Appearance of F-wave during electrophysiological study of carpal tunnel syndrome

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Abstract

To evaluate the appearance of F-wave in patients with carpal tunnel syndrome through electrophysiological study. Fifty patients with carpal tunnel syndrome(CTS) of the median nerve who were diagnosed clinically and through electrophysiological study for median and ulnar nerve. Fifty normal subjects of healthy volunteers of similar age and gender were compared to the patients and examined for nerve conduction study. Nerve conduction study for median and ulnar nerve (motor and sensory) were done for each patient and subject in neurophysiology department to study the distal motor and sensory latency (DML,DSL), compound motor and sensory action potentials (CMAP,SNAP) ,motor and sensory nerve conduction velocities (MNCV,SNCV) and F-wave latencies(maximum, mean and minimum). There are prolonged distal motor and sensory latency, decrease of compound motor and sensory action potential, decrease of motor and sensory nerve conduction velocity and prolongation of F-wave latencies(minimum, mean and maximum.) of the median nerve (motor) in carpal tunnel syndrome patients compared with the controls and these differences are statistically significant p-value < 0.01. The F-wave parameters for median nerve must be added in electrophysiological study to establish the diagnosis of carpal tunnel syndrome.

Key word: F-wave, carpal tunnel syndrome, median nerve, ulnar nerve.

الخـلاصـــة

دراسة ظهور موجة (أف) عند أجراء فحص توصيل الأعصاب الكهربائي للعصب الوسطي لدى المرضى المصابين بمتلازمة ضغط العصب الوسطي . شملت الدراسة (50) شخص من الحالات الطبيعية و (50) مريض من المرضى المصابين بمتلازمة ضغط العصب الوسطي . أجريت الدراسة في قسم المفاصل وقسم الجملة العصبية في مستشفى ابن سينا التعليمي في الموصل للفترة من 1 اذار 2011 ولغاية 30 كانون الاول 2011. تم إملاء الاستمارة الخاصة بالمعلومات للمرضى وإجري الفحص الطبي السريري والشعاعي للكفين والفقرات العنقية لجميع المرضى المصابين بمتلازمة ضغط العصب الوسطي . تم إجراء فحص توصيل الأعصاب الكهربائي للعصب الوسطي والزندي (الحسي والحركي) لدراسة الكمون العصبي القاص (الحسي والحركي) وسعة العصب الحسي والحركي (المدى) وسرعة توصيل العصب (الحسي والحركي) وموجة (أف) للعصب الوسطي الحركي. عند مقارنة الكمون العصبي القاص (الحسي والحركي) وسعة العصب (الحسي والحركي) وسرعة توصيل الأعصاب للعصب الوسطي والزندي (الحسي والحركي) للحالات الطبيعية والمرضى المصابين بمتلازمة ضغط العصب الوسطي تبين أن هناك استطالة في زمن الكمون العصبي القاص (الحسي والحركي) وقصور في سعة العصب (الحسي والحركي) فضلا على بطء في سرعة توصيل العصب (الحسي والحركي) عند المرضى المصابين بمتلازمة ضغط العصب الوسطي مقارنة بالحالات الطبيعية. وكان الفرق بينهما معنويا من ناحية التحليل الإحصائي . كما أظهرت الدراسة أن هناك استطالة في زمن الكمون العصبي القاص لموجة (أف) للعصب الوسطي (الحركي) للمرضى المصابين بمتلازمة ضغط العصب الوسطي مقارنة بالحالات الطبيعية وكان الفرق بينهما معنويا من ناحية التحليل الإحصائ ي. كما ظهر أن هناك استطالة في زمن الكمون العصبي القاص لموجة (أف) للعصب الوسطي (الحركي) مقارنة بالعصب ألزندي (الحركي) للمرضى المصابين بمتلازمة ضغط العصب الوسطي وكان الفرق بينهما معنويا من ناحية التحليل الإحصائي . يجب أدراج فحص

موجة (أف) عند أجراء فحص توصيل الأعصاب للعصب الوسطي (الحركي) للمرضى المصابين بمتلازمة ضغط العصب الوسطي.

