Research Article

F Wave Parameters and F-Jitter

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Abstract

Objective: F response is one of the late EMG responses occurring with peripheral motor nerve stimulation. It is generated by firing of anterior horn motor neurons as a result of antidromic propagation of the stimulus on the motor nerve. The aim of this study was to evaluate the feasibility of using average variability in consecutive F response latencies (F-jitter) as a new parameter.

Method: The fundamental characteristic of the F-jitter distinguishing it from other parameters is that it describes the chrono-dispersion among the neurons stimulated consecutively. The F-jitter was investigated in patients with polyneuropathy (PNP, n = 20), spasticity (SPS), (n = 10) and in 30 healthy subjects.

Results: The sensitivity of F-jitter was observed to be at least as much as of other parameters.

Conclusions: It is therefore concluded that F-jitter might be a useful parameter to be included in new-generation digital EMG instruments beyond its significant contributions to physiological studies.

Significance: The F-jitter values in PNP and SPS groups were significantly different from the healthy group, and this difference was more prominent in the PNP group

Key words: EMG, parameters, F waves, F-jitter, polyneuropathy, spasticity

INTRODUCTION

F waves were first defined in 1950 by Magdalery and McDougal on foot muscles. Thus, letter F was assigned to define this response (13). F waves are one of the late responses generated following the M response by supramaximal electrical stimulation of peripheral motor nerves. It is generated by
firing of anterior horn motor neurons following antidromic propagation of the stimulus on the motor nerve. It can be evoked in most limb muscles and facial muscles (1,5,8,9,12,17,22).

F waves in clinical practice are used to evaluate the conductive characteristics of proximal motor nerve and motor nerve excitability. Parameters, such as minimal latency, maximal latency, mean latency, dispersion or chrono-dispersion (difference between the longest and the shortest latencies), persistence (number or percent rate of F waves generated by consecutive stimuli), amplitude of F waves, ratio of F/M amplitudes and tachy-dispersion are used to evaluate F waves. Some of these reflect proximal conductive properties of motor nerves whereas others provide information on the excitability of motor neuron pool (2,4,6,11,20,22).

This study aimed to evaluate the feasibility of using average variability in consecutive F wave latencies (F-jitter) as a new parameter for the evaluation of F waves.

METHODS

Subjects: The study was carried out on healthy subjects (n = 30, 17 females and 13 males, mean age: 42 ± 15 years) and on patients with polyneuropathy (PNP, n = 20, 6 females and 14 males, mean age: 58 ± 13 years) and spasticity (SPS, n = 10, 4 females and 6 males, mean age: 61 ± 6 years). Prior to testing, each subject underwent a detailed neurological examination, evaluating sensitivity to pain, touch and vibration, as well as reflexes in all limbs. In addition, routine electromyography was conducted, which included median, ulnar, peroneal, posterior tibial motor and median, ulnar and sural sensory nerve conduction velocity measurements. These were performed according to previously described standard methods. From the results of neurological examination and routine electromyography, subjects were categorized into normal, PNP and SPS groups.

Ten patients with SPS were referred from the Stroke Outpatients Unit of Ege University Hospital. These patients had spastic hemiparesis due to cerebral infarction or hemorrhage and their level of spasticity varied between grade 3 and grade 5 on Ashworth Scale (3). None of the patients had any peripheral nerve abnormality, both clinically and electrophysiologically.

The study was approved by the local ethics committee of Ege University Hospital and informed consent was obtained from each subject.

EMG recording procedures: The recordings were made by a 2-channel EMG instrument (Medelec Synergy) using the F wave and, motor and sensory nerve conduction programs. All recordings were performed through silver/silver chloride disc electrodes with 10 mm diameter. The room temperature was constant to maintain a minimum skin temperature of 32°C.

All subjects included in the study underwent motor and sensory nerve conduction studies on upper and lower extremities and F wave study of the ulnar nerve recorded from the hypothenar muscles in response to 20 consecutive stimuli delivered at the wrist level on the non-dominant side. During the F wave recording, bandpass filtering was set to 20 Hz and 5 kHz; the amplifier gain was adjusted to 100 µV/div and the total sweep time was 50 ms. The active recording electrode was placed over the belly of the muscle and the reference electrode was placed at the nearest electrically silent distal region (over the 5th metacarpophalengial joint). The ulnar nerve was stimulated at the wrist with a superficial bipolar electrode (Medelec, UK). The anode was placed proximally and electrical pulses of 0.1 ms duration were delivered at 1 Hz, and 20 consecutive traces were recorded. The F wave was identified as the first action potential after the M wave, with an amplitude of at least 20 µV (10,17).

