# Transcranial facial nerve stimulation by magnetic stimulator in normal subjects

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**Abstract**

*Magnetic stimulation provides a new method to stimulate facial nerve transcranially. Stimulation can be directed to the intracranial part of the facial nerve, whereas the conventional electic stimuli are delivered extracranially to a more peripheral part of the nerve. Fourty healthy volunteers were examined to determine the normal responses for transcranial facial nerve stimulation. The center of the inducing coil ring was located so that its center was 3 cm posterior and 6 cm lateral to the vertex. Responses were recorded on the nasolabial fold. Latencies were 4.5 ± 0.4 ms on both sides, being 1.1 ms longer than those elicited by electric stimulation of the nerve at the stylomastoid foramen. Amplitudes with magnetic stimuli were equal to those obtained with electric stimuli.*

*The transcranial magnetic stimulation seems to be an accurate and promising method to examine the facial nerve.*

## Introduction

Articifical transcranial stimulation of central nervous system has become more easy to perform since the introduction of motor cortical stimulation by magnetic stimulator (2). The method has been proven to be safe without significant side effects (1, 6). The technique has also been applied to the facial nerve (5, 10, 11, 13). However, the number of studies to establish normal values for intracranial facial nerve responses is still quite limited. We studied 40 healthy subjects to determine the normal values for transcranial magnetic stimulation of facial nerve on its intracranial course and compared the responses to those evoked by electric stimulation at the stylomastoid foramen.

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## Material and methods

### *Subjects*

Fourty healthy persons without any history of nervous disease were examined. Of the subjects 26 were females and 14 males. Their median age was 32 years (range 19-52 years). All of them were members of the staff of our hospital.

During the examination the subjects were seated in a comfortable sitting position. They were asked to relax and especially to avoid any voluntary contraction of the facial muscles.

All subjects were informed about the examination procedure and gave their consent to the study. The study was approved by the local ethical committee.

### *Electric stimulation*

The examination was conducted by the Medelec Mystro MS 20 EMG-system. The constant current stimuli were rectangular pulses of 200 μs in duration and the current intensity was

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increased up to 40 mA. The electric stimulation was performed by delivering an electric impulse at the stylomastoid foramen. The cathode of the stimulating electrode was placed on the skin just anterior to the mastoid process. The anode was situated posteriorly on the mastoid process, 25 mm from the cathode.

*Magnetic stimulation*

Electromagnetic stimulations were delivered by using the Cadwell MES-10 magnetic stimulator. The capacitor was discharged into a circular coil with the diameter of 9 cm. The coil was placed tangentially on the head so that the shield of the coil ring was in contact with the scalp surface. The tip of the coil was always directed anteriorly.

With proximal facial nerve stimulation the capacitor was charged up to 30%-50% of its maximum to elicit the maximal responses. Most prominent responses with the same wave form as in electric stimulation at the stylomastoid formanen could be evoked by locating the center of the circular coil ring so that it was 3 cm posterior and 6 cm lateral to vertex. The determining of the coil location according to the coil center made it easy to relocate the area of stimulation.

For comparison we also studied the magnetic stimulation of the facial nerve by placing the center of the coil ring at the stylomastoid foramen in three persons thus delivering distal stimuli to the facial nerve. The stimulus intensity was up to 40% of the capacity in our device. Higher intensities caused discomfort and contraction of the neighboring facial muscles.

We checked the delay between the onset of the measured sweep and the appearance of the electric field in the tissue. The magnetic stimulus pulse was delivered to a saline solution and the voltage pulse between the two electrodes was measured. For our instrumentation a latency of 0.10 ms was obtained. This delay, probably arising from the triggering of the magnetic stimulator, was subtracted from all measured latencies of magnetically induced responses.

The induced current pulse in the saline phantom had a biphasic waveform. The coil was labeled so that it had a particular side for the stimulation of each hemisphere.

*Recording*

Optimal site for recording the responses was at first sought in five normal subjects. Responses were measured at several muscles innervated by the facial nerve. It was concluded that the compound muscle action potentials distinguish best when recorded at the nasolabial fold. This site was therefore preferred to the superior orbicularis oris muscle, the corner of the mouth and the inferior orbicularis oris muscle or the platysma. Responses from the masseter muscle, if they appeared, were excluded.

Active electrode, 5 mm in diameter, was placed on the nasolabial fold, just lateral to the nasal ala. Referential electrode was situated laterally on the nose at the level of the nasal bones.

