response as in the extreme Italian grade of CTS. However in this work we used to average those few signals when possible to be recorded. They were of significant prolonged distal and peak latencies, enormously low amplitude and remarkably slowed conduction velocity. These parameters were considered as absent responses by some authors [10,11,16,17]. Also these findings were in accordance with the Canterbury scale 4 to 6 grades with the same differences explained above. They showed that in their extremely severe grade six, motor response could be recorded but their amplitude is less than 0.2 μV peak to peak; in the mild and very mild grades of these results, few minor difference were elicited when compared to the Italian, they summed these two grades as one minimal grade, but used comparative tests to determine the severity of the grade. Here in our very mild grade we used a comparative test with the other hand. As the NCS was normal in both hands, however showed considerable drop in SNAP and to a lesser extent CMAP parameters in the symptomatic hand. With regard to our mild grade we found that peak latency is usually prolonged while onset latency is at the lower limit of normal which is slightly different from both Italian and Canterbury scales where they showed that the conduction velocity is mildly slowed. This difference could be attributed to the normal parameters of each lab.

These results showed a trend towards more severe electrophysiologic CTS in our study group than in those reported in the literature [1,5,10,11,16,18-23]. Also these compared favorably with the existing literature in regard to the classic history of CTS [10,15,16,24] with some discrepancies, as our severe and very severe grades of CTS showed considerably higher number of patients with obvious weakness and wasting of the APB muscles. This difference could be attributed to many factors: firstly as 66.6% of our patients are above 50 years, aging was found to account for the disease severity [10,11]. Secondly patients (particularly females) used to ignore their pain unless extremely severe, for which they receive by their own simple analgesics and pain killers. Thirdly: patients seek medical consultation very late after a long duration of symptoms; however the diagnosis might not be reached because they might be seen by junior practitioner or those not in the field of neuroscience. Fourthly the delayed introduction of NCS and presence of very few machines in Sudan may contribute to our findings.

The study showed F wave prolongation in the right and left median nerve in compare with the severity and clinical grading which makes the F wave latency one of the important electrophysiological parameters in evaluating carpal tunnel syndrome; and this is in agreement with other studies [25-27].

The results show a ratio of 4 females to 1 male which is in consistence with similar many studies [11,28]. The increased incidence in women may be partly due to hormonal factors [11,29].

Conclusion

Studies have shown that intense repetitive motion, vibration and extreme postures of the hand and wrist during job performance may contribute to the development of carpal tunnel syndrome. From these results, jobs like driving, teaching, manual workers, or home duties like cooking and cleaning may temporarily increase pressure in the carpal tunnel, which threatens the viability of the median nerve and affects normal hand function [5,30,31].

Bilateral CTS was found in 418 patients, and more frequently in the dominant hand. This agrees with other studies where bilateral CTS was found to be a frequent finding. The dominant hand is usually affected first and produces the most severe pain [11,32]. Moreover patients with bilateral CTS have a greater incidence of familial disease than those with either unilateral disease or no carpal tunnel syndrome [11,33].

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