Introduction

Carpal tunnel syndrome (CTS) is the most common compressive neuropathy, patients may have numbness, tingling in the radial four fingers, night awakness accompanied by a positive Tinel's, Phalen's, or carpal tunnel compression test. It frequently requires surgical therapy [1,2,3,4]. The condition is usually bilateral, although the dominant hand tends to be more severely affected[5,6]. The etiology of this syndrome is diverse, although a significant number of these conditions result from median nerve entrapment at the transverse carpal ligament resulting in median neuropathy at the wrist[7] . Utility of electrodiagnostic studies is still a matter of controversy, although many practitioners recognize their usefulness in evaluating CTS. A consensus statement regarding the utility of various electrodiagnostic tests in the evaluation of CTS has been published[8]. The most informative tests for CTS diagnosis are sensory nerve conduction over palm-wrist segment and terminal latency of median nerve. Classic abnormalities in these tests are abnormal sensory conduction over the tested segments and prolonged terminal latency. With more severe CTS cases, electro diagnostic study (EDX) usually shows some secondary axonal loss. Axonal injury is reflected in reduced amplitude and area of the compound motor action potential (CMAP) in response to the stimulation at any point along the nerve [9]. F-wave is a long latency muscle action potential obtained in the small foot and hand muscles. It is elicited when the supramaximal stimulation 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. Conventionally, ten to twenty F-waves are obtained and the shortest latency F-wave among them is used. F-response shape was variable, the majority containing two or more negative peaks. F-response amplitudes tended to be a relatively small proportion of the compound M-response, with median F\M values ranging from 0.8% to 4%. [10,11] . Measurements in unpublished cadaver studies have demonstrated that the length of the median nerve from the nerve roots to the abductor pollicis brevis (APB) is shorter than the length of the ulnar nerve from the nerve roots to the abductor digiti minimi (ADM). As a lesser distance was involved, it was reasoned that the median nerve F-wave minimal latencies (FWML) to the APB would be less than that of the ulnar nerve to the ADM [12]. The aim of the study is to evaluate the appearance of F-wave in patients with carpal tunnel syndrome through electrophysiological study and to compare these finding with the normal subjects and to study the relation between the severity of median nerve injury and the F- wave parameter finding.

Materials and Methods

The study has been conducted at the Rheumatology and Neurophysiology Department in Ibn- Sina Teaching Hospital, in Mosul, during the period from 1st of March 2011 to 30th of November 2011. Fifty patients (39 female & 11 male) with carpal tunnel syndrome of median nerve whose ages were above 20 years participated in this study from out

patients consulting Rheumatology Department diagnosed clinically and sent for electrophysiological study for median and ulnar nerve(motor and sensory). Fifty normal subjects(40 female and 10 male) with similar age and gender compared to patients were included in this study and they were subjected for nerve conduction study also. Full history and clinical examination of the locomotor and neurological system were done for all. X-ray of both hands and cervical spine (lateral and anterior view) were done for all patients. Patients were excluded from the study for the following reasons: history of neurologic disease, hand surgery, hand trauma, refusal to participate in the study, diabetes mellitus, radiological findings of cervical spine disc prolaps or asteoarthritis, chronic renal failure, connective tissue disorders and patients who had no electrophysiological abnormalities. All the patients and controls were subjected to the follow electrophysiological tests. Nerve conduction study for median and ulnar nerve (motor& sensory) were done for each patient and subject in the neurophysiology department, to study the distal motor and sensory latency (DML, DSL), compound motor and sensory action potentials (CMAP, SNAP), motor and sensory nerve conduction velocities(MNCV,SNCV) and F-wave latencies (maximum, mean and minimum). The procedure was explained for the patients. The room temperature was kept above 26^{o}C; the axillary temperature was measured by thermometer. Before the application of the surface electrodes, the skin was prepared.

All the patients had clinical criteria for diagnosis of CTS. Standard electro diagnostic study was made and using the criteria of the American Association of Electrodiagnostic Medicine (AAEM) [12,13,14]. Normal ranges calculated according to Shin J Oh. and these measures were compared with results of tests on patients[15]. Two of the following criteria for abnormal values were accepted to identify the patients with CTS[16]:

1) Antidromic sensory conduction velocity for the wrist-second digit segment less than48.2m/s.
2) The difference between median and ulnar sensory nerve distal latencies with recording from the fourth digit (recording-stimulation distance was 14cm) exceeding0.5ms.
3) Distal motor latency to abductor pollicis brevis muscle greater than 4.2ms.

