

# Motor Evoked Potentials in Masseter, and Anterior Belly of Digastric Induced by Transcranial Magnetic Stimulation

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= 국문 초록 =

## 경두개 자기 자극에 의한 교근, 및 악이복근 전복의 운동 유발 전위

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**연구목적** : 경두개 자기 자극에 의한 교근, 및 악이복근 전복의 운동 유발 전위를 얻어 기시 잠시와 진폭의 정상 범위를 구하고 동측, 및 반대측 운동 유발 전위를 비교하고자 하였다.

**연구방법** : 정상 성인을 대상으로 원형 코일을 이용하여 일측 경두개 자기 자극을 가하였고 표면 전극을 이용하여 양측 교근, 및 악이복근 전복의 운동 유발 전위를 기록하였으며, 운동 유발 전위의 최소 기시 잠시와 최대 진폭을 구하였다.

**연구결과** : 경두개 자기 자극에 의한 동측 교근 운동 유발 전위의 기시 잠시와 진폭은 각각  $2.03 \pm 0.90$  ms와  $4.38 \pm 3.21$  mV이었으며, 반대측 교근 운동 유발 전위의 기시 잠시와 진폭은 각각  $3.49 \pm 0.96$  ms와  $0.42 \pm 0.35$  mV이었다. 경두개 자기 자극에 의한 동측 악이복근 전복 운동 유발 전위의 기시 잠시와 진폭은 각각  $3.39 \pm 0.99$  ms와  $2.81 \pm 1.49$  mV이었으며, 반대측 악이복근 전복 운동 유발 전위의 기시 잠시와 진폭은 각각  $3.73 \pm 0.73$  ms와  $3.17 \pm 1.72$  mV이었다.

**결론** : 정상 성인에서 경두개 자기 자극에 의한 양측 교근, 및 악이복근 전복의 운동 유발 전위를 얻어 기시 잠시와 진폭의 정상 범위를 구하였다. 동측 교근의 운동 유발 전위는 반대측 교근에서 기록한 운동 유발 전위와 비교해 볼 때 기시 잠시가 더 빠르고 진폭이 더 크게 나타났는데, 이는 동측 경두개 자기 자극 시에 두개강 내 동측 삼차 신경이 자극된 결과로 여겨진다.

**중심 단어** : 운동 유발 전위 · 교근 · 악이복근 · 경두개 자기 자극.

## Introduction

Three main branches of trigeminal nerve consist of

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ophthalmic nerve, maxillary nerve and mandibular nerve. Most of the branches innervate sensory area of the face scalp, teeth, oral cavity and the nasal cavity, but mandibular nerve gives branch to masticatory muscles<sup>24)</sup>. Lesions of the trigeminal nerve result from pathology of trigeminal nucleus in the brainstem, nerve root and peri-

pheral nerve branch, most likely sensory symptom, less likely motor component only<sup>4)19)</sup>.

Recently more patients with mandibular nerve lesions from trauma have increased than before<sup>20)</sup>. It was assumed that motor evoked potential study is useful test for diagnosis of motor neuron disease, or syringomyelia<sup>13)23)</sup>. In majority of studies, somatosensory evoked potential, blink reflex, T reflex were used to evaluate the trigeminal nerve<sup>1)2)5)</sup>, but it is not easy to estimate the motor component of trigeminal nerve and few study reports on this.

In the present study we used transcranial magnetic stimulation to collect the normative data of motor evoked potentials of the masseter, and the anterior belly of digastric innervated by the mandibular branch of trigeminal nerve, and to apply clinical reference.

## Subjects and Methods

### 1. Subjects

Fourty one healthy subject between 18 and 35 years of age gave their written informed consent for the experiments (Table 1). They were without evidence of neuromuscular disease or trigeminal neuropathy, and excluded if they had a cardiac pacemaker or other biomedical device.