F wave measurements: The latency, duration and amplitude of consecutive F waves were calculated by off-line manual analyses. The F wave's latency and peak-to-peak amplitude in each trace were recorded on a Microsoft Excel® sheet. The minimum latency, chrono-dispersion, tachy-dispersion and persistence
were calculated with a semiautomatic process on Microsoft Excel® according to standard methods described elsewhere (10,15,17), whereas F-jitter was calculated with the same method according to the following formula:

\[ F\text{-jitter} = \left( \left| f_2 - f_1 \right| + \left| f_3 - f_2 \right| + \ldots + \left| f_n - f_{(n-1)} \right| \right) / (n - 1) \]

Here, \( f_{(1,2,\ldots,n)} \) corresponds to latencies of consequent F waves. If an F wave was absent in a trace, it was omitted from the analysis and the next trace was examined. If it contained an F wave the latency was measured and included in the calculation. The estimation method for F-jitter is schematically shown in Figure 1.

![Figure 1: Schematic illustration of estimating the F-jitter](image)

For statistical analyses, descriptive and non-parametric comparison tests (Mann-Whitney U test) were used, with significance set at the 0.05. When a gaussian distribution was not observed in any of the parameters, these values were normalized by logarithmic transformation. For assessment of diagnostic sensitivity, Z scores were calculated for each F wave parameter in PNP and SPS groups.

**RESULTS**

The mean values for F wave minimum latency, chronodispersion, tachydispersion, persistence and F-jitter obtained from the hypothenar muscles of the non-dominant side are presented in Table 1. The F-jitter values in PNP and SPS groups were significantly different from the healthy group, and this difference was more prominent in the PNP group (Table 1 and Figure 2).
Table 1: Results of various F wave parameters in healthy controls, and in patients with polyneuropathy and spasticity

<table>
<thead>
<tr>
<th>GROUP</th>
<th>Number of cases</th>
<th>Min. Latency (ms)</th>
<th>Chrono-dispersion (ms)</th>
<th>Tachydispersion</th>
<th>Persistence</th>
<th>F Jitter (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>30</td>
<td>24.7 ± 2</td>
<td>4.1 ± 2</td>
<td>10.7 ± 5.6</td>
<td>94.7 ± 7</td>
<td>1.07 ± 0.52</td>
</tr>
<tr>
<td>PNP</td>
<td>20</td>
<td>27.4 ± 4*</td>
<td>9.8 ± 6*</td>
<td>20.2 ± 16*</td>
<td>78.9 ± 18</td>
<td>2.67 ± 1.65*</td>
</tr>
<tr>
<td>SPS</td>
<td>10</td>
<td>24.5 ± 3</td>
<td>6.8 ± 4*</td>
<td>16.8 10*</td>
<td>88.3 ± 11</td>
<td>1.42 ± 0.44*</td>
</tr>
</tbody>
</table>

Mean ± SD
** Significant difference from normal group.

As seen in the table, in the PNP group, the minimum latency, chrono-dispersion, tachydispersion and F-jitter mean values were significantly different from the healthy group (p<0.05, Z score=1.35, 2.85, 1.69, 3.07 respectively). Although all these parameters showed deviation from normal values, the F-jitter appeared to be the most sensitive parameter for PNP diagnosis (Z score=3.07). On the other hand, persistence of F waves in the PNP group was not different from healthy subjects (p>0.05).

In the SPS group, the chrono-dispersion, tachy-dispersion and F-jitter mean values were significantly different from the values obtained from the healthy group (p<0.05, Z scores =1.35, 1.09, 0.7, respectively). Although, the F-jitter mean value was statistically different, the Z score of F-jitter was low because of relatively high standard deviation. On the contrary, the minimum latency and persistence of F waves in the SPS group were not found to be different from the healthy group (p>0.05).