According to electrophysiological testing results, the patients were grouped into mild, moderate or severe CTS [16]:

Mild CTS: Prolongation of median distal sensory latency >3.5 ms or relative prolongation of median compared to ulnar distal sensory latencies over identical distances.

Moderate CTS: Reduced median SNAP amplitude (<50% compared to unaffected side or <25mv) or prolonged median motor distal >4.5 ms.

Severe CTS*:* Reduced median CMAP amplitude (<50% compared to unaffected side or <4mv) denervation of median innervated muscles on needle exam.

The CMAP was recorded with the active recording surface electrode placed on the abductor pollicis brevis muscle (APB), the reference electrode was placed 3 cm distal to the recording electrode and the ground electrode placed between the stimulating electrode at the wrist and the active electrode, the distance between the

stimulating electrode and the recording electrode was 8 cm.

Sensory nerve studies were carried out in an antidromic manner. The stimulation of ulnar and median nerve was carried out at 14 cm from the finger recording electrode; the recording electrode was placed at the index finger for the median nerve and the fifth digit for the ulnar nerve. F-wave studies[17]; Ten consecutive F-waves were obtained by supra maximal stimulation in both the median and ulnar nerves(motor) at the wrist. The recording surface electrode was placed over the APB for median, and ADM for the ulnar nerve, the ground electrode was placed on the dorsum of the hand. The F-wave latencies(minimum, mean and maximum) for ulnar nerve was recorded.

The electrophysiological data for median and ulnar nerve (motor and sensory) were grouped separately for controls and patients. The ulnar F-wave minimal latency(FWML) was subtracted from the median FWML to calculate FWML difference for each limb for controls and patients separately: FWML - difference= Median FWML-Ulnar FWML. The Statistical Package for Social Sciences (SPSS version 17, Chicago) was used for analysis. Descriptive characteristics of the study patients were calculated as mean ± SD and range for continuous variables, and as percentages for categorical variables. Student's t-test was used for comparison between different groups. A p-value of <0.05 was considered statistically significant [18].

Results

In the present study the total number of CTS patients and normal subject were (50) for each; with matched age and sex, the mean ages for the CTS patient were (40±14.32) and the mean ages for normal subjects were (38 ±13.21). The sex distributions in CTS patients were 11 males (22%) and 39 females (78%), while for normal subjects were 10 males (20%) and 40females (80%). The ratio of male to female for CTS patients was nearly (1\4). Thirty six(72%) of CTS patient show right hand involvement and 14(28%) patient show bilateral hand involvement.

Table(1): There are prolong of DML, decrease of CMAP, decrease of NCV and prolong of F-wave latencies(min, mean and max.) of the median nerve (motor) for the CTS patients compared with controls and these differences are statistically significant p-value < 0.01.

Table(2): Show there are prolong of DSL, decrease of SNAP and decrease of NCV for the median nerve(sensory) for the patients than controls and these differences are statistically significant p-value < 0.01.

Table(3): Show there is prolong of DML, decrease of CMAP, decrease of NCV and prolong of F-wave latencies(min, mean and max.) of the median nerve (motor) for the CTS patient compared with ulnar nerve (motor) of the CTS patients and these differences are statistically significant p-value < 0.01.

Table(4): Show that; there are prolong of DSL, decrease of SNAP, decrease of NCV of the median nerve (sensory) for the CTS patients than that of ulnar nerve (sensory) of the CTS patients and these differences are statistically significant p-value < 0.01.

Table(5): F-wave minimal latency(FWML) difference between median and ulnar nerve for CTS patients which appear to be statistically significant P<0.01. While the F-wave minimal latency(FWML) difference between these nerves in normal

subjects are not significant as shown in this table.

Table (6): The F-wave latencies (maximum, mean and minimum) for mild, moderate and severe CTS patients compared with the controls; the differences are statistically significant $p<0.01$.

Table(1):- Distal motor latency(DML),compound motor action potential(CMAP),nerve conduction velocity(NCV) and F-wave latencies(minimum, mean and maximum) of median nerve(motor) for CTS patients and controls.

