Characteristics of the Perioral Muscle Electromyographic Activities during Jaw Functions in Healthy Young Adults

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Clinical significance
The results of the present study indicated that the mentalis muscle (Ment) acted in coordination with the actions of the masticatory muscles during various jaw functions. Further study is considered to be necessary to explore the relationship between the stability of mandibular dentures and the EMG activity of Ment during various jaw functions.

Abstract
Purpose: The aim of the present study was to record the electromyographic (EMG) activity of the mentalis muscle (Ment) during various jaw functions in healthy young subjects.

Methods: Twelve healthy males were enrolled for the study. A portable EMG recording device was used to record the EMG activity from the Ment, anterior belly of the digastric muscle (Dig), and the masseter (Mm) muscles. The EMG activities of these muscles were recorded during maximal voluntary clenching (MVC), maximal voluntary jaw opening (MVO), and the masticatory process. The EMG activity of Ment was compared with the EMG activities of Dig and Mm during various jaw functions.

Results: (1) The EMG activities of Ment and Dig were significantly greater during MVO than during MVC (P<0.05). A strong correlation was found between the activities of Ment and Mm during MVO (r=0.739, P<0.01), and between those of Ment and Dig during MVC (r=0.664, P<0.05). (2) It was observed that during mastication of peanuts, Ment showed synchronous activity with that of Dig and reciprocal activity with that of Mm.

Conclusion: These results indicate that Ment acts in coordination with the actions of Dig and Mm during various jaw functions.

Key words: mentalis muscle, masticatory muscles, electromyogram (EMG), jaw function

Introduction
The synchronized activity of the lower orbicularis oris and mentalis muscle (Ment) in lip function has been clarified by many studies. These muscles seem to closely affect the retnainment retention and stabilization of the lower denture. The mandibular labial flange is situated in the labial vestibule. The function of this vestibule is affected by contraction of the Ment and orbicularis oris muscles. Ment provides a supportive function to the orbicular oris muscle. The muscles of the lips have a critical role in the successful use of dentures. Ment arises from the anterior alveolar bone of the mandibular bone. From the origin of Ment, Ment fibers diverge in their course toward the skin and at the same time, the fibers converge toward and interlace with those of the contralateral muscles after crossing the midline of the skin in the mentalis region. Only the most lateral fibers end in the skin of the same side. Ment elevates the skin of the chin and causes protrusion of the lower lip outward. Since its origin is at a higher level than the fornix of the vestibule, Ment pushes the lower vestibule superficially during contraction. Contraction of this muscle can, therefore, dislodge mandibular dentures, particularly when the residual ridge in the anterior region is at the same height as the fornix of the vestibule. Itsuki reported significant increased EMG activity of the orbicularis oris muscles and Ment in open bite patients during swallowing. Stavridi showed that the use of lip pads, Ment activity increased during lip closure. However, the relationship between contraction of Ment and the jaw functions has not yet been
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clarified. Furthermore, it has also not been clarified as to contraction of Ment associated with which jaw functions is capable of dislodging mandibular dentures.

The aim of this study was to record the electromyographic (EMG) activity of Ment during masticatory movements, maximal voluntary clenching and maximal voluntary jaw opening in healthy young subjects.

Materials and methods

1. Subjects
The subjects consisted of 12 adult male volunteers with a mean age was 26 years and 6 months. All had complete natural dentition (except for the third molars), a healthy periodontal condition, no nasal disease, respiratory disease or parafunctional habits (e.g.: bruxisms, tongue habit, repetitive swallowing, lip biting). The study was approved by the ethical committee of our university. The purpose and methods of the study were explained to all the volunteers, informed consent was obtained from each of them prior to their participation in the study.

2. Experimental procedures
In this experiment, a digital EMG recording device (Muscle Tester ME3000P, Mega Electronics Ltd, Kuopio, Finland) and bipolar surface Ag-AgCl electrodes with a diameter of 5mm (Blue sensor, type-N-00-S, Medico test A/S, Osyka, Denmark) were used to record the EMG activities of the Ment, the anterior belly of the digastric muscle (Dig), and masseter (Mm) muscles. After careful preparation of the skin, each pair of electrodes was placed in the main direction of the muscle fibers according to their anatomical orientation at an interelectrode distance of 15 mm (Fig.1). The impedance of each active electrode was maintained at under 10 kΩ. Reference electrodes for the muscles were attached to the back of the neck. The EMG was recorded at a sampling frequency of 1 kHz. The mean values of the rectified EMG data for every 0.1 second were stored in a personal computer, and the integrated EMG values (μVs) were measured after the recording.