### 2. Methods

The subject were studied sitting comfortably in a quiet room, and experiments were Keypoint<sup>®</sup> (Dantec, Denmark) and MagLite<sup>®</sup> (Dantec, Denmark). Motor cortex was stimulated with magnetic stimulator connected to a 13cm outer diameter MC-125 circular Coil<sup>®</sup>, the coils are

**Table 1.** Age distribution of subjects (N)

Age (years)	Male	Female	Total
10–19	0	1	1
20–29	13	19	32
30–39	4	4	8
Total	17	24	41

**Table 2.** Motor evoked potentials of masseter, and digastric muscle

Recording	Ipsilateral stimulation		Contralateral stimulation	
	Latency (msec)	Amplitude (mV)	Latency (msec)	Amplitude (mV)
Masseter	2.03 ± 0.90	4.38 ± 3.21	3.49 ± 0.96	0.42 ± 0.35
Digastric	3.39 ± 0.99	2.81 ± 1.49	3.73 ± 0.73	3.17 ± 1.72

Values are mean ± standard deviation

able to generate 3.5 Tesla of magnetic field with maximal stimulator output. The magnetic coil was placed tangentially at C5, 6 area in international 10–20 system such as 0–3cm anterior to bi-auricular line, 7–10cm lateral to vertex on a line connecting the vertex and external auditory meatus. The current flow in the coil was clockwise when stimulating the trigeminal nerve on the right side and counterclockwise on the left side. The output of the stimulator was set at 20% above threshold for inducing a motor response, usually between 70% and 85% maximum output.

Following parameter were measured : onset latency, and peak to peak amplitude. Signals were recorded by surface electrode at ipsilateral & contralateral muscles simultaneously, and recording electrodes were placed at masseter muscles and anterior bellies of digastrics. For masseter muscle, the active electrode was over the muscle belly, and the reference electrode was placed at the mandibular angle approximately 2.5cm occipitally and caudally to the active electrode. As for digastric, the active electrode was placed over the anterior one third of the anterior belly of digastric and the reference electrode was 2cm anterior, adjacent to the inferior border of the mandible.

### 3. Statistical analysis

Statistical analysis was performed with a statistical analysis program package (SPSS 11.0, SPSS, Chicago, IL USA). Paired t tests ( $p < 0.05$ ) were used to compare the side-to-side difference. The significance of differences of onset latencies and peak-to-peak amplitudes of motor evoked potentials obtained between ipsilateral and contralateral side with transcranial magnetic stimulation was determined with the Wilcoxon Signed Rank Test ( $p < 0.05$ )

## Results

The output of the stimulator was set at 20% above

threshold for inducing maximal motor response, usually between 70% and 85% maximum output.

### 1. Ipsilateral transcranial magnetic stimulation

From ipsilateral trigeminal area stimulation, MEP were evoked at about 70% of subjects. Mean onset latency and amplitude of the masseter with ipsilateral transcranial magnetic stimulation were  $2.03 \pm 0.90$ msec,  $4.38 \pm 3.21$ mV respectively. Mean onset latency and amplitude of the anterior belly of digastric were  $3.39 \pm 0.99$ msec,  $2.81 \pm 1.49$ mV respectively. There was no significant side-to-side difference in mean onset latency and amplitude (Table 2).

### 2. Contralateral transcranial magnetic stimulation

From contralateral transcranial stimulation, MEP were evoked at about 70% of subjects in masseter, and about 90% in digastric muscle. Mean onset latency and amplitude of the masseter with contralateral transcranial magnetic stimulation were  $3.49 \pm 0.96$ msec,  $0.42 \pm 0.35$ mV respectively. Mean onset latency and amplitude of the anterior belly of digastric with contralateral transcranial magnetic stimulation were  $3.73 \pm 0.73$ msec,  $3.17 \pm 1.72$  mV respectively. There was no significant side-to-side difference in mean onset latency and amplitude (Table 2).

