

# Electromyography data in chronic migraine patients by using neurostimulation with the Cefaly<sup>®</sup> device

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**Abstract** The objective of this observational study is to report clinical and instrumental results obtained in 23 chronic migraine sufferers treated with transcutaneous neurostimulation with the Cefaly<sup>®</sup> device. The electromyography (EMG) parameters of the patients monitored before and during neurostimulation with the Cefaly<sup>®</sup> device showed a significant increase in the EMG amplitude and frequency values in the frontalis, anterior temporalis, auricularis posterior and middle trapezius muscles. The Cefaly<sup>®</sup> device could act on the inhibitory circuit in the

spinal cord thus causing a neuromuscular facilitation and may help reduce contraction of frontalis muscles.

**Keywords** EMG (electromyography, K7 electromyograph) · TNS (neurostimulation) · Supraorbital nerve · TA (anterior temporalis muscle) · FR (frontalis muscle) · TP (auricularis posterior) · TR (middle trapezius)

## Introduction

The objective of this study is to examine the potential role that surface EMG can play in detecting myoelectrical signals with a transcutaneous neurostimulator called Cefaly<sup>®</sup> placed on the supraorbital nerve and recording frontalis, anterior temporalis, auricularis posterior and middle trapezius muscles.

## Patients and methods

The study included 23 patients, 18 women and 5 men (whose mean age was 44 years, ranging from 20 to 76). All 23 patients were chronic migraine sufferers who met ICDH-3 beta 2013 criteria [1]. 14 out of the 23 subjects were overusing medications.

Migraine days were on average 20 a month. All patients signed the written informed consent.

The results of clinical and neurological examinations were normal for all patients. None of them had serious health problems or psychiatric disorders. All subjects were treated with prophylactic antimigraine drugs.

All 23 patients underwent a neurological examination and surface EMG of frontalis, anterior temporalis, auricularis posterior and middle trapezius muscles at rest

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before using the Cefaly® device and during the neurostimulation.

The test was carried out using a K7 electromyograph and Au-C1 Duotrode bipolar electrodes (by Myotronics-Noromed Inc., Seattle, WA).

The parameters observed were: amplitude ( $\mu\text{V}$ ), mean frequency (Hz) and median frequency (Hz) of the myoelectrical signal.

With regard to the neurostimulator (the Cefaly® device), programmes 1 and 2 were used, respectively, recommended for ‘crisis treatment’ and ‘prevention’. The stimulation parameters were as follows: Programme 1 is 250  $\mu\text{s}$  long–16 mA max intensity–100 Hz frequency; Programme 2 is 300  $\mu\text{s}$ –16 mA max intensity–60 Hz frequency.

All patients experienced symptoms of paresthesia and tingling on the area of neurostimulation (frontalis muscle) and the impulse intensity was just below the pain perception threshold.

All subjects underwent surface EMG evaluation of their frontalis, anterior temporalis, auricularis posterior and right and left trapezius muscles, using Scan 18 in compliance with current guidelines set by Jankelson [2].

Bipolar, skin, adhesive and disposable electrodes (duotrodes) were placed over the muscles to be examined, specifically the anterior temporalis, the frontalis at the level of the motor point located along the vertical axis of the eye pupil, the auricularis posterior just above the mastoid process, the trapezius at the level of its intermediate region,

using as landmarks four fingers laterally from the VII cervical vertebra.

The evaluation of the myoelectrical signal was conducted at rest and during the neurostimulation with the patient seated and resting their elbows on their knees, inviting them to be as relaxed as possible. The objective is to assess possible differences between the myoelectrical signal at rest and electrically elicited in the above mentioned muscles. The evaluation regarded the myoelectrical activity at rest 2' from EMG start and at the 14th minute, choosing two time windows pre-stimulation and during the stimulation which lasted 1.44' as showed in Figs. 1, 2 and 3. Each patient gave a pre-stimulation value for the right muscles and one for the left ones and as many during the stimulation for a total of 16 values.

