The Value of Central Wave Segment in a Focal Nerve Entrapment (F-wave) parameters of Both Median and Ulnar Nerves in Patients with Carpal Tunnel Syndrome

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Abstract

This study aims to assess the effect of focal median nerve injury in patients with carpal tunnel syndrome (CTS) on F-wave of median and ulnar nerves, determine the importance of F-wave inversion in the patients with mild CTS and find out the effect of increasing body mass index (BMI) on median nerve and its association with the severity of CTS. The study was conducted in neurophysiological unit at Merjan Medical City, in the period from September 2015 to March 2016. Including (139) patient with clinical presentation of CTS as well as positive NCS with age ranged from (20-60) years. The study also includes(139) apparently healthy person as a control group of which were matched in age, gender and BMI to patients group. F-wave of median, ulnar and median-ulnar nerve difference are highly significant ($p < 0.01$) in patients than control group. There is a significant association between mean median F wave minimal latency (FWML) and severity of CTS as most severe cases have higher mean. There is a significant relationship between F- wave inversions in mild CTS as compared to control group. Body mass index acts as an independent risk factor to develop CTS and most of patients with CTS are obese and overweight. There is a significant association between BMI and severity of CTS and most cases with mild, moderate and severe are obese ($P < 0.05$). The electrophysiological findings of sensory and motor parameters of median nerve including (latency, amplitude and conduction velocity) between patients and control groups all show highly significant difference ($p < 0.01$).

Key words: CTS, FWML, F-inversion, BMI, Median nerve

قيمة الموجة المركزيه (الموجة ف) للعصب الوسطي والرسغي للمرضى المصابين بمتلازمة النفق الرسغي

الخلاصة

تهدف هذه الدراسة إلى معرفة تأثير إصابة العصب المتوسط الموضعي في المريض المصاب بمتلازمة النفق الرسغي على متوسط الموجة ف للعصب المتوسط والعصب الزندي، تحديد أهمية انقلاب الموجة ف في المرضى الذين يعانون من متلازمة النفق الرسغي ذو الشدة الخفيفة و دراسة تأثير زيادة مؤشر كتلة الجسم على العصب المتوسط وارتباطه بشدة الاصابة بهذه المتلازمة. أجريت هذه الدراسة في وحدة الفسلجة العصبية في مدينة مرجان الطبية، في الفترة من أيلول 2015 إلى مارس ٢٠١٦. تضمنت الدراسة مجموعة من المرضى الذين يعانون من اعراض سريرية لمتلازمة النفق الرسغي بالإضافة الى تأكيد هذه الاعراض عن طريق دراسة توصيل الاعصاب التي اظهرت ان جميع المرضى مصابين بالمتلازمة اعلاه ويبلغ عددهم ١٣٩ مريض تراوحت أعمارهم بين ٢٠-٦٠ سنة. وتشمل الدراسة أيضا ١٣٩ شخص من الاصحاء كمجموعة مقارنة وتطابقت هذه المجموعة مع المرضى من ناحية العمر والجنس ومؤشر كتلة الجسم. أظهرت الدراسة أن علاقة الموجة ف للعصبين المتوسط و الزندي والفرق بين الموجتين لكلا العصبين هامة جدا ($P < 0.01$) في المرضى الذين يعانون من متلازمة النفق الرسغي بعكس مجموعة الاصحاء. كما اكدت الدراسة وجود ارتباط كبير بين متوسط كمون الموجة ف للعصب المتوسط وشدة متلازمة النفق الرسغي حيث أن معظم الحالات الشديدة كانت لديها معدلات متوسط عالية للموجة ف. هناك علاقة ذات دلالة إحصائية بين انقلاب الموجة ف في الحالات خفيفة الشدة لمتلازمة النفق الرسغي مقارنة بمجموعة الاشخاص الاصحاء. كما بينت الدراسة ان مؤشر كتلة الجسم يعمل كعامل خطر لحدوث هذا المرض، ومعظم المرضى المصابين بمتلازمة النفق الرسغي يعانون من السمنة و زيادة الوزن. اكدت الدراسة وجود علاقة ارتباط كبيرة بين مؤشر كتلة الجسم وشدة متلازمة النفق الرسغي حيث ان معظم المرضى الذين يعانون من اصابات خفيفة، معتدلة وحادة كانوا يعانون من السمنة المفرطة ($P < 0.05$). وكشفت الدراسة ان معايير الدراسة الكهروفسيولوجية الحسية والحركية للعصب المتوسط بما في ذلك (الكمون، السعة وسرعة التوصيل) بين المرضى ومجموعة الاصحاء عن تغييرات بفروقات معنوية عالية ($P < 0.01$).

