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Low sensitivity of F-wave in the electrodiagnosis of carpal tunnel syndrome

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ABSTRACT

Objective: Previous studies showed "F-wave inversion" (F-INV) as a sensitive method in the electrodiagnosis of early stage of carpal tunnel syndrome (CTS). This study aimed at evaluating the sensitivity and specificity of F-wave and nerve conduction velocity (NCV) testing in CTS.
Methods: We consecutively enrolled 244 cases and 108 controls. F-waves analysis included: Fwave minimum and mean latencies, F-wave persistence and chronodispersion, mean-F/CMAP amplitude ratio, F-INV. Specificity and sensitivity of F-waves parameters were calculated in the whole sample of CTS patients and by grouping the patients according to CTS severity. Multivariate logistic regression was also performed using F-INV as a dependent variable.
Results: In the whole sample the sensitivity of F-mean-INV and of median–ulnar NCV comparative testing was 50.8% and 93.7%, respectively. F-INV sensitivity dropped to 8% in CTS early stage. F-INV could be predicted only by distal motor latency of the median nerve. The sensitivity of all F-wave parameters increased only in the most severe stages of CTS.
Conclusions: This study does not confirm the electrodiagnostic usefulness of F-INV in early stage of CTS. All F-wave parameters, including F-INV, are much less sensitive than conventional NCV in CTS electrodiagnosis. F-wave does not add further useful information specifically related to CTS.

1. Introduction

F-wave is a motor response generated by the antidromic activation of a small motoneuron pool, provides information especially on proximal conduction in motor fibers and is commonly used in the electrodiagnosis of polyneuropathies. Any injury of motor neuron and peripheral nerve regardless of the site may be reflected in F-wave (Panayiotopoulos and Chroni, 1996; Fisher, 2002, 2007; Puska et al., 2003; Mesrati and Vecchierini, 2004). F-wave abnormalities have been also shown in nerve entrapment syndromes, as carpal tunnel syndrome (CTS) (Macleod, 1987; Kuntzer, 1994; Anastasopoulos and Chroni, 1997; Fisher and Hoffen, 1997; Deniz et al., 2012; Aygül et al., 2014).

Due to length differences between median and ulnar nerves, F-wave latency of the median nerve is usually shorter than that of ipsilateral ulnar nerve. Two studies showed in early stage of CTS a difference between F-wave latency of the median nerve and that of the ulnar nerve greater than 1 ms (Menkes et al., 1997; Cevik et al., 2012). This finding is known as "F-wave inversion" (F-INV). The aim of this study was to verify the sensitivity and specificity of the most common F-wave parameters, including F-INV, and of the most usual electrodiagnostic testing (EDX) in a consecutive sample of patients with idiopathic CTS and to evaluate the sensitivity of F-wave and NCV parameters according to CTS severity.

2. Methods

2.1. Enrolment and definition of cases and controls

The cases and controls were prospectively enrolled among all consecutive patients, regardless of age and gender, admitted from July to December 2013 to our outpatient electromyography (EMG) lab to perform EDX for the first time.

CTS diagnosis was made on the basis of clinical findings according to the recommendations of American Academy of Neurology (Quality Standards Subcommittee of the AAN, 1993). In addition, because the criterion of case enrollment was only clinical, when the symptoms could suspect root or spinal cord disorders, additional investigations other than EMG, such as cervical MRI were carried out.

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We excluded from cases and controls all patients who had undergone surgery of the upper limb, or with radiculopathy, mononeuropathy and plexopathy of the arm, polyneuropathy, amyotrophic lateral sclerosis, diabetes, rheumatic or thyroid diseases, renal failure, history of alcoholism and central nervous system diseases, malignancy in the previous 5 years, and previous intake of medication considered toxic to the peripheral nervous system. Therefore only subjects with clinical examination and EDX negative for neuromuscular diseases were included in the controls.

Clinical assessment of CTS severity was evaluated using a validated five-stages scale (for details see Table 5) (Giannini et al., 2002).

Local ethics committee approved the study and all patients gave informed consent.

2.2. Electrophysiological methods

Nerve conduction velocity (NCV) study of all cases and controls was performed using the standard methods detailed below. In addition we performed other EDX in the patients included in the control group according to the clinical suspicion.

Motor conduction velocity (MCV) of the median nerve was measured in elbow–wrist segment and MCV of the ulnar nerve in above–below elbow and below elbow–wrist segments, recording from the abductor pollicis brevis (ABP) and abductor digiti minimi muscles, respectively. Distal motor latency (DML) was calculated at a fixed distance of 7 cm from the point of stimulation at the wrist to the muscle from which compound muscle action potential (CMAP) was recorded. Sensory nerve conduction (SCV) was orthodromically measured in the third (M3) and fourth finger–wrist (M4) tracts for the median nerve and in the fourth (U4) and fifth (U5) finger tracts for the ulnar nerve.