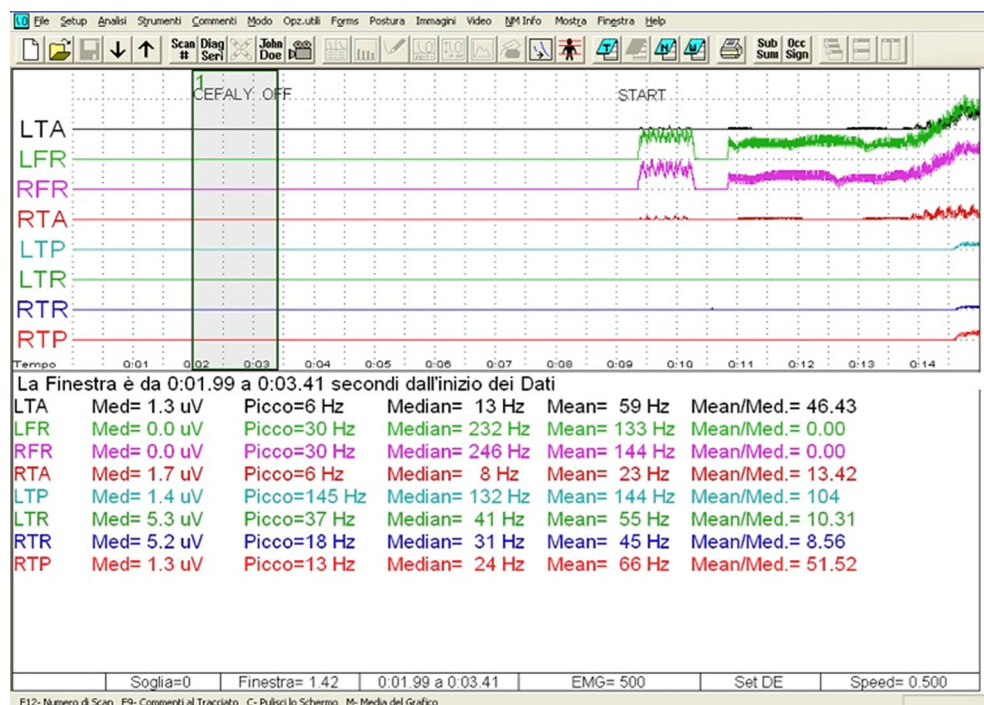
### Statistical analysis

Electrophysiological data were analyzed with the two-tailed Student's *t* test. The requested statistical significance level is  $p < 0.01$ .

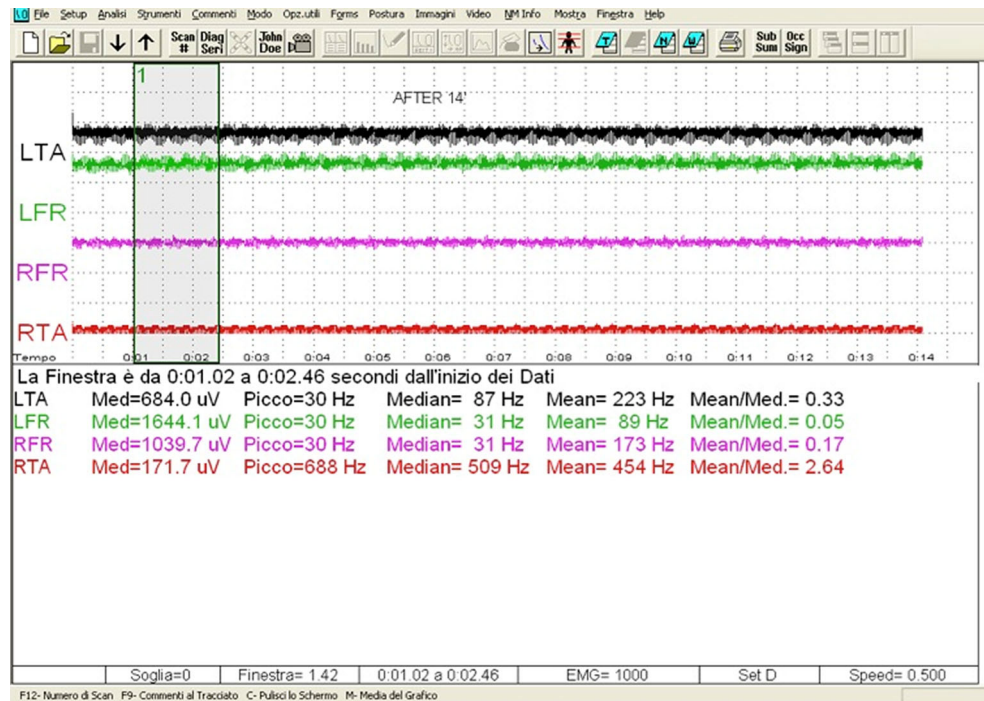
### Results

Our study on temporalis, auricularis posterior and trapezius muscles has indicated a significant difference in frequency domain parameters between values recorded at rest and