الكلمات المفتاحية: متلازمة النفق الرسغي, الموجة ف, انقلاب الموجة ف, مؤشر كتلة الجسم.

1-Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment mononeuropathy and costly disease among adults in working-aged group. It is the best identified and most carefully studied entrapment neuropathy and commonly occurs as a result of localized compression of median nerve (MN) in carpal tunnel [1]. The frequency of carpal tunnel syndrome greatly increased due to the introduction of new technology, including computers, smart phones and tablets and it has been reported to represent about 90% of all entrapment neuropathies [2]. Carpal tunnel syndrome is likely to affect 3% - 6% of United States adults and females are 3 times more affected than males specially those between 40 and 60 years [3].

The characteristic symptoms of carpal tunnel syndrome are numbness, tingling or pain in the distribution of the median nerve (the thumb, index, and middle fingers, and the radial half of ring finger) and sometimes affect the whole hand that is frequently worse at night and causes awakening from sleep. Pain may become more persistent, and may include the forearm, elbow, arm and shoulder. Weakness may be observed in hand grip and opposition of the thumb [4]. It is confirmed that the most important predisposing factors for idiopathic CTS are old age, being female, family history and size of the carpal tunnel, while repeating hand movement, cold weather, sleep positioning and obesity are considered the least important [5] [6].

Nerve conduction study is considered as the gold standard in the identification of CTS as it is an objective test that gives details on the physiological fitness of the median nerve (MN) runs across the carpal tunnel [7].

The F-wave is a long latency muscle action potential occurred after supramaximal stimulation to a nerve. Although elicitable in a different muscles, it is the best obtained in the small foot and hand muscles. It is generally believed that the F-wave is elicited when the stimulus travels antidromically along the motor fibers and reaches the anterior horn cell at a critical time to depolarize it. The response is then fired down along the axon and causes a minimal contraction of the muscle. Usually, ten to twenty F-waves are obtained and the shortest latency F-wave among them is used [8].

F-wave parameters such as mean median F-wave latency, median-ulnar nerves F-wave latency difference and F-wave inversion are valuable for screening patients with carpal tunnel syndrome and confirming their diagnosis [8] [9] [10].

2-Materials and Methods

2.1-Patients

This case/ controlled study include 139 patients (124 female and 15 male) and their ages ranged from (20_60 years old). Those patients presented with signs and symptoms of carpal tunnel syndrome and are apparently free from any systemic and / or local disease that might affect the nerve function. The data are analyzed at the patient level and not at the hand level. The procedure was explained to them and their oral consents were taken to be included in the study. The patients are included in the study if they had one or more of the following in one or both hands and for at least one month confirmed by nerve conduction study as carpal tunnel syndrome:

1- Paresthesia or tingling sensation in all fingers or in the distribution of the median nerve in the hand (the thumb, second, middle and lateral aspect of the ring finger).
2- Paresthesia or hand pain that awaken the patient from sleep.
3-Paresthesia relieved by shaking or wavy hand movement.
4-Wasting of thenar muscle.

Patients with one or more of the following conditions were excluded from the study: 1-Diabetes mellitus. 2. Hypothyrodism. 3. Renal failure. 4. Acromegaly. 5. Rheumatoid arthritis, systemic lupus erthymatosus and scleroderma. 6. Pregnant women.

