



SOME DIAGNOSTIC OPPORTUNITIES OF FUNCTIONAL ELECTRONEUROMYOGRAPHY IN RADICULAR SYNDROME

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Objective. To analyze dynamic changes in the average F-wave latency in non-operated and operated patients with disc herniation and radicular compression syndrome.

Material and Methods. A total of 81 patients were examined including 29 with non-operated nerve root compression, 32 with remaining pain syndrome (failed back surgery syndrome) and recurrent disc herniation after surgery, and 20 control patients. All patients underwent electroneuromyographic study of the average F-wave latency using a functional test in the supine and sitting positions.

Results. There was no significant change in the average F-wave latency in non-operated patients with radicular syndrome, in the group of operated patients with failed back surgery syndrome and in the group of operated patients with recurrent disc herniation. The average F-wave latency decreased in the group of operated patients with instability of the spinal motion segment and in the group of operated patients with soft-tissue compression of the nerve root.

Conclusion. The study of the late neurographic phenomenon of F-wave can be performed not only in the classical static position of a patient, but also in functional tests. The absence of significant changes in the average F-wave latency in a dynamic study indicates organic nerve root compression, while its decrease serves as an indicator of functional compression.

Key Words: functional electroneuromyography, spine, disc herniation, radicular syndrome.

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The spine is the main axis of the body characterized by preserved segmental structure [1]. The spinal motion segment (SMS) is the basic structural unit of the spine, consisting of two adjacent vertebrae and their connecting disc, fibrous tissue (joint capsule, ligament), and intervertebral muscles [2]. The flexibility of this segment underlies the movement, which allows us to consider the SMS as a functional element of the spinal column, and the spine as a whole as a functional system [3].

The intervertebral space in the SMS is formed by the upper notch of the pedicle of the underlying vertebra and the lower notch of the pedicle of the overlying vertebra, the intervertebral disc (anteriorly and medially), and the facet joints (posteriorly and laterally) [8]. Nerve roots and radiculomedullary vein exit the SMS

through the intervertebral foramen (along the anterior surface of the root) [7]. There is a lot of free space filled with fat tissue in all the intervertebral foramina, and only the last foramen (L5–S1) is almost completely filled with a root [5].

According to modern data, F-wave is the motor response of the muscle, which is occasionally recorded during supra-maximal stimulation of the mixed nerve and characterized by significantly higher latency than the M-response [6]. Physiological nature of the F-wave corresponds to the muscle response to a recurrent discharge, resulting from antidromic motoneuron stimulation [4].

The study was aimed at analyzing the dynamic changes in the average latency of the F-wave in non-operated patients and in those who were operated on for

herniated disc with compression radicular syndrome.

Material and Methods

The studies were carried out on the Sapphire Premiere electroneuromyograph (Great Britain). The method of late response recording (F-wave) during *n. Tibialis* stimulation was used in the study. The study complied with Good Clinical Practice and Helsinki Declaration principles. The study protocol was approved by the ethical committees of all participating clinical centers. All participants signed written informed consent prior to inclusion to the study.

We examined 81 patients with posterolateral hernia of L5–S1. This location of hernia is the most common and convenient for research as opposed to

the median and paramedian hernia, since it compresses only one root. Patients were divided into three groups: group 1 included 29 non-operated patients with radicular syndrome at S1 caused by compression exerted by posterolateral herniation of the L5–S1 intervertebral disc as evidenced by clinical presentation, ENMG, and MRI; group 2 – 32 patients who were operated on for clinical manifestations of S1 root compression caused by posterolateral hernia of the L5–S1 disc; all patients had persisting radicular pain syndrome in this dermatome at the time of examination. The patients were examined by neurosurgeon 6 weeks after the surgery.

Group 2 was divided into two subgroups according to the time of pain onset. Subgroup 2.1 included 10 patients who complained of persisting pain syndrome despite the surgical treatment. According to the MRI, they retained herniated disc. The condition of patients was regarded as the failed back surgery syndrome. Patients refused reoperation while staying at the neurosurgical unit; they were treated at their place of residence. During follow-up examination by a neurosurgeon in 6 weeks, the pain was localized at the same place.

