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Mismatch between Correlation Coefficient and Visually Evaluation for Similarity of F-wave Waveform

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Abstract

Objective: F-wave is one of indexes for excitability of the spinal nerve function. Our previous study suggested the change in F-wave waveform also shows the state of voluntary movement. In our previous study, we reported correlation coefficient 0.95 to one of the same criteria of the F-wave waveform. However, there were F-wave waveform that judged to be the same waveform by visual observation despite of although low C.C. In this study, we consider factors.

Methods: We measured the F-waves, presented 5 trials of 30 F-wave to 3 people. As a result of analyzing the inconstancy between judged as same waveform and C.C. of each F-wave waveform, a pairs waveforms with C.C. of less than 0.95 were analyzed.

Results: The C.C. of the waveform in a pair of waves was 0.71. The waveform shifted while visually confirming that the onset latency of matched. As a result, latency was extended 0.625 ms and C.C. improved from 0.71 to 0.96.

Conclusions: It was suggested that the C.C. shows a low value even when slight latency deviation occurs.

Significance: It is appropriate to use objective evaluation of the C.C. when judging the same waveform.

Keywords: F-wave; Repeater F; Waveform

Introduction

To evaluate the excitability of the spinal motor neural function, the F-wave in evoked electromyogram is often used [1-3]. As the dominant nerve to the muscle is electrically stimulated, retrograde action potentials are transmitted from the stimulation point to the anterior horn cells of the spinal cord. Action potentials that are regenerated in the anterior horn cells of the spinal cord are transmitted to the muscle in an anterograde manner, which are recorded in the muscle (Figure 1). Therefore, the F-wave is an indicator of the excitability of spinal motor nerve function. The F-wave is a complex action potential which is characterized that various waveforms can be recorded (Figure 2). Motor units of various sizes exist in the anterior horn cells of the spinal cord, and neurons are excited from small cell bodies to large cell bodies. It is a mechanism that the F-wave waveform differs depending on the size of neuron firing [4].

There are few reports that focus on the shape of the waveform of the F-wave [5-7]. For example, Suzuki et al. reported the analysis of an F-wave waveform measured from the thenar muscle of hemiplegic patients with cerebrovascular disorder by exercise therapy process [8,9]. Their results showed that although no increase in amplitude was observed, waveform variety was recognized. At the same time, they reported that voluntary movement and muscle tone functions have improved. In other words, the ability to analyze the waveform diversity of F-waves may be a new way to evaluate voluntariness and muscle tone.

In a previous study, we examined the reference values of waveform identity using correlation coefficients (C.C.). In the method, the measured F-waves were presented to three persons who have been studying F-waves for many years. They were asked to visually judge whether the waveforms were the same or not. Next, the results of visual judgment and the C.C. calculated by the system were compared. It was suggested that C.C. of 0.95 is the basis of identity [10]. However, despite the low C.C., there were combinations that were visually judged as the same waveform by the three persons who have been studying F-waves for many years. In this research, we considered factors related to visual and C.C. on mismatch.

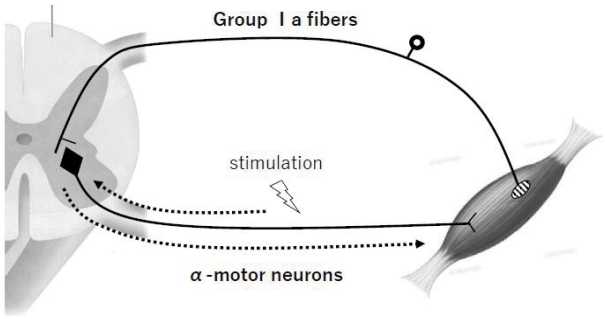

Figure 1: Mechanism of generation F wave. As the dominant nerve stimulated, retrograde action potentials are transmitted from the stimulation point to anterior horn cells of spinal cord. Action potentials that the stimulation point to anterior horn cells of spinal cord, so recorded in the muscle.

Analyzing the waveform of the F-wave is important in pursuing the influence on excitability of the spinal nerve function. In addition, we believe that it will become one indicator of objective evaluation of voluntary in clinical scene.

Method

Subject

Five healthy volunteers (two males and three females; mean age,

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21.6 years ± 0.89) participated in the study. All study participants provided informed consent, and the study design was approved by of Kansai Medical University Ethics Review Board.