7. Cervical pathology. 8. History of any systemic neurological disease. 9. History of wrist trauma or fracture. 10. History of hand surgery.11. Women on oral contraceptive pills

(OCCP) and patients on corticosteroids.

The same exclusion criteria were used to select the control group and their oral consents were taken to be included in the study.

2.1.1 - Control

139 apparently healthy persons (121 female and 18 male) assessed by specialist were selected randomly as a control group from rheumatology department at Marjan Medical City. They were almost matched similar to patients in age ranges, sex, occupation, body mass index and their residence. Their permission was taken to be included in this study.

Instruments The following table (Table 1) refers to the main instruments used in this study and their sources.

Nerve Conduction Study Procedure Each participant has two motor nerves and two sensory nerves tested (median and ulnar nerves). All measurements were done in a quiet environment in the examining room with a modulated temperature to be 25 to 28 C°, and they were kept in this room for at least 15 minutes before being examined [11]. Limb temperatures were measured using a adhesive skin patch and were maintained between 33- 36C° by exposing the patient to radiant heater when needed, especially during Winter, and the skin was prepared when necessary using abrasive skin cleanser [11].

Table (1): Instruments used in the study

No.	Instruments	Company	Source
1.	Nerve conduction study machine	Nicolate Biomedical	USA (2004)
2.	Neurological hammer	Eschmann	UK
3.	Weight and height scale	Phelips	France
4.	Flexible tape measure		China

Maximal responses are obtained using electrical stimuli. Distal latency, conduction velocity and waveform amplitude, duration and shape were assessed and recorded for each nerve at each stimulus site [12].

A-Sensory nerve conduction studies (SNCS)

The supramaximal stimulating current is kept below threshold for motor fibers especially in the mixed nerves, since sensory fibers generally had lower threshold of stimulation than that of motor fibers [13] (Aminoff, 2012).The sites of the electrodes SNCS for the tested nerves were (**Median nerve**) the stimulation was applied with surface electrode at the plantar aspect of forearm near the wrist joint between the tendons of palmaris longus and flexor carpi radialis .

The recording electrode was placed over the median nerve at the index finger [14] and (**Ulnar nerve**) the stimulation was applied with surface electrodes at the wrist, just radial to the flexor carpi ulnaris. The recording electrode was placed over the ulnar nerve around the fifth digit [13] .

-B-Motor nerve conduction studies (MNCS)

In motor nerve conduction studies, the nerve is stimulated at multiple points along its course, by applying stimuli at distal and proximal sites of the nerve and recording from the muscle innervated by that nerve. The stimulus intensity must be high enough to activate all nerve fibers during stimulation [15]. The sites of the electrodes for MNCS of the tested nerves were (**Median nerve**), the stimulation was performed at two sites:

1. **Distally:** at the wrist, 8 cm proximal to the recording electrode, over the skin between the tendons of palmaris longus and flexor carpi radialis muscles.
2. **Proximally:** at the elbow, in the medial aspect of the anticubital fossa, just lateral to the brachial artery.

Surface electrodes are placed over the prominence of abductor pollicis brevis muscle, between the metacarpophalangeal joint of the thumb and the midpoint of the distal wrist crease [16] and (**Ulnar nerve**), the stimulation was performed at two sites:

1. **Distally:** at the wrist, 8 cm proximal to the recording electrode, and just over the flexor carpi ulnaris tendon.
2. **Proximally:** at the elbow just distal to the ulnar groove.

Surface electrodes are placed at the abductor digiti minimi muscle, on a point mid-way between the distal wrist creases and the crease at the base of the fifth digit [17]

C- F.wave

For recording the F-wave parameters, the skin and electrodes preparations and handling of the subjects were just like that of the NCS and for the same reason. The only difference from the NCS is that the cathode of the stimulating electrodes was placed proximally, instead of the anode. Square pulses of 0.1 msec. du- ration, a frequency of 1 stimulus / sec. and negative polarity were used.