DISCUSSION
F waves have been used to evaluate proximal motor nerve conduction and excitability of the motor neuron pool. Unfortunately, there is not a consensus on its routine use and its usefulness. Although its diagnostic value is controversial, F wave measurement is included in the battery of electrophysiologic parameters evaluated in most electromyography laboratories. For example, it is frequently used in the diagnosis of polyneuropathy (2,11,18). Furthermore, it has also been used in the diagnosis of focal nerve lesions such as radiculopathies, entrapment neuropathies and, to evaluate the excitability of motor neuron pool in central nervous system involvements (1,4,5,6,7,14,16,19,20,21).

There are a number of described and used parameters for the evaluation of F waves. These parameters are basically the measurements derived on the basis of latency, variation of latencies of consecutive F waves, amplitude and number of F waves (persistence), and may show different
sensitivities in different diseases. For example, the parameter used most frequently and of which sensitivity is highest in demyelinizing polyneuropathy is minimal latency (2,11,18,22).

A study on 23 patients with spinal cord injury compared the chrono-dispersion and tachy-dispersion values and found that these values, especially chrono-dispersion is more sensitive than other parameters of F waves (20). However, it has been suggested in a study on patients with lumbosacral radiculopathy that chrono-dispersion values of F waves were not different from latency values of F waves and were not sensitive (5,14,19). Another method, based on the number of F waves, is persistence and a study on patients with L5-S1 lumbosacral radiculopathy indicated that persistence of F waves were a more reliable measure than the minimum latency of F waves (20). However, it should be noted that normality of F waves do not exclude the possibility of radicular or plexus lesions and this is not a reliable diagnostic method in radiculopathy and compression syndromes. Furthermore, F waves are not helpful in locating the lesion.

Overall, F waves are abnormal in hereditary motor and sensorial neuropathy, acute or chronic demyelinizing neuropathy, diabetic neuropathy, uremic neuropathy, alcoholic neuropathy and other neuropathies (2,11,18). F waves are also used to evaluate the excitability of motor neuron pool. In this regard, they have been used in spinal cord injuries, chronic tetanus and stiff-person syndrome. Chrono-dispersion, tachy-dispersion, persistence, amplitude and minimum latency of F waves have been used for evaluating the excitability of motor neuron pool in previous studies (4,6,8,16,20). Unfortunately, there is not a consensus on their routine use and usefulness (8).

There are 2 application for F waves on which a consensus could be reached: early stages of demyelinizing polyneuropathies, especially Gullian-Barré syndrome; and chronic inflammatory demyelinating polyradiculoneuropathy (2,8,11,18,22).

Electrical signals propagating toward the motor neuron pool by consecutive supramaximal motor nerve stimulation do not activate all of the alpha motor neurons simultaneously and a few motor neurons can fire immediately after their initial discharge. Probability for immediate firing of the same motor neuron by consecutive stimuli is 0% to 5% (17). Accordingly, latencies, durations and amplitudes of F waves generated by consecutive stimuli reflect the conductive properties of different motor units indirectly. The main distinguishing characteristic of F-jitter described in this study is that it defines chrono-dispersion between the alpha motor neurons stimulated consecutively. The proposed underlying principle in the generation of high jitter is with each stimulus, a different neuron or an axon with different properties is activated. Minimal latencies, chrono-dispersion, tachy-dispersion, persistence and F-jitter values determined for patients with PNP and SPS in this study were shown in Table 1. All of the parameters, except minimal latency and persistence, easily distinguished the patients with PNP from normal subjects. Although the minimal latency was significant statistically, the distinguishing capacity appeared to be low. In patients with SPS, chrono-dispersion, tachy-dispersion and F-jitter were statistically different from normal subjects. However, contrary to expectation, the persistence values were not higher than normal subjects. Overall, the distinguishing capacity of F-jitter was found to be at least as powerful as for other parameters. We, therefore, suggest that in addition to its conventional application as a latency parameter, the F-jitter could also provide information on the excitability of neurons.

In conclusion, F-jitter measurement might be a useful additional parameter to be included in new-generation digital EMG instruments to further contribute to clinical and physiological studies.

**ABBREVIATIONS**

PNP: polyneuropathy

SPS: spasticity
REFERENCES


2) Andersen H, Stalberg E, Falck B. F-wave latency, the most sensitive nerve conduction parameter in patients with diabetes mellitus. Muscle Nerve 1997;20:1296-1302


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