The latency of the muscle response was measured from the beginning of the negative deflection (directing upwards). The amplitude was calculated from the start to the peak of the negative deflection.

*Statistics*

Student's paired $t$-test was used to compare the significance of differences.

**Results**

The maximal response with magnetic stimulation was achieved with 30% of the maximal capacity of our device. The amplitude of the response was essentially the same when stimulating with 40% and 50% of the maximal capacity (Fig. 1). Greater intensity caused discomfort in the vicinity of the stimulus coil and in the ear.

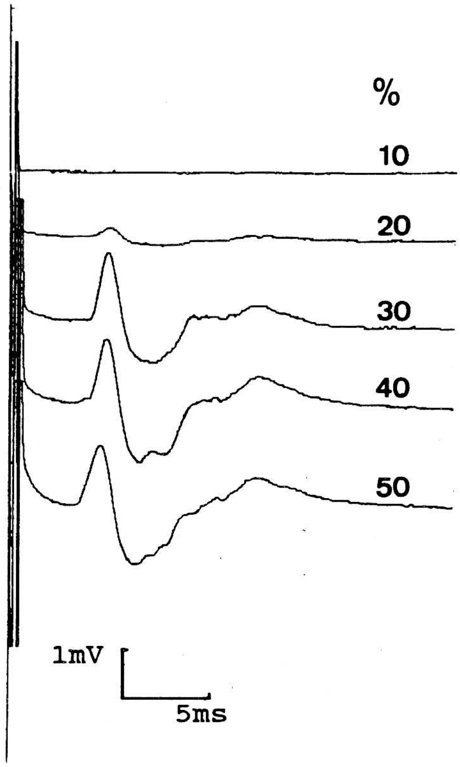


Fig. 1. — The relationship of magnetic stimulation intensity and response with transcranial facial nerve stimulation technique.

The mean amplitude of the responses for electric stimulation was 2.3 (SD 1.0) mV on the right and 2.3 (SD 0.9) mV on the left. The mean difference between the sides, 0.01 mV, is statistically not significant ($p > 0.05$). For magnetic stimulation, the mean amplitude was 2.5 (SD 1.0) mV on the right side and 2.7 (SD 1.2) mV on the left. The mean difference between the sides was 0.18 mV, also this being statistically not significant ($p > 0.05$).

The mean latency of the ipsilateral electric stimulation was 3.4 (SD 0.44) ms on the right side and 3.4 (SD 0.45) ms on the left. The mean latency of the responses achieved by transcranial magnetic stimuli was 4.5 (SD 0.40) ms on the right and 4.5 (SD 0.43) ms on the left. The magnetically induced responses appeared on an average 1.1 ms later than the electrically induced ones (Table 1). The mean latency difference between the sides was 0.02 (SD 0.36) ms with the electric stimuli and 0.07 (SD 0.30) ms with magnetic stimuli. The differences were statistically not significant ($p > 0.05$). Typical responses are shown in Figure 2.

Table 1. — *Mean latencies and amplitudes of the responses for electric stimulation at the stylomastoid foramen and for transcranial magnetic stimulation*

| | Electric stimulation | | Magnetic stimulation | |
|---|---|---|---|---|
| | Right | Left | Right | Left |
| Number of examinations | 40 | 40 | 40 | 40 |
| Latency (ms) | 3.4 | 3.4 | 4.5 | 4.5 |
| SD | 0.44 | 0.45 | 0.40 | 0.43 |
| Amplitude (mV) | 2.3 | 2.3 | 2.5 | 2.7 |
| SD | 1.0 | 0.9 | 1.0 | 1.2 |

Magnetic stimulation in 3 subjects at the stylomastoid foramen produced on an average 1.5 ms shorter latencies of the responses than those obtained through intracranial stimulation. The range of the amplitudes was 1.8-2.5 mV. The magnetic stimulation near the stylomastoid foramen produced more discomfort to the subjects than the electric stimulation.

## Discussion

Magnetic stimulation provides a new method to stimulate the proximal part of the facial nerve. The procedure is noninvasive and painless with the stimulus intensities and locations required to elicit the optimal responses.