The stimulus intensity is increased gradually to the supramaximal level that is 50% higher than the current producing the maximal direct muscle response. 15 trials were displayed on the storage oscilloscope automatically shifting successive sweeps vertically, a facility that is provided by the Nicolet F-wave program, and the clearly identified F-waves were recorded and automatically analyzed, manual adjustment of the pointers also is quite possible and easy.

The electromyography setting is as follows: The sweep speed: 10 msec / division. The amplifier frequency: 20 Hz-2 KHz. The input sensitivity for split 1: 1 mV / division for split 2: 100-200 μV / division.

The latency of the F-wave is measured from the stimulus artifact to the onset of the first negative or positive deflection from the baseline for the fastest (F min) that contribute to the antidromic activation of the motor neurons [18] [19] [20] [11].

F-wave inversion can be defined as when the median of F-wave minimal latencies (FWML) exceeds a normal ipsilateral ulnar FWML by 1 ms [9].

6.1- Statistical analysis

Statistical analysis Statistical analysis is carried out in this study by using SPSS (Statistical Package for Social science) program, version 19. Categorical variables are expressed as frequencies and percentages. Continuous variables are expressed as mean and standard deviation (M ± SD). Student t-test is used to estimate differences between control and patients groups in continuous variables and Chi-square test is used to estimate differences between groups in categorical variables. The differences are considered significant when the probability (p) is less than 0.05 ($p < 0.05$) and highly significant when the probability (p) is less than 0.01 ($p < 0.01$) [21]

Results and Discussion

7.1-F-wave study

The results of F-wave studies of both median and ulnar nerves show that there are highly significant differences between patients with CTS and a control group in median F-wave minimal latency (m-FWL), ulnar F-wave latency (u-FWL) and median-ulnar nerve F- wave latency difference m-u FWLD ($p < 0.01$), (Table 2).

Table (2): F-wave studies in patients and control groups

Variable	Patients (Mean ± SD)	Control (Mean± SD)	P value
Median F-wave latency (m-FWL) (ms)	27.51 ± 2.38	22.59 ± 0.97	P < 0.01**
Ulnar F-wave latency (u-FWL) (ms)	25.93 ± 1.86	23.57 ± 1.26	P < 0.01**
median-ulnar nerve F-wave latency difference (m-u FWLD) (ms)	1.62 ± 2.14	¯0.73 ± 1.04	P < 0.01**

** P value < 0.01 is highly significant

7.1.1 Relation between severity of carpal tunnel syndrome patients and mean median F-wave latency

The results of this study show a significant relationship between severity of CTS patients and mean of median F-wave latency, (Figure 1).

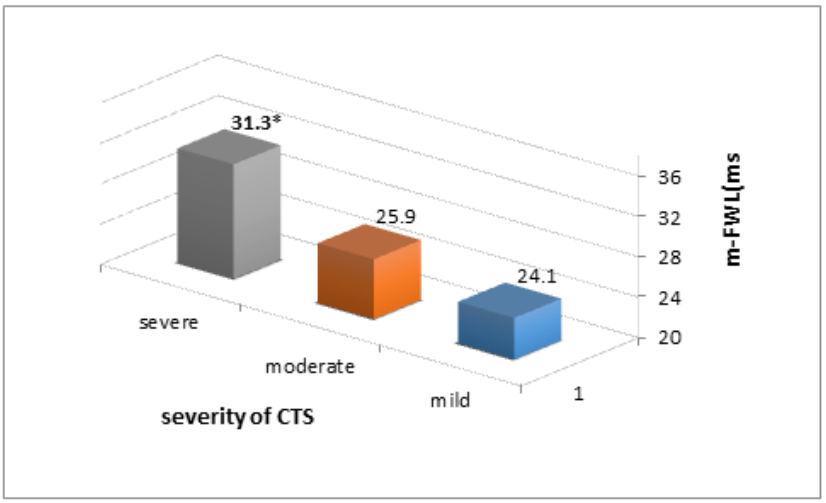

Figure (1): Relation between severity of CTS patients and mean of median F-wave latency

Distribution of F-wave inversion in mild carpal tunnel syndrome and control group

Out of (62) patient with mild CTS (32) patient have F-wave inversion (51.6%) while in only (4) of control group is present (2.9%). So, F- wave inversion is significant in mild CTS, (Figure 2).