Parameters	Patient No =50	Control No =50	P-value
DML(ms)	Mean 5.244±1.327 Range 4.00-10.10	Mean 3. 242 ± 0.406 Range 2.60 - 3.90	< 0.01**
CMAP(mv)	Mean 8.324±7.501 Range 2.00-15.10	Mean 12.482 ± 4.700 Range 5.90 - 19.90	< 0.01**
NCV(m\s)	Mean 46.712±6.769 Range 30.40-73.10	Mean 54.332 ±6.619 Range 45.80-74.20	< 0.01**
F- MAX(ms)	Mean 33.714±5.323 Range 27.80-37.50	Mean 26.4380±1.647 Range 23.60-30.90	< 0.01**
F-MEAN(ms)	Mean 30.786±3.139 Range 25.80-37.20	Mean 25.288 ±1.443 Range 22.30-28.20	< 0.01**
F-MIN(ms)	Mean 28.342±3.316 Range 21.90-37.60	Mean 24.0320 ±1.405 Range 21.10-27.20	< 0.01**

**p < 0.01 very significance.

Table(2): Distal sensory latency(DSL),sensory nerve action potential(SNAP) and nerve conduction velocity(NCV) of median nerve(sensory) for CTS patients and controls.

parameters	Patient No =50	Control No =50	P-Value
DSL(ms)	Mean 5.124±1.880 Range 3.20-12.60	Mean 2.730±0.387 Range 2.10-3.70	< 0.01**
SNAP(µv)	Mean 336.308±185.536 Range 33.3-773.0	Mean 617.560±182.922 Range 299 - 980	< 0.01**
NCV(m\s)	Mean 33.988±11.455 Range 12.50-85.60	Mean 51.830±3.074 Range 46.00-61.60	< 0.01**

**p < 0.01 very significance, *p < 0.05 significance, p > 0.05 not significance

Table(3): Distal motor latency(DML),compound motor action potential(CMAP),nerve conduction velocity and F-wave latencies (minimum, mean and maximum) of median and ulnar nerve(motor) for CTS patients.

parameters	Median nerve (motor)-patient(No=50)	Ulnar nerve(motor)-patient(No=50)	P-value
DML(ms)	Mean 5.244±1.327 Range 4.00-10.10	Mean 2.372±0.228 Range 2.10-3.10	< 0.01**
CMAP(mv)	Mean 8.3240±7.501 Range 2.00-15.10	Mean 11.290±2.361 Range 7.10-16.10	< 0.05*
NCV(m\s)	Mean 46.712±6.769 Range 30.40-73.1	Mean 56.576±6.947 Range 45.60-76.30	< 0.01**
F-MAX(ms)	Mean 33.714±5.323 Range 27.80-37.50	Mean 28.476±2.117 Range 25.50-35.10	< 0.01**
F-MEAN(ms)	Mean 30.786±3.139 Range 25.80-37.20	Mean 27.064±1.652 Range 24.20-30.40	< 0.01**
F-MIN(ms)	Mean 28.342±3.316 Range 21.90-37.60	Mean 25.544±1.338 Range 23.3-29.20	< 0.01**

**p < 0.01 very significance, *p < 0.05 significance.

Table(4): Distal sensory latency(DSL),sensory nerve action potential(SNAP) and nerve conduction velocity(NCV) of median and ulnar nerve(sensory) for patients with CTS.

parameters	Median nerve (sensory)-patient No =50	Ulnar nerve(motor)-patient N0 =50	P-value
DSL(ms)	Mean 5.124±1.880 Range 3.20-12.60	Mean 2.372±0.228 Range 2.10-3.10	$< 0.01^{**}$
SNAP(µv)	Mean 336.30±185.56 Range 33.3-773.0	Mean 665.18±217.450 Range 243-1000	$< 0.01^{**}$
NCV(m\s)	Mean 33.98±11.45 Range 12.50-85.60	Mean 56.84±4.59 Range 51.00-66.00	$< 0.01^{**}$

**p < 0.01 very significance, *p < 0.05 significance, p > 0.05 not significance

Table (5): F-wave minimal latency difference between median and ulnar nerve(motor) for CTS patients and controls.