The subgroup 2.2 included 22 patients who demonstrated pain relief after surgical treatment. Increase in physical activity 4–5 weeks after the operation (augmentation of motion regimen) resulted in recurrence of radicular pain syndrome at the level of the previously operated intervertebral disc. MRI showed signs of recurrent herniation. X-ray examination of the lumbar spine with functional flexion tests showed signs of instability in the operated SMS in 7 (31.8 %) patients.

Group 3 (control) included 20 patients without complaints and no involvement of the peripheral nervous system.

ENMG study of F-wave parameters was carried out on the couch in two positions of patient's body: lying on the back and sitting. The active electrode was applied to *m. abductor hallucis*, the side of the lead corresponded to the side of the posterolateral hernia. Stimulation was carried out in the distal section

in the projection of the studied nerve. Stimulation parameters: stimulus duration – 0.2 ms, frequency – 1 Hz, amplitude – supramaximal with respect to motor response, analyzed epoch – 100 ms. Then we carried out a series of rhythmic stimulation. Forty stimuli were used in the series for analysis.

Results

In group 1, the change in the average F-wave latency by 0–1 % was detected in 26 (89.7 %) patients; in three cases, it was 1.8 % (Fig. 1).

In subgroup 2.1, neurophysiological study in patient's prone position showed decrease in the average F-wave latency by 0.5–0.9 % with respect to the maximum flexion position (Fig. 2a).

In subgroup 2.2, decrease in the average F-wave latency in the patient's prone position by 0.4–9.5 % with respect to the maximum flexion position was detected (Fig. 2b).

Decrease in the average F-wave latency by 0.6–2.7 % (Fig. 3) was observed in the control group of patients.

Discussion

In the control group, the average F-wave latency changes by 0.6–2.7 % due to normal functional mobility of the SMS, which does not cause signs of involvement of the peripheral nervous system.

In the group of patients with radicular syndrome (group 1) caused by compression of root by posterolateral herniation of the intervertebral disc, the average F-wave latency value does not change by more than 1 % in 89.7 % of cases due to radicular compression, which is not eliminated by functional SMS unloading.

In subgroup 2.1, F-wave value changed by 0.5–0.9 %. Patients' condition was considered as a failed back surgery syndrome.

In subgroup 2.2, five patients showed clinical signs of S1 root compression, signs of radicular lesion on ENMG, absence of instability on the X-ray image with functional tests. MRI shows the condition after surgery, signs of epiduritis

and herniated disc at L5–S1. In these patients, F-wave value changed by 0.4–1.2 %. The results suggest the true recurrence of disc herniation.

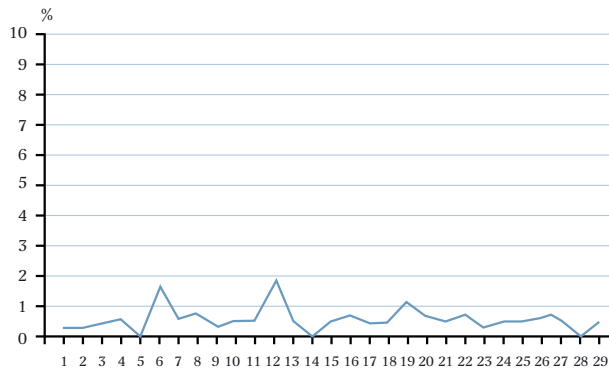
In subgroup 2.2, seven patients showed clinical signs of S1 root compression, signs of radicular lesion on ENMG, signs of instability in the L5–S1 segment of the operated SMS, condition after surgery, symptoms of epiduritis and L5–S1 disc herniation. X-ray images with functional tests showed reversible compression, which was eliminated by functional unloading of the SMS. In these patients, F-wave value changed by 2.1–9.5 %. Instability provoked compression of the S1 root in the sitting position and compression was eliminated in prone position.