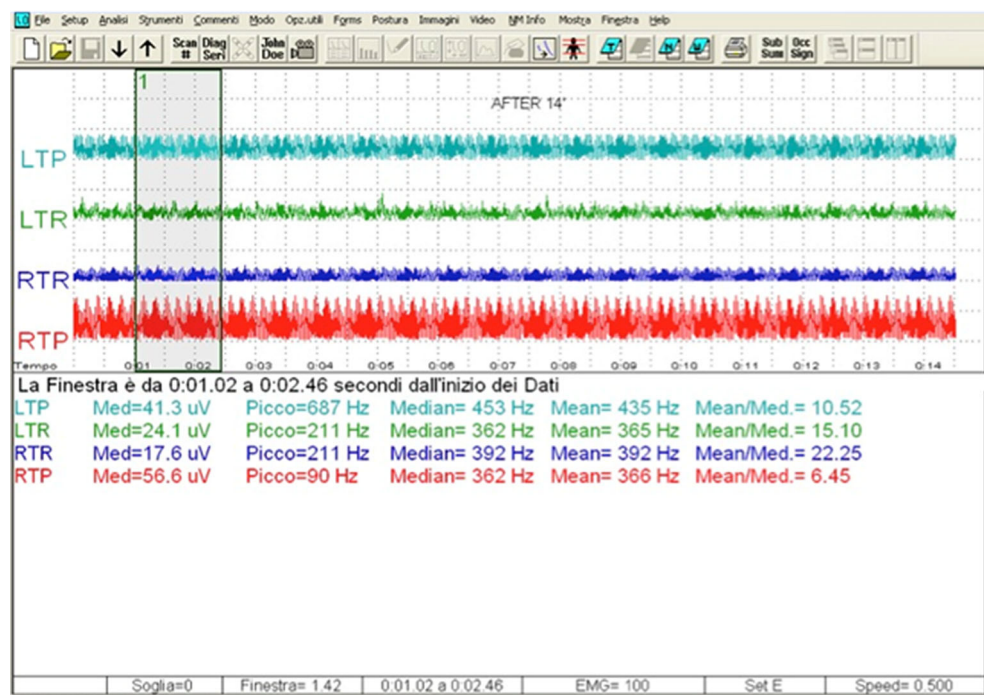
**Fig. 1** With Cefaly® off and at the response of the eight muscles (auricularis posterior and trapezius muscles respond approximately 5 s after frontalis and temporalis)



**Fig. 2** With Cefaly® on, 14 min later, monitoring frontalis and temporalis muscles

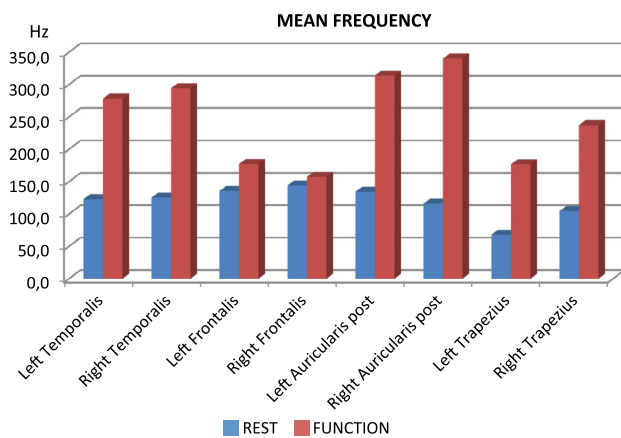


**Fig. 3** With Cefaly® on, 14 min later, monitoring auricularis posterior (TP) and trapezius (TR) muscles

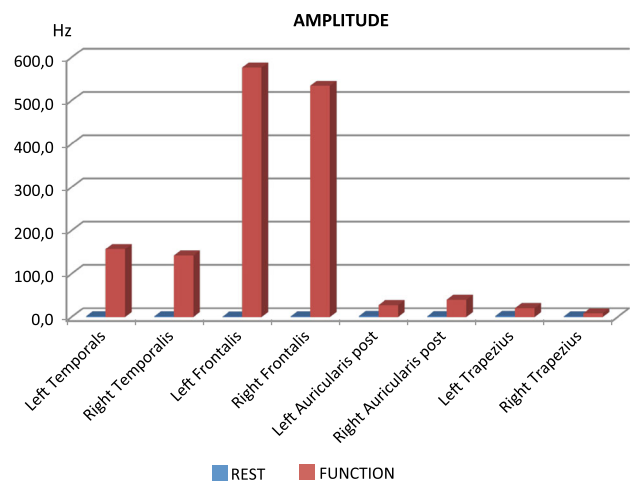


during neurostimulation ( $p < 0.0001$ ). On the frontalis muscle, the difference is significant in amplitude parameters ( $p < 0.0001$ ) between values recorded at rest and those during neurostimulation. The median frequency values do not show a  $p$  value which can be statistically significant ( $p$  0.248 for the left frontalis muscle and  $p$  0.083