## Discussion

Previous investigators suggested that corticobulbar tract have the bilateral projections for the masseter muscles. In 1998, Trompetto et al<sup>23)</sup> proved responses to activation of cortico-bulbar descending fibers were absent or delayed in amyotrophic lateral sclerosis patients, and abnormalities of masseter MEPs were more frequent than abnormalities of limb MEPs and could be observed both in patients with and without clinical bulbar signs. Hort-Legrand<sup>13)</sup> proved that trigeminal somatosensory evoked potential and MEP were more sensitive to detect subclinical evidence of spinal cord dysfunction in syringomyelia than those in limbs.

It is unlikely that every patient with trigeminal neuralgia go through the exam with trigeminal motor study, because the incidence of trigeminal motor neuropathy is

very low in patient with trigeminal neuralgia. In Korea, Lee et al<sup>4)</sup> reported the case about trigeminal neuralgia, only motor branch involved. There was one report about normal trigeminal motor conduction study in Korea<sup>1)</sup>, and no other study reported about motor evoked potential of trigeminal nerve innervated muscle with transcranial magnetic stimulation, in Korea.

Magnetic stimulation was relatively safe and less painful than electrical stimulation. Moreover magnetic stimulation is prior to electrical stimulation for stimulating deep suited structure which was not accessible to electrical stimulation and it is especially useful to excite the brain structure surrounded by the skull. But it is relatively more bulky and expensive than electrical stimulating apparatus. Moreover it is difficult to localize the exact site of stimulation in magnetic stimulator verses electrical current is localized to the cathod area of electrical stimulator<sup>6)15)</sup> It is more difficult to evoke the MEPs of trigeminal nerve than those of facial nerve or intrinsic hand muscle. Transcranial magnetic stimulation threshold to excite the nerve is high for trigeminal nerve and low for facial nerve. Optimal coil placement is critical for trigeminal nerve, but not critical for facial nerve.<sup>12)</sup> In transcranial magnetic stimulation of trigeminal area, the direct stimulation of the pyramidal tract is more easily achieved than the trans-synaptic activation, which is in contrast to the intrinsic hand muscles. They hypothesize the presynaptic projections to pyramidal cells of the masticatory muscle are less abundant than in hand muscles, and are therefore less accessible to trans-synaptic stimulation#. Masseter cortical MEPs, in comparison with those of the hand muscles shows reduced amplitude, a higher threshold, and a greater variability in both latency and amplitude<sup>6)12)</sup>.

In 1992, Lee et al<sup>3)</sup> evaluated response at nasalis muscle after stimulation of facial nerve on stylomastoid foramen. There were no significant differences between latencies of magnetic induced response and those of electrically induced ones, But the electric stimulation was more comfortable and it elicited more sharp wave. The amplitude of electrical stimulation was  $3.9 \pm 1.7$ mV and it was larger than those of magnetic stimulation,  $1.8 \pm 0.8$ mV. By comparing CMAP amplitudes obtained in response to magnetic stimulation with those in response to electrical stimulation, it become evident that it is not pos-

sible for the magnetic stimulation device to excite all nerve fibers that contribute to activation of the muscle. and the values of CMAPs is largely affected by coil orientation itself.

Most of previous study proved that corticotrigeminal projections to masseter are bilateral which are consistent with activation of a fast corticobular pathway, with a stronger contralateral projection. Most of the results reported that corticotrigeminal projection are stronger at contralaterally than ipsilaterally. But they have some differences according to the various stimulation technique<sup>7)8)16)18)</sup>. Close to vertex, contralateral response was dominant, with approximation to the auricle, ipsilateral response was dominant<sup>22)</sup>. At low stimulation intensity, TMS activate the low threshold fiber which is indirect I wave, And at high stimulation intensity TMS facilitate the high threshold fiber which is direct D wave<sup>21)</sup>. In 1989, Cruccu et al<sup>10)</sup> reported that threshold of stimulating contralateral corticobular tract is much less than that of stimulating ipsilateral motor nerve fiber from motor nucleus. We used magnetic stimulator with 3.5 tesla, 70–80% of maximal stimulation intensity, so it is more likely that ipsilateral motor pathways are easily stimulated than those of contralateral.