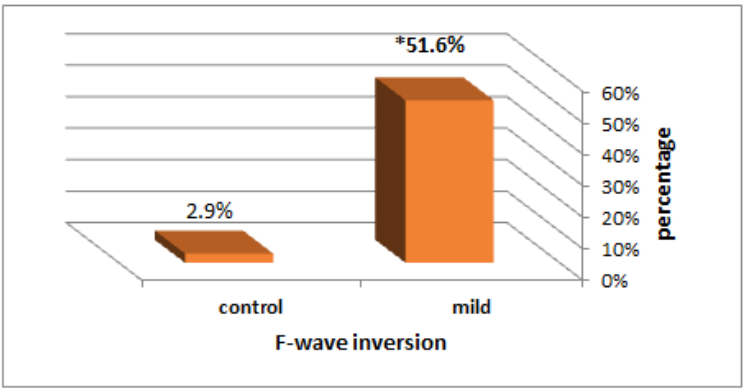

Figure (٢): Distribution of F-wave inversion in mild carpal tunnel syndrome and control group

Severity of carpal tunnel syndrome and body mass index BMI The relation between BMI and severity of CTS are shown in (Table 3). Most patients with mild, moderate and severe are obese ($P < 0.05$).

Table (3): Severity of carpal tunnel syndrome and body mass index in patient group

Severity by NCS	BMI (kg/m^2)		
	Normal (18.5-24.9)	Over weight (25 -29.9)	Obese ≥ 30
Mild	7.2%	42.6%	50.2%
Moderate	4.3%	22.3%	73.4%
Severe	9.4%	15.4%	75.2%
P value	P < 0.05*		

BMI: body mass index, NCS: nerve conduction study, *P value < 0.05 is significant

The results of nerve conduction study of median nerve show prolonged distal sensory latency and distal motor latency in patient group as compared to the control and decrease sensory nerve action potential, compound muscle action potential, sensory and motor conduction velocity in the patients as compared to the control.

4-Discussion

The results of this study show that F-wave latency of median and ulnar nerves together with median-ulnar nerve F-wave latency difference were significantly higher in patients than control group ($P < 0.01$), (Table 2).This finding is confirmed by other scientists such as [22] [23] [24] [25] [26] [10].

The results of this study show a significant relationship between severity of CTS patients and mean median F-wave latency in which there is an increment in mean median FWML as the severity of CTS increase, (Figure 1).This finding is in consistence with [8] Yazdichi *et al.*, 2005 and Mondelli and Aretini, 2014. Mondelli and Aretini, 2014 found

that all F-wave parameters and their sensitivities increased in most severe cases of CTS.

The data of this study revealed that F-wave inversion is significant in patients with mild carpal tunnel syndrome as compared to control group, (Figure 2).This result is in consistence with [9] and[27]. While, it disagrees with [28].

The relation between BMI and severity of CTS shows that there are significant differences among patient groups ($P < 0.05$), (Table 3). Most patients with mild, moderate and severe CTS are obese. However, results are in consistence with [29] and [30]. While, it disagrees with [31] [32] and [33] who stated that there was no significant difference between the three grade severity of CTS and BMI.

The results of this study demonstrate that the distal sensory latency (DSL) and distal motor latency (DML) of MN were significantly higher in patients than control group ($P < 0.01$), while sensory nerve action potential (SNAP), sensory conduction velocity (SCV), compound muscle action potential (CMAP) and motor conduction velocity (MCV) of MN were significantly lower in patients than control group ($P < 0.01$).

This finding agrees with other scientists such as [34] [35] [36] [37] [38] [39] [40].

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