Long-term home-based Surface Electrostimulation is useful to prevent atrophy in denervated Facial Muscles

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Abstract: *5 patients with facial paralysis received a home-based electrostimulation (ES) with charge-balanced biphasic triangular impulses 3x5min twice a day. Before the first ES, and every 4 weeks during the ES, all patients underwent regular needle electromyography (EMG), ultrasound and 3D-video measurements. Additionally, stimulation settings, patients' home-stimulation diaries and parameters were recorded. No patient reported relevant adverse events linked to ES. Training with optimized electrode positioning was associated with stable and specific zygomaticus muscle activation, accompanied by a reduction of the necessary minimum pulse duration from 250 to 70ms per phase within 16 weeks. Even before reinnervation, objective 3D-videos, sonography, MRI, and patient-related parameters (FDI, FaCE) improved significantly compared to the pre-stimulation situation. Preliminary results suggest that ES home-based training is beneficial for patients with denervated facial muscles in reducing muscle atrophy, maintaining muscle function and improving facial symmetry. A lack of relevant adverse events shows that such ES is safe. The patients showed excellent compliance with the protocol and rated the stimulation easy and effective.*
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Keywords: *surface electrostimulation, facial palsy, paralysis, muscles, atrophy, home-based training, 3D-scans*

Introduction

Often, skull base or petrosal bone tumors and surgeries cause facial nerve paralysis and consequently result in neuromuscular atrophy of facial muscles. Because of the distance between the lesion site and the denervated muscles, reinnervating axons need several months to reach the muscles. To reduce or even prevent the muscle atrophy, electrostimulation (ES) could have a beneficial effect for facial muscles (1, 2) similar to limb muscles (3). The aim of the present study is to evaluate the effects of transcutaneous facial muscle stimulation on the denervated zygomaticus muscle.

Material and Methods

As far as May 2019, we enrolled 5 patients (4 female) with facial paralysis (duration between 1 month and 16 years). The affected hemiface was the right side in 3 and the left side in 2 cases. The etiology of the facial paralysis, confirmed by needle electromyography (EMG), was in all cases iatrogenic, i.e. following vestibular schwannoma surgery. Before the first ES, and every 4 weeks during the ES, all patients underwent regular needle EMG, ultrasound (4), MRI (5) and 3D-video measurements (6). The stimulation parameters and patients home-stimulation diaries were recorded. Additionally, all patients completed the forms for Facial Disability Index (FDI) and the Facial clinometric evaluation scale (FaCE). Stimulation settings and parameters were recorded and both objective and subjective outcome measures ware used for the result analysis.

The test stimulation was performed every four weeks with the STMISOLA; BIOPAC Systems Inc. Two surface electrodes (60x40mm Flextrode Plus; Krauth+Timmermann) were placed as close as possible to the lip corner on the ailing hemiface. The amplitude required to elicit a selective zygomaticus muscle contraction on the ailing hemiface was investigated at the following pulse durations: 1000, 500, 250, 100, 50, 25, 15, 10, 5 and 1ms both with triangular and rectangular waveform. Burst frequency was constantly kept at 1Hz.

The most effective combination of pulse duration and intensity was chosen based on the results obtained with the STMISOLA and the visual evaluation of the patient's response. Once the parameters were selected and programmed on the Stimulette r2x (Dr. Schuhfried GmbH, Vienna), the patient was asked to perform 5 min stimulation in order to exclude potential muscle fatigue. The stimulation was given in charge-balanced biphasic triangular impulses with fixed build-up time (5s); build-up pause (1s); and training duration of 5 min.

To quantify the effect of such a 5 min training, at some follow-up days, 3D-videos were not only recorded before, but also after this 5 min of ES training. After fine-registration between the 3D scan before and after the ES, the point-wise distances to the closest points between both 3D scans are calculated and coloured (Figure 1).

Blue means 0 mm distance and red means 3 mm distance. White and black squares indicate facial landmarks (black = before ES; white = after ES).
At home, the training was performed 3x5min with 5 min pause between in the morning and in the evening every day till the next follow-up after 4 weeks. All patients recorded every stimulation in a dairy.