Measurement method of F-wave

We measured the F-waves from thenar muscles by stimulating the left median nerve at the wrist with the muscles relaxed. The F-wave recording condition is described. We used the machine Viking Quest Ver.9.0 (Natus Medical Inc.). The sampling frequency is 8 kHz while the bandwidth filter ranged from 5 Hz to 2 kHz. Next, the stimulation condition of the F-wave is described. The maximal stimulus was adjusted up to a value 20% higher than the maximal stimulus that can generate action potentials in the largest compound muscle. To generate F-waves, 30 supramaximal shocks were delivered at 0.5 Hz. A pair of round disks was attached with collodion to the skin of the left thenar muscle over the muscle belly, and the bone of the metacarpophalangeal joint of the thumb. The ground electrode was attached to the center of the palm side of the forearm. The stimulation electrode is a bipolar and has a space of 2 cm. The recording electrode used Ag/AgCl with a diameter of 1 cm (Figure 3).

Analysis method of waveforms to obtain F-wave waveform values

We referred to the previous study of Suzuki et al. First, we applied the moving average of three terms to the F-wave data in order to smooth the raw waveform using Windows Excel software (Figure 4). Next, the C.C. of the combination of F-wave waveforms was calculated using the CORREL function in Windows Excel.

Method of examining the same waveform by visual observation

All 30 F-waves (each trial) were measured by the above method, presented the measured the waveform. Three researchers familiar with F-waves judged the same F-wave waveform. The waveforms were judged to be similar by two out of three people.

Result

As a result of visual judgment, 12 pairs of F-waves were selected as the same waveform. Eleven out of the 12 pairs of F-waves recognized had C.C. of 0.95 or more (Table 1). There was a pair of F-waves

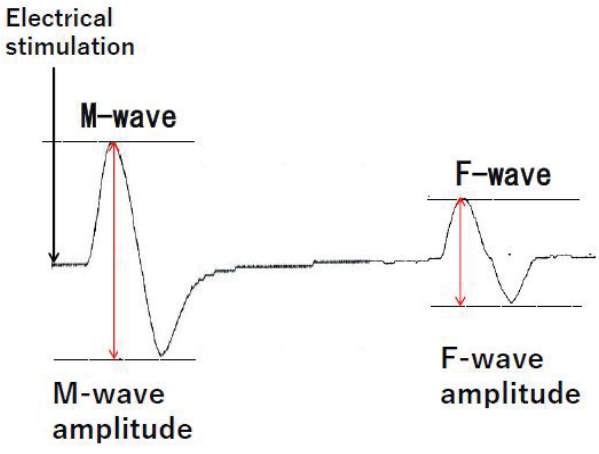

Figure 2: Actual F Figure. The first wave is M -wave, the second wave is F-wave. Wave height means amplitude.

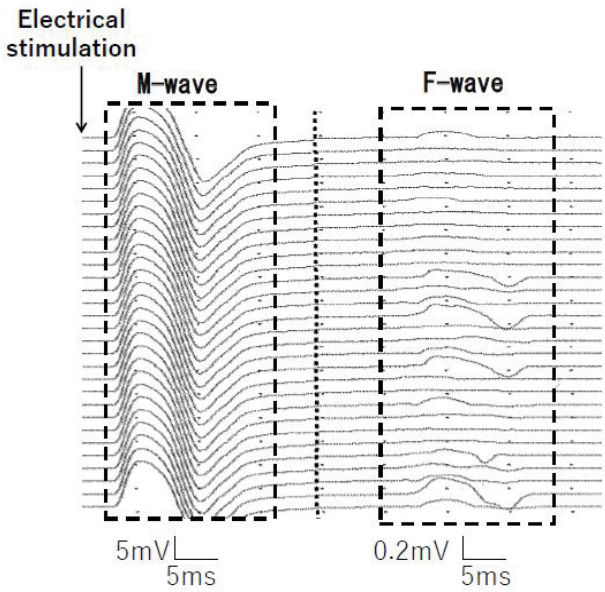

Figure 3: F-wave by 30 electrical stimuli. There are various shapes of F waves.

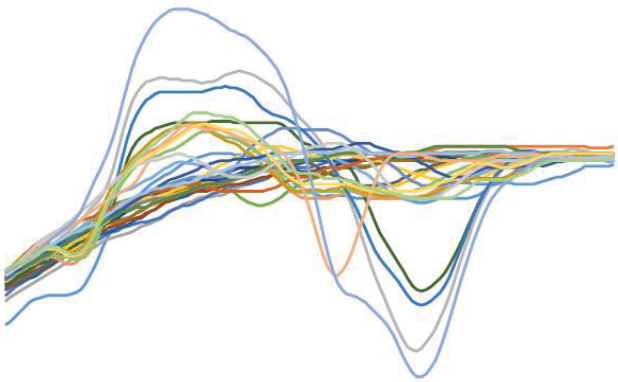

Figure 4: Raw F-wave waveform. Only the f wave was cut out from measured waveform.

waveforms that had C.C. of 0.95 or less. The C.C. of the waveform in a pair of waves was 0.71. We superimposed in one combination and visually confirmed. Although the waveforms were similar, we observed slight differences in latency; the waveform shifted while visually confirming that the onset latency of matched. As a result, latency was extended 0.625 ms and C.C. improved from 0.71 to 0.96 (Figure 5).