The median and ulnar nerves were also stimulated in the midpalm at 8 cm distal to the recording site of the wrist and difference of palm–wrist latencies (PALM-diff) was calculated. Difference between U4–M4 SCV was also measured (AAEM et al., 2002; Mondelli et al., 2010; Werner and Andary, 2011). Skin temperature of the hand was kept constant above 32 °C with an infrared lamp.

Neurographic findings were considered abnormal if they differed by more than two standard deviations (SD) from the mean of normative data of our EMG lab.

F-wave study was performed in the median and ulnar nerves after NCV. Median and ulnar nerves were stimulated at wrist at a 0.5 Hz, with 25% supramaximal intensity, cathode proximal, and relaxed muscle. Twenty consecutive stimuli were used to obtain F-waves. We considered the presence of F-wave if the amplitude was at least 20 μV. The amplitude of F-waves was measured peak-to peak and the latency of each F-wave placing the cursor on the first deflection from the baseline. The following parameters were analyzed: (1) the latency of minimal F-wave (Fmin) i.e. the shortest latency out of all elicited F-waves, (2) the mean of the latencies of all elicited F-waves (Fmean), (3) the chrodispersion (Fc) i.e. the difference between the slowest and shortest F-wave latencies, (4) the percentage mean of F-waves amplitudes/CMAP amplitude (mF/M), (5) the F-wave persistence (Fp) i.e. the number of elicited F-waves in relation to 20 stimuli delivered, (6) F-wave conduction velocity (FCV) = distance from the spinous process of C7 to wrist in cm (with the arm in abduction at 90° via mild clavicular) × 2/(Fmin-DML-1).

Because F-wave latencies are related to height and age, Fmin and Fmean of the median and ulnar nerves were considered abnormal if they exceeded 2 SD the values obtained with the regression equations (Mesrati and Vecchierini, 2004). The other F-wave abnormal values of our lab were respectively for the median and ulnar nerves: 6.1 and 5.5 ms for Fc, 13 and 16 for Fp, 4.2% and 4.4% for mF/M. In addition we considered abnormal a difference between the median and ulnar Fmin and Fmean greater than 1 ms (i.e. F-INV) (Fmin-INV and Fmean-INV).

For statistical analysis we used a validated five-stages scale of CTS electrophysiological severity (for details see Table 4) (Padua et al., 1997).

In the patients with bilateral symptoms clinical and electrophysiological results of the hand with worst symptoms were enclosed or, if there was no difference between sides, the results of the dominant hand were chosen. Therefore the data were analyzed at the patient level and not at the hand level (Padua et al., 2005).

2.3. Statistical analysis

Descriptive statistics were given as mean and SD. Mann–Whitney nonparametric test was employed to test the differences between cases and controls. An alpha-error of 0.05 was accepted. Multiple differences between CTS groups were analyzed according to electrophysiological and clinical severity with Kruskal–Wallis test and Mann–Whitney test with Bonferroni correction was used to test the differences between two successive individual groups of clinical and electrophysiological severity scales of CTS patients.

Using the cut-offs of normative data of our lab we created 2 × 2 tables to calculate the sensitivity and specificity of all F-wave variables and U4–M4 SCV difference, PALM-diff, M4 SCV and DML of the median nerve in all cases and between CTS groups according to clinical and electrophysiological severity scales.

Stepwise multivariate logistic regression analysis was performed to estimate odds ratio (OR) and 95% confidence interval (95%CI) with the aim to assess the strength of association between the dependent variable, presence of Fmin-INV (no = 0, yes = 1), and independent variables represented by the type of patient (control = 0, case = 1), gender (female = 0, male = 1), age, height, M3 SCV, MCV, DML, CMAP amplitude of the median nerve (continuous variables).

Another multivariate logistic regression was also performed using Fmean-INV as dependent variable and the same above independent variables.

All statistics were run on SPSS 13.0 (Chicago, IL, USA) software packages.

3. Results

We consecutively enrolled 244 cases (mean age 56.8 years, females 70.9%) and 108 controls (mean age 52.4 years, females 69.4%). The dominant hand was the worst or the only affected hand in 206 cases (84.4%).

Table 1 shows the demographic and anthropometric, NCV and F-wave findings of the median and ulnar nerves and differences between cases and controls. No F-wave of the median nerve was elicited following 20 stimuli in 13 cases, that belonged to stage 4 or 5 of clinical severity scale and to stage 3 or 4 of electrophysiological severity scale. There were significant differences in almost all variables of NCV of the median nerve between cases and controls, but not of the ulnar nerve. CTS patients had prolonged F-wave latencies, decreased Fp and increased mF/M amplitude ratio of the median nerve when compared with controls. Only Fc of the cases was not different from that of controls. There were no differences of all F-wave parameters of the ulnar nerve between cases and controls. Because the controls were younger and higher than the cases, we normalized F-wave values to a new value based on regression equations for F-wave latencies including age and height. The normalized values of Fmin and Fmean latencies of the median nerve were more prolonged in cases than in controls. On the contrary there were no differences of F-wave normalized latencies of