	FWML median nerve - FWML ulnar nerve	p-value
Patient No=50	Mean 2.68 ± 1.51 Range 1.2 - 6.	p<0.01**
	FWML.ulnar nerve- FWML. median nerve	

Control No=50	Mean 0.79 ± 0.60 Range 0.5 -1.5	NS

p < 0.01 very significance.** NS: not significant

Table (6): The F-wave minimum latency (FWML) for mild, moderate and sever CTS patients compared with the controls.

parameters	Patients No=50	Control No=50	P-value
F-MIN (ms)	Mild CTS(no =25) Mean 28.18±3.70 Range 21.90-33.60	(N0=25) Mean 24.80 ± 1.58 Range 22.50- 27.20	<0.01**
F-MIN (ms)	Moderate CTS(no =22) Mean 29.76 ± 2.93 Range 23.40 – 31.90	(No=22) Mean 23.80 ± 1.29 Range 21.10 - 27.20	< 0.01**
F-MIN (ms)	Severe CTS(no=3) Mean 31.35 ± 1.20 Range 25.50 - 33.20	(No=3) Mean 23.40 ± 0.28 Range 22.20 – 26.60	<0.01**

p < 0.01 very significance.**

Discussion

Carpal tunnel syndrome is a common clinical problem[19]. It happens due to median nerve entrapment leading to demyelination in the carpal tunnel. Even with a good history and physical examination at times it may be difficult to diagnose.[20] The electrophysiological studies are now regarded as the gold standard diagnostic tests, it has a high degree of sensitivity and specificity.[21] . F- wave determination could show injury to proximal and also severe injury to distal parts of median nerve, especially axonal injury. According to abnormalities of this test the surgical release of nerve for prevention of irreversible changes must be considered. While the conduction block is a sign of demyelinating injury, and this finding suggests that a conservative treatment such as splinting or steroid injections could be a proper method for patient managment [16,22]**.** Also F-wave latencies were useful in differentiating between distal and proximal entrapments [23]. The present study reveals that CTS was more common in females, this may be due to obesity, pregnancy and the women are attending the hospital more than men. This is reported by other studies.[24,25]. The right hand was more commonly affected than left hand in the present study and this may be due that; all the patients in this study were right handed and they may be have a heavy daily activities, which is in agreement with other researches.[25,26,27]. In the present study the nerve conduction study show a prolongation of DML and DSL, decreased amplitude of CMAP and SNAP, decrease of MNCV and SNCV of median nerve(motor and sensory) for CTS patients compared with controls (table-1&2); Also it shows a prolong of DML and DSL, decreased CMAP and SNAP and decrease of MNCV and SNAP for median nerve (motor and sensory) compared with ulnar nerve for CTS patients (table-3&4); and these differences are highly significant (p-value < 0.01). These results are similar to other works [19,25]. There were a prolongation of F-wave latencies (minimum, mean and maximum.) of the median nerve (motor) for the CTS patient compared with control(table-1); Also there were a prolongation of F-wave latencies(minimum, mean and maximum.) of the median nerve (motor) compared with ulnar nerve (motor) for the CTS patient(table-3); and these differences are highly significant (p-value < 0.01) and these are in agreement with other studies[12,16,24,25]. Also it reveals that the nerve conduction in control group show reduction in F-wave minimal latency (FWML) of the median nerve(motor) as compared to the ulnar nerve(motor) and this difference less than 1 (0.79 ± 0.60)(table-5) and this difference is not significant; While in the CTS group, the FWML of the median nerve was longer than the ulnar nerve; FWML more than 1(2.68 ± 1.51) (table-5). This difference in latency is highly significant (p<0.01) and this is similar to other works[12,16,24,25].

This study reveals that there are 25patient(50%) with mild CTS and the F-wave minimal latency(FWML) for them are (28.18±3.70) while the matched controls (24.80±1.58); and 22 patient(44%) show moderate CTS the FWML for them(29.76±2.93) while the matched controls (23.80±1.29) ; and only 3patients(6%) show severe

CTS and the FWML for them (31.35±1.20) while the matched controls (23.40±0.28) (table-6); and all the differences are highly significant $p<0.01$;and these mimic the other study[16]. These could be explained on the basis of either demyelination or axonal loss occurring due to nerve entrapment in the distal course of the median nerve and the severity of the injury goes with nerve conduction study (specially the F-wave parameters).

Conclusion

Results of this study supported the adding of F wave parameters to standardize electrophysiological evaluation of CTS; so the F-wave method is more practical in routine electrophysiologic testing for CTS patients.

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