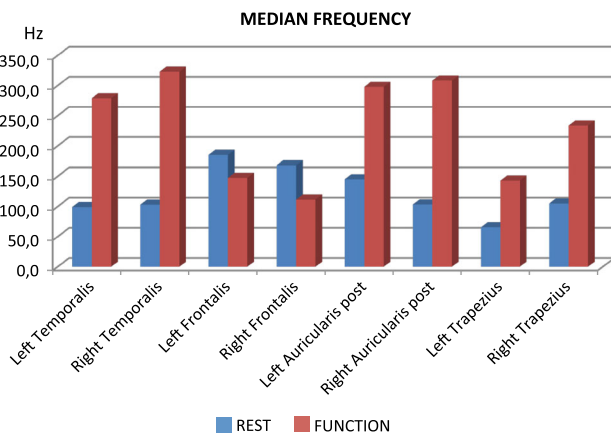
for the right frontalis), however, the sample of patients has shown a reduction in the median frequency, although not significantly, between before and during neurostimulation from 184.4 Hz pre-stimulation to 147.5 Hz during stimulation as to the left frontalis muscle and from 168.0 to 111.4 Hz for the right frontalis muscle.



**Fig. 4** Temporalis, auricularis post and trapezius muscles has indicated a significant difference in domain parameters between values recorded at rest and during neurostimulation (Function)



**Fig. 6** Significant difference in amplitude parameters between values at rest and during neurostimulation (Function)



**Fig. 5** The median frequency values do not show a *p* value statistically significant, however, has shown a reduction in the median frequency during neurostimulation (Function)

The hypothesis is that, the different neuromuscular response of the frontalis muscle is caused by the direct action of neurostimulation on the frontalis muscle that elicits the intramuscular nerve endings of the facial nerve which, being very small, become exhausted quickly (Figs. 4, 5). This decrease in median frequency could indicate premature fatigue of the frontalis muscle during neurostimulation [3].

With regard to the possible myorelaxant effect of neurostimulation on the frontalis muscle with the Cefaly<sup>®</sup> device, no significant contraction was measured by EMG on these muscles at rest.

20 out of the 23 patients, before and during neurostimulation, had EMG results within a normal range, one patient during a migraine attack had an increase in the EMG activity after 20 min of neurostimulation and two patients, experiencing as well increasing EMG activity at rest, reached normalization after 20 min of neurostimulation with the Cefaly<sup>®</sup> device.

It is necessary to increase the sample size to interpret the role played by surface neurostimulation in relaxing the frontalis muscle.

## Discussion

The sensory trigemino cervical complex is an area in the upper cervical spinal cord where nerve fibers in the descending tract of the trigeminal nerve (spinal trigeminal nucleus caudalis) interact with the spinal root of the spinal accessory nerve (CN XI) which originates from the anterior horn of the first five segments of the cervical cord.

This functional intersection between motor and sensory fibers of the spinal root of CN XI and the descending tract of the trigeminal nerve [4] is thought to provide a functional connection of somatosensory, proprioceptive and nociceptive information between cervical muscles, i.e. sternocleidomastoid and trapezius muscles, and the trigemino cervical nucleus [5].

The physiological communication between the first cervical spinal nerve roots and the spinal trigeminal tract, involving the ophthalmic branch of the trigeminal nerve, could trigger migraine attacks with pain radiating behind the corresponding eye [6–9]. Transcutaneous neurostimulation (TNS) applied to the supraorbital nerve is supposed to use this nerve pathway to spread the impulse from the frontalis muscle to peripheral muscles thus being recorded in other muscles far from the application area of stimulation.

The Cefaly<sup>®</sup> device could act therapeutically on the inhibitory circuit in the spinal cord causing a neuromuscular facilitation. The increase in the amplitude values recorded on all muscles under examination may support this theory.

The data collected prove a significant increase in the electrical activity in an area where signals of certain muscles converge, such as: frontalis, temporalis, trapezius, sternocleidomastoid and auricularis posterior muscles. Such increase could explain the therapeutical effect of the Cefaly<sup>®</sup> device (Fig. 6).

## Conclusions

The results of this preliminary study, although a further research on a larger sample size is necessary, show that the decrease in the median frequency in the frontalis muscle is probably due to the direct neurostimulation.

The median frequency can be a particularly interesting parameter, whose decrease indicates the premature fatigue of a muscle. The study confirmed the fact under examination i.e. that neurostimulation of the first branch of the trigeminal nerve can also activate peripheral muscles that are far from the area of the electrical stimulation and recordable using a non-invasive technology such as surface electromyography.

**Conflict of interest** The authors certify that there is no actual or potential conflict of interest in relation to this article.

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