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The Importance of F-Wave Patterns in a Patient with Cerebrovascular Disease Characterized by a Markedly Increased Tone of the Thenar Muscles

Toshiaki Suzuki[a, b] Yuki Fukumoto[a, b] Marina Todo[a, b] Makiko Tani[a, b] Sohei Yoshida[a, b]

[a]Graduate School of Health Sciences, Graduate School of Kansai University of Health Sciences, Osaka, Japan; [b]Research Center of Neurological Disease, Kansai University of Health Sciences, Osaka, Japan

Keywords
Spasticity · F-wave patterns · Muscle tone

Abstract
F-waves are used to measure the excitability of spinal motor nerve function. This study aimed to investigate the F-wave patterns in a patient with cerebrovascular disease who had no voluntary movement of the hand, particularly the thumb, caused by a considerably increased tone of the thenar muscles. A patient with right hemiplegia caused by left cerebral hemorrhage (putamen) showed a considerably increased tone of the thumb flexors and no voluntary movements. F-waves were recorded from the affected thenar muscles with median nerve stimulation in the supine lying position during the first trial. Exercise therapy that included stretching of the affected thenar muscles was performed twice a week for 20 min for 8 months. Subsequent changes in the F-wave waveform were examined and considered as second trial. The latency and persistence of the F-wave and F-wave conduction velocity did not show any significant change between the two trials. Compared with the first trial, the F/M amplitude ratio in the second trial was increased. Following 8 months of exercise therapy, muscle tone improved slightly, and minimal voluntary movements of the affected thumb were noted. Since motor function of the affected thumb improved with exercise therapy but there was no improvement in F-wave data, it was determined that the main factor underlying the hypertonicity of the thenar muscles in this patient was more likely due to secondary muscle shortening than to spasticity. Unclear waves that possibly were F-waves were also observed approximately 20 ms after the appearance of the M-wave in the first trial but not in the second trial. Because exercise therapy showed muscle tone improvement and did not result in the appearance of unclear

Correspondence to:
Toshiaki Suzuki, suzuki@kansai.ac.jp

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waves, F-wave patterns should be monitored for evaluating spasticity, which markedly increases muscle tone in patients with cerebrovascular disease.

Introduction

The F-wave is an index of excitability of spinal neural function. It can be recorded from any spinal muscle upon supramaximal stimulation of α-motoneurons. The impulse induced by supramaximal stimulation of α-motoneurons is transmitted to the anterior horn cell and to the recorded muscle via backfired potential of the anterior horn cell. It is also characteristic that the F-wave parameter changes when muscle tone is increased due to factors such as spasticity, but no F-wave changes are seen when muscle tone is increased due to secondary factors such as muscle shortening.

In this study, we investigated the F-wave patterns in a patient with cerebrovascular disease who displayed no voluntary movement of the thumb caused by a markedly increased tone of the thenar muscles. In this case, although the F-wave parameter did not change, an unclear wave appeared between the M- and F-waves in the first trial, but this wave disappeared following exercise therapy.

Case Report/Case Presentation

A 70-year-old male patient with right hemiplegia caused by left cerebral hemorrhage (putamen) presented with a markedly increased muscle tone of the thumb flexors (Modified Ashworth Scale [MAS], level 4) and no voluntary movements. The MAS scores for hypertonicity of the affected muscles use six separate grades (0, 1, 1+, 2, 3, and 4). We tested MAS by measuring the resistance of the muscle being stretched. A score of 4 represented difficulty in moving due to severe hypertonia. He provided informed consent prior to the study's commencement. The experiments were conducted in accordance with the Declaration of Helsinki.

In the first trial, the patient was positioned comfortably in a supine lying position. The skin was prepared with an abrasive gel so as to maintain the impedance below 5 kΩ. We tested the F-wave of the affected thenar muscles using a pair of round disks attached to the skin with collodion and placed over the belly and the bone of the metacarpal-phalangeal joint of the thumb. The median nerve at the wrist joint was stimulated using a Viking Quest electromyography machine (NATUS, USA). The stimulation electrodes comprised a cathode placed over the right median nerve at the wrist joint and an anode placed 2 cm proximally. The maximal stimulus was determined by delivering square-wave pulses of 0.2 ms of increasing intensity for eliciting the highest compound muscle action potentials. Supramaximal shocks (adjusted to achieve a value 20% higher than the maximal stimulus) were delivered at 0.5 Hz for the acquisition of F-waves. The range of the bandwidth filter was 2–3 kHz. For the recording conditions, the exploring electrode was placed over the belly of the right thenar muscles, the reference electrode on the proximal phalanx of the thumb, and the ground electrode on the forearm. The peak-to-peak amplitude of the F-wave was measured using an oscilloscope at 0.2 mV/D. Waveforms with peak-to-peak amplitudes of 30 μV or more were considered F-waves, and the average amplitude of 30 waveforms recorded was calculated. The amplitude ratio of F/M was defined as the mean amplitude of measurable waves divided by the amplitude of the M-wave. Persistence was defined by the number of measurable F-wave responses divided

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Table 1. Results of F-wave and FWCV

	First trial	Second trial
F-wave		
Latency (ms)	32.2	32.3
Persistence (%)	100	100
F/M amplitude ratio (%)	1.27	2.68
FWCV (m/s)	57.7	58.6