Ten subgroup 2.2 patients demonstrated residual clinical signs of S1 root compression, signs of radicular lesion on ENMG, condition after surgical treatment, signs of epiduritis, and signs of herniated L5–S1 disc on MRI. There was no instability on the X-ray image with functional tests. In these patients, F-wave value varied by 2.8–9.5 %. Compression of S1 root was reversible because of postoperative changes in soft tissues in the L5–S1 segment, including cicatricial-adhesive process, deformed and thickened posterior longitudinal ligament, as well as due to augmentation of motion regimen. These factors provoked compression of the S1 root in patient's sitting position and compression was eliminated in the prone position.

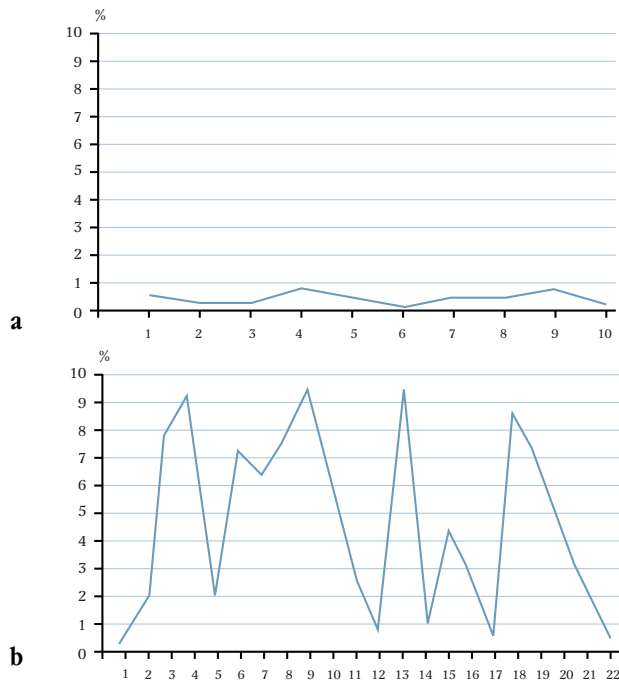
Conclusion

Electroneuromyography enables assessing the functional state of the neuromuscular system. It is based on recording and qualitative and quantitative analysis of various types of neuromuscular activity. The late neurographic F-wave phenomenon can be studied not only in the conventional static position, but it also can be used to evaluate functional changes in the neuromuscular system in a dynamic study.

Preserved F-wave latency values are indicative of persistent manifestations

**Fig. 1**

Change in the average F-wave latency in non-operated patients with radicular syndrome caused by compression of root by posterolateral herniation of the intervertebral disc (ordinate axis — change in the average latency; abscissa axis — patients)

**Fig. 2**

Change in the average F-wave latency in patients who were operated on for posterolateral hernia (ordinate axis — change in the average latency, abscissa axis — patients): **a** — with persisting clinical manifestations of compression immediately after surgery; **b** — with clinical signs of radicular compression that occurred 4–5 weeks after the operation

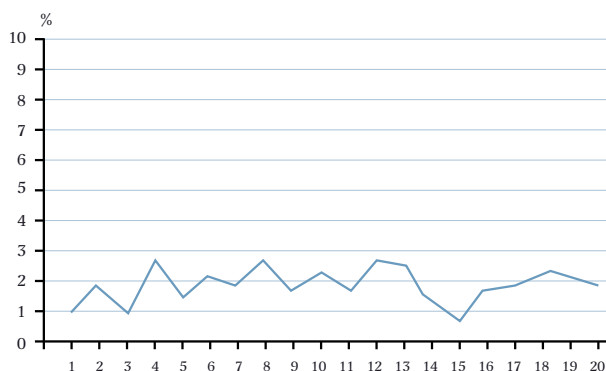
associated with compression by hard-tissue structures.

Change in F-wave values in functional tests enables detection of the recoverable (soft-tissue) compression.

The results of the functional study of F-wave in dynamic tests can be used for differential diagnosis of functional and organic radicular compression and evaluation of dynamic changes in SMSs. The method is cheap, fast, and less labor-intensive.

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**Fig. 3**

Change in the average F-wave latency in the control group of patients (ordinate axis — change in the average latency, abscissa axis — patients)

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