One of the factor influencing results was the type of magnetic stimulation coil. Circular coil has been used previously with TMS to investigate the nature of the cortical projections to human masseter. In general, circular coil have more benefit in stimulating the high threshold fibers and the pyramidal tract, directly. Most previous investigators used the circular coil to study the bilateral projection of corticobulbar tract. Circular coil leave the debate about volume conducted response at contralateral cortex. Using the focal stimulation coil, Carr was the first who showed the bilateral corticotrigeminal projections.<sup>9)</sup> But author chose the circular coil, with which we got prominent responses with more reproducibility, high amplitude, and short latency with the circular coil in the preliminary study.

In 1989, Cruccu et al<sup>10)</sup> reported similar result, the mean latency and amplitude of ipsilateral masseter were 2ms, 5.4mV each. Especially, he stimulated the trigeminal nerve intracranially in the operation field. When he stimulated the trigeminal nerve at the foramen ovale,

mean latency was about 2ms and at the clivus, mean latency was 2.4ms. So trigeminal nerve could be stimulated at the intracisternal portion after transcranial magnetic stimulation. Characteristic of ipsilateral MEP was shorter latency and larger amplitude. In addition, it did not vary its waveform from trial to trial. All of these things support that the peripheral portion of trigeminal nerve was stimulated in intracranial portion in transcranial magnetic stimulation. Macaluso et al<sup>14)</sup> elicited MEPs from 16 healthy subjects and he found that there were no response without facilitation at contralateral masseter. and the mean latencies from his study were 4ms at ipsilateral masseter and 6.9ms at contralateral masseter. In this study, the distal latency, and the amplitude of motor evoked potential in ipsilateral masseter with transcranial magnetic stimulation were significantly shorter and larger than those in contralateral masseter.

In evaluating the motor evoked potentials of masseter, and anterior belly of digastric with transcranial magnetic stimulation, it is very difficult of recording selective responses avoiding volume conduction of facial nerve.<sup>25)</sup> For motor evoked potential of masseter, it is reported that surface electrode is rather acceptable if it is placed in muscle belly<sup>17)22)</sup>. Schmod et al<sup>22)</sup> reported that in recording motor evoked potential of masseter using surface electrode, responses of stimulation of facial nerve were shown independent of stimulation intensity or recording site. As for the anterior digastric muscle, mean latency is not so different from ipsilateral to contralateral muscle after transcranial magnetic stimulation. The mean latency of the ipsilateral digastric muscle was 3.5ms, 2.9mV and the values from the contralateral digastric muscle were 3.8ms, 3mV respectively. In 1999, Gooden et al<sup>11)</sup> found that at the anterior belly of the digastric muscle, bilateral response was evoked with surface electrodes but only ipsilateral response was elicited with needle electrode recording. The mean latency of the anterior digastric muscle was 3ms, so the result was not different from the author's. They assumed that the electrical activity of the ipsilateral muscle was delivered at the contralateral muscle and proved this assumption through recording the action potential of single motor units of the digastric muscle (cross talk). We cannot rule out the cross talk effect in our results because the very approximation of

the bilateral muscles and the mean onset latency were not so different from ipsilateral to contralateral results.

In our study, we evoked motor evoked potentials at the bilateral masseter and digastric muscle about 70% of the subjects from transcranial magnetic stimulation. All the experiments were performed without facilitation, because we could hardly measure the exact values of the onset latency and amplitude with facilitation. The mean latency of the contralateral masseter was about 0.5mV. So, with facilitation, the background activity of contacting muscle conceals the MEP response.

Further studies using various magnetic stimulation intensity and site of stimulation for earning Korean clinical criteria, and application.

## Conclusion

MEPs from transcranial magnetic stimulation were evoked both the ipsilateral and contralateral muscles, and even in a healthy subject, without facilitation, there was the case that the MEPs were not evoked. Ipsilateral masseter MEPs from transcranial stimulation were shorter latency and larger amplitude and it is supposed that the intracranial portion of the trigeminal nerve was stimulated. This study datas are useful for standard criteria and practical reference.

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