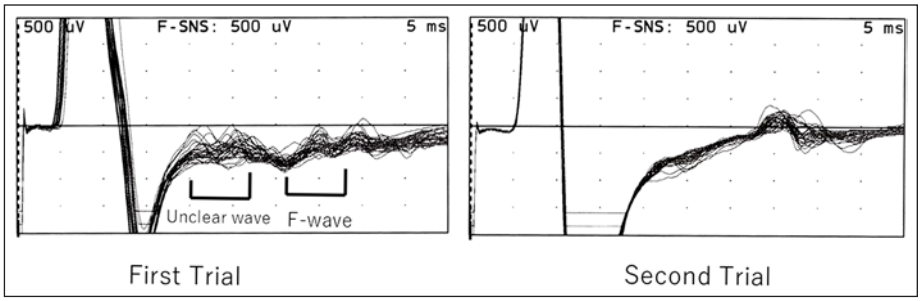

Fig. 1. F-wave with wrist stimulation in the first and second trials.

by 30 trials of supramaximal stimulation. Exercise therapy that included stretching the affected thenar muscles was performed twice a week for 20 min per session over a span of 8 months.

In the second trial conducted after exercise therapy, the patient was positioned comfortably in a supine lying position, and we tested the F-wave of the affected thenar muscles after stimulating the median nerve at the wrist joint using the methods described above. In both trials, we analyzed the following F-wave parameters: latency, persistence, F/M amplitude ratio, F-wave conduction velocity (FWCV), MAS, and the state of voluntary movement of the thumb.

The latency and persistence of the F-wave and FWCV did not show any remarkable change between the two trials (Table 1). The F/M amplitude ratio in the second trial showed an increasing trend in comparison with the first trial (Table 1). Following 8 months of exercise therapy, the short latency waveform disappeared, muscle tone slightly improved to reach MAS 3, and minimal voluntary movements of the affected thumb were noted. Unclear waves that possibly were F-waves were also noted approximately 20 ms after the appearance of the M-wave in the first trial but not in the second trial (Fig. 1).

Discussion/Conclusion

The patient had a markedly increased muscle tone in the flex or digitorum brevis and was unable to perform voluntary movements. We investigated the effect of exercise therapy of the affected thumb extension using the F-wave, which is an index of spinal cord anterior horn cell excitability. The F-wave is generated after a backfiring of α-motoneurons following antidromic propagation of the nerve impulse across the axon hillock [1]. Its occurrence reflects changes in the excitability of spinal motoneurons, as reported in patients with spasticity [2]. The persistence and F/M amplitude ratio are indicators of spinal motor nerve excitability and function. In the case that we investigated, the persistence of F-waves was 100%, which

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was increased compared with normative data, but the F/M amplitude ratio was within the normal range. Although the result obtained on evaluating for persistence reflects a markedly increased muscle tone of the thenar muscles, the result obtained on assessing for the F/M amplitude ratio suggested that factors other than spasticity are responsible for the increased muscle tone.

The previous findings indicate that these factors include a secondary dysfunction such as muscle shortening of thenar muscles, but not neurologic factors in a patient with hypertonus by taking into account the normal F/M amplitude ratio data [2]. Based on the previous report and the results obtained in this study, we believe that the main factor responsible for the hypertonus of the thenar muscles in this patient was muscle shortening caused by secondary dysfunction without spasticity.

In addition, the occurrence of unclear waves in the first trial needs to be considered. We believed that this wave was either an A-wave, a stimulus-induced repetitive discharge (SIRD), or an F-wave. Because A-waves and SIRDs often have the same latency and waveform, the unclear wave was unlikely an A-wave or SIRD.

Overall, evidence indicates that the unclear wave was an F-wave. Because the FWCV measured from the actual F-wave latency is normative, considering that this unclear wave with a latency of approximately 20 ms is a waveform that travels through the anterior horn of the spinal cord is difficult.

The latency and persistence of the F-wave and FWCV did not change after exercise therapy. However, unclear waves disappeared after the exercise therapy focusing on stretching of the thenar muscles, and voluntary movements were noted with suppression of muscle tone of the thenar muscles. The neurological mechanism underlying the unclear wave is not well understood, but it may be a waveform that expresses a degree of excitability from the brain.

Because there were no differences in the F-wave parameters before versus after exercise therapy, we concluded that the main factor underlying the hypertonicity of the thenar muscles in this patient was muscle shortening caused by secondary dysfunction instead of spasticity. Furthermore, because exercise therapy showed muscle tone improvement and did not result in the appearance of unclear waves, F-wave patterns should be monitored for evaluating spasticity, which considerably increases muscle tone in patients with cerebrovascular disease.

Statement of Ethics

This study protocol was reviewed and approved by the Research Ethics Committee of Kansai University of Health Sciences (Approval No.: 19-27). Written informed consent was obtained from the patient for publication of the details of their medical case and any accompanying images.

Conflict of Interest Statement

The authors declare no conflicts of interest associated with this manuscript.

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Author Contributions

Toshiaki Suzuki: conceptualization and acquisition of data; Toshiaki Suzuki, Yuki Fukumoto, Marina Todo, and Makiko Tani: analysis and/or interpretation of data; Toshiaki Suzuki, Makiko Tani, and Sohei Yoshida: drafting the manuscript.

Data Availability Statement

All data relevant to this case are made available in this case report. Further inquiries can be directed to the corresponding author.

References

1 Kimura J. F-wave velocity in the central segment of the median and ulnar nerves. A study in normal subjects and in patients with Charcot-Marie-Tooth disease. Neurology. 1974;24(6):539–46.
2 Odusote K, Eisen A. An electrophysiological quantitation of the cubital tunnel syndrome. Can J Neurol Sci. 1979;6(4):403–10.