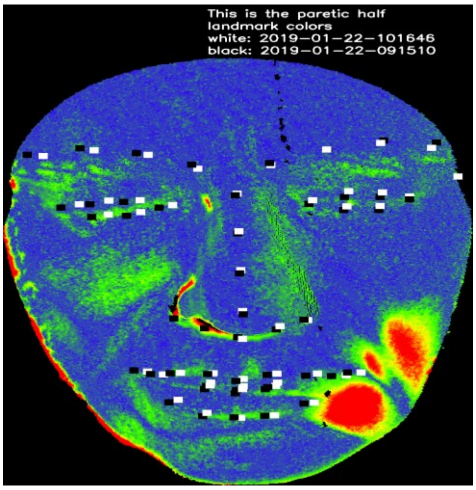

Figure 1: The changes of the surface of the face due to 5 minutes of electrostimulation are visualised as "Heatmap". Example of one patient with denervated facial muscles on the left side. After fine-registration between the 3D scan before and after the ES, the point-wise distances to the closest points between both 3D scans are calculated and colored. Blue means 0 mm distance and red means 3 mm distance. White and black squares indicate facial landmarks (black = before ES; white = after ES). The red area corresponds to the activated zygomatic muscle. So a positive increase of muscle tension even after the ES can be detected.

Results

No patient reported relevant adverse events linked to ES home-based-training. Training with optimized electrode positioning associated with stable and specific zygomaticus muscle activation, accompanied by a reduction of the necessary minimum pulse duration from 250 to 70ms per phase within 16 weeks (Figure 2). Even before reinnervation, objective parameters (3D-videos (Figure 1), sonography, MRI) and subjective parameters (FDI, FaCE) improved significantly compared to the pre-stimulation situation.
The changes of the surface of the face recorded by 3D-videoas were visualised by this "Heatmap". In Figure 1, the example of one patient is provided: The Patient had denervated facial muscles on the left side. After fine registration of the 3D scans before and after ES, the corner of the paralytic left corner of the mouth moved 5.3 mm latero-cranial. The red area with changes from at least 3 mm corresponds to the activated zygomatic muscle. So a positive increase of muscle tension even after the ES can be detected.

Conclusions

ES home-based training is beneficial for patients with denervated facial muscles in reducing muscle atrophy, maintaining muscle function and improving facial symmetry. The accurate selection of the stimulation parameters and positioning of the electrode is necessary to ensure the training specifically for the selected facial muscle. A lack of relevant adverse events shows that such ES is safe. The patients showed excellent compliance with the protocol and rated the stimulation easy and effective.

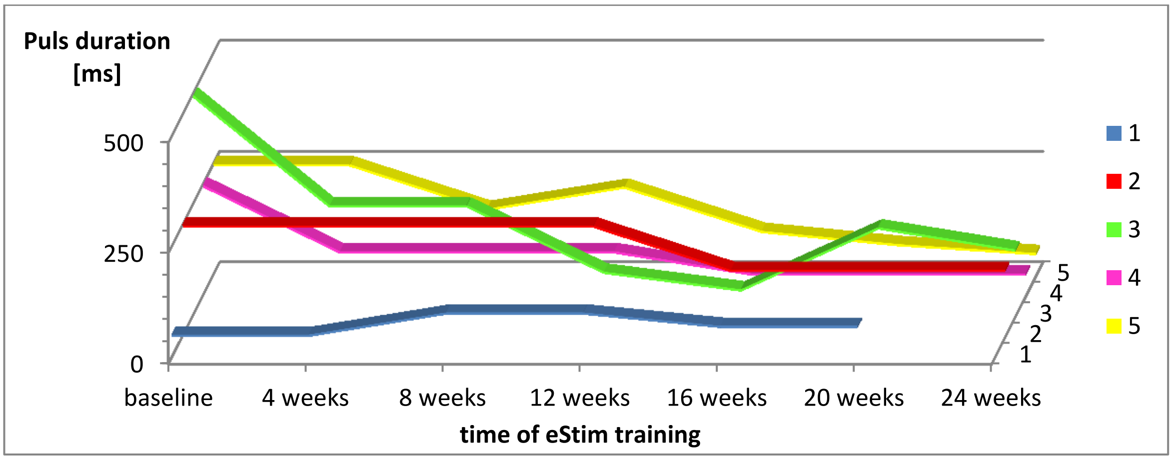

Figure 2: Change of pulse duration used for daily electrostimulation (ES) home training over the first 24 weeks. The different colour coded graphs show the values of each single patient. A reduction of the pulse duration needed is seen over time in most patients.

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