The optimal site for transcranial magnetic stimulation of proximal course of the facial nerve was located in a position where the center of the circular coil ring was 3 cm posterior and 6 cm lateral to vertex, ipsilaterally. This corre-

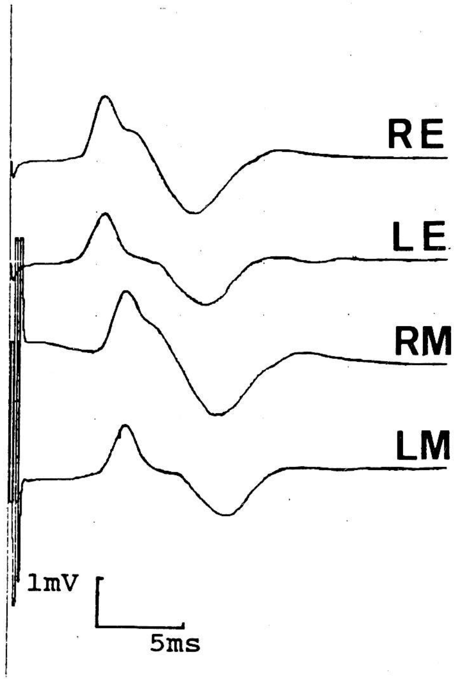


Fig. 2. — Typical ipsilateral responses with electric stimulation to the right (RE) and left (LE) facial nerve at the stylomastoid foramen. Similar ipsilateral facial nerve responses (RM and LM) recorded with transcranial magnetic stimulation but the latencies of the responses are longer.

sponds to the observations in earlier studies in this field (7, 11).

The site of recording the responses was performed as suggested by Fisch (4) and Thomander et al. (12). The site provides anatomical landmarks which are easy to define and relocate, and gives responses with distinguisable onset and amplitude.

The use of magnetic stimulation in evoking facial motor responses has, so far, been relatively limited. Maccabee et al. (5), using themselves as subjects (N = 5), measured latencies of 4.9-5.4 ms on the nasal bridge and inferior orbicularis oris muscle. The latencies were 1.0-1.3 ms longer than those achieved by electrical stimulation at the posterior tragus, which corresponds to the outlet of the facial nerve at the stylomastoid foramen. Schriefer et al. (11) have given data of 15 healthy subjects, in whom latencies of 5.1 ms $\pm$ 0.76 ms were recorded by transcranial magnetic stimulation. These were on an average 1.3 ms $\pm$ 0.15 ms longer than those received by electrical stimulation at the stylomastoid foramen. Recently Rösler et al. (10) reported on 14 healthy subjects the transosseal conduction time to be 1.2 (SD 0.18) ms. In our experiments the average difference between the latencies of the two stimulation procedures was 1.1 ms on both sides. In our study the electrically and magnetically produced latencies are slightly shorter than those received by the groups of Rösler and Schriefer (10, 11). This may be due to different registration site and to the subtraction of the delay of 0.1 ms in our magnetic stimulation technique.

Based on the recorded latencies of ipsilateral stimuli, it has been estimated that the site of stimulus is located between the brain stem and the site at or just distal to the porus acousticus internus (11). Because the magnetic stimulation with a coil of 9 cm in diameter covers a large area, it is difficult exactly to determine the precise location of stimulation. However, assuming the facial nerve conduction velocity of about 50 m/s (9), the location of magnetically induced stimulation would be 50-60 mm proximal from the site of electric stimulation of facial nerve near its outcome at the stylomastoid foramen. This correlates to a site between the brain stem and porus acousticus internus. Similar latencies were achieved by Møller et al. (8, 9) when they delivered electric stimuli during operation at the facial nerve root zone and recorded the responses on the orbicularis oculi muscle.

For comparison, we also evoked facial nerve responses by placing the coil ring near the stylomastoid foramen. In this way the stimuli provide latencies that correspond to those produced by the electric stimulation at the same place. However, with electric stimulation technique the exact stimulation site is much easier to determine than with magnetic stimulation.

The transcranial magnetic stimulation of the facial nerve appears to be more convenient and better tolerated than the traditional electrical stimulation at the stylomastoid foramen. The responses are also easy to elicit. The magnetic stimulation techniques provides access to intracranial stimulation of the facial nerve. Because magnetic stimulation i.a. in Bell's palsy gives primarily information about the conduction through the site of the lesion but the conventional electric stimulation technique about the degeneration of the nerve distal to the lesion, their combination might prove a useful diagnostic tool in examining and assessing the facial nerve lesions. Since the magnetic stimulation technique is still quite new, more studies are required to prove the benefits and pitfalls of this procedure in various diseases affecting the facial nerve.

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