Discussion

In the F-wave, retrograde impulses transmitted from the electric stimulation site re-fire in the spinal cord anterior horn cells. At this time, not all of the spinal cord anterior horn cells fire at the same time. It is said that slight cell re-fires with one electrical stimulation. The F-wave was recorded with various waveforms. Suzuki et al. reported that F-wave waveforms diversified with improvement of voluntary movement and muscle tone in patients with cerebrovascular disease. When electrical stimulation is applied, the waveform varies depending on the size of cells that re-fire. In other words, activating many kinds of

	No. 1	No. 2	No. 3	No. 4	No. 5
2 people out of 3	0.71	0.98	1.00	0.96	0.98
	-	0.98	0.97	0.99	-
	-	0.99	0.98	-	-
All People	0.95	-	-	0.99	-
2 people out of 3	1	3	3	2	1
All People	1	0	0	1	0

Table 1: The same waveform selected by visually and correlation [2].

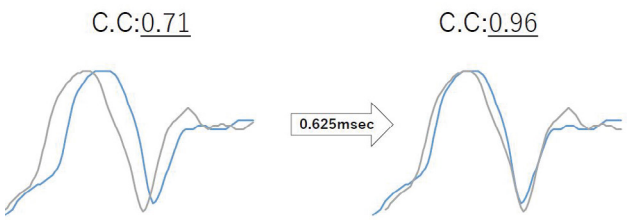

Figure 5: Onset latency time extended result waveform. The waveform shifted while visually confirming that the onset latency of matched. As a result, latency was extended 0.625 ms and C.C. improved from 0.71 to 0.96.

cells becomes an evaluation criterion for the improvement of voluntary movement.

This study showed high C.C. of waveforms selected by visual examination. Although these were judged visually as the same waveform, there was one set waveforms with low C.C. value. We considered the mismatch between visual observation and C.C. We also analyzed waveforms to show the low C.C. value. These waves differed with latency of 0.625 ms. There are two factors that can cause latency deviation. The first is the influence of the inhibition system arising from the motion-related region of the brain. The second is the possibility that latency may be different owing to re-firing of similar cells. Cells to be re-fires were re-fires rather than the same cells, similar in size. It is thought that the spatial positional relationship of re-fire similar cell has an influence.

Conclusion

It is appropriate to use objective evaluation of the C.C. when judging the same waveform. However, it was suggested that the C.C. shows a low value even when slight latency deviation occurs. Further improvement of software is necessary from now on.

References

1. Fukumoto Y, Bunno Y, Suzuki T (2016) Effect of motor imagery on excitability of spinal neural function and its impact on the accuracy of movement-considering the point at which subjects subjectively determine the 50% MVC point. J Phys Ther 28: 3416-3420.
2. Hale BS, Raglin JS, Koceja DM (2003) Effect of mental imagery of a motor task on the Hoffmann reflex. Behav Brain Res 142: 81-87.
3. Suzuki T, Bunno Y, Onigata C, Tani M, Uragami S (2014) Excitability of spinal neural function by motor imagery with isometric opponens pollicis activity: Influence of vision during motor imagery. NeuroRehabilitation 34:725-729.
4. Kimura J, Kohara N (2010) For those studying nerve conduction tests and electromyograms. (In Japanese) IGAKU-SHOIN Ltd.
5. Peioglou-Harmoussi Fawcett PR, Howel D, Barwick DD (1958) F-responses: A study of frequency, sharp and amplitude characteristics in healthy control subject. J Neurol Neurosurg Psychiatry 48: 1159-1164.
6. Komatsu N, Take N, Takamori K, Ohnuma T (2016) F-wave of healthy subjects by voluntary mevements of different muscle contraction strengths: Consideration of the type of F-wave waveforms. J Kansai Phys Ther 16: 69-77.
7. Tetsuo K (1988) F-wave waveform and appearance frequency (In Japanese). 30: 1-6.
8. Suzuki T, Bunno Y, Tani M, Onigata C, Fukumoto Y, et al. (2016) F-Wave waveform values based on the correlation coefficient of each waveform increased following improved voluntary movements in a patient with cerebrovascular disease: A case study with long-term follow-up. Int J Neurorehabilitation 3: 206.
9. Suzuki T, Bunno Y, Tani M, Onigata C, Fukumoto Y, et al. (2016) A new analysis method of F-wave to obtain “F-wave waveform Values”. SM J Neurol Neurosci 2:1005.
10. Todo M, Suzuki T, Fukumoto Y, Tani M, Bunno Y, et al. (2017) Application of F-wave waveform for the effect of physical therapy-relationship between the correlation coefficient of the f-wave waveforms and waveform identification by investigators. Int J Neurorehabilitation 4: 287.