During the EMG recording, the subjects were comfortably seated upright on a chair without head support, and asked to carry out the following tasks:

(1) Maximal voluntary clenching (MVC): to keep their teeth clenched as strongly possible at the intercuspal position for a duration of approximately 3 seconds.
(2) Maximal voluntary jaw opening (MVO): to keep their mandibles jaws at the maximum opening position for a duration of approximately 3 seconds.
(3) Mastication: to freely masticate on 3 grams of peanuts as a test food prior to swallowing.

All the tasks were required to be repeated 3 times. Between the tasks, the subjects were instructed to relax to avoid muscle fatigue.

3. Quantitative data analysis
After the recording of the EMG activities, data analysis was performed with an accessory software (Muscle Tester ME3000P Software v.2.1-program, Mega Electronics Ltd, Kuopio, Finland), and the following variable were calculated:

The integrated EMG values for Ment, Dig and Mm at MVC and MVO were calculated for 3 seconds of each test. In each subject, the mean integral values of the measurements were calculated for each muscle.

4. Statistics analysis
The statistical analysis was performed using a statistical software (Smart Mate III). The EMG activities of individual muscles during MVO and MVC were compared by Wilcoxon’s rank test. Spearman’s rank correlation test was used to analyze the relationship among the activities of Ment and Dig, and Mm during MVC and MVO.
Results

1. EMG activity during MVC and MVO
The EMG activity of Ment and Dig during MVO were significantly greater ($P<0.05$) than those during MVC (Fig. 2). A strong correlation was found between the activities of Ment and Mm during MVO ($r=0.739$, $P<0.01$) (Fig. 3), and between those of Ment and Dig during MVC ($r=0.664$, $P<0.05$) (Fig. 4).

2. EMG activity during peanut mastication
Figure 5 shows an example of a raw EMG recording during peanut mastication. It was observed that the EMG activity of Ment during peanut mastication was synchronous with that of Dig and reciprocal to that of Mm.

Discussion

Many researchers$^{4,6,11,13}$ have reported that the morphological characteristics of the maxillofacial area may affect the perioral muscle EMG activities. Therefore, young healthy males with normal occlusion or and maxillofacial morphology were enrolled for this study. Mandibular movements are carried out mainly by the closing and opening muscles of the mouth, but are also affected by the facial muscles acting on mandibular movements. Most notably, the opening and closing muscles of the mandible act antagonistically and have a cooperative relationship with each of the
other muscles. In this study, the EMG activities of Ment, Dig, and Mm were recorded during MVO, MVC, and mastication, in order to clarify the behavior of Ment. The researches mentioned above examined in activity of Ment using EMG recordings, with the surface electrodes placed over the skin of the lower lip. The orientation of the electrodes is important when examining the activity of these muscles. Stavridi and Ahlgren placed the electrodes, 2 cm apart, at the level of the suprapognion point. Kurashima and Fukui placed the electrodes over the skin of origin of Ment in relation to the midline of the face. Yamaguchi et al determined the orientation of the electrodes through anatomical orientation and placed the electrodes over Ment. In our study, the surface electrodes were placed on the skin of origin of Ment according to the anatomical orientation: the divergence of the Ment fibers was not confirmed by an objective test. Therefore, there is some possibility that the EMG activity of Ment recorded in this study also includes some EMG signals from the periphery of Ment.

As previously stated, contraction of Ment elevates the chin and causes the lower lip to protrude. In addition, the depressor muscle of the lower lip causes the lower lip to be drawn outward. In this study, no movements of the lower lip to an outward position was observed during MVC or MVO in any of the subjects. Therefore, we do believe that the surface EMG recorded from the skin of the chin is reliably indicative of the muscle activity of Ment.

Chewing gum and peanuts are usually used as the tester objects in this type of studies. The mechanical properties of chewing gum change little during mastication. Evaluation of the muscle activities using chewing gum as the tester substance is useful for the examination of masticatory movements in a fixed condition. Because peanuts are crushable, evaluation of the masticatory process using peanuts as the tester substance is also useful for evaluating masticatory movements. In this study, we selected peanuts as the tester substance for evaluating the activity of Ment during mastication.

Prior to the start of the experiments, EMG recordings were carried out for 10 seconds in the physiological rest position. The EMG activity in the resting position ranged from 1~5 μV. No unusual EMG activity during the resting position was observed in any of the subjects. Accordingly, the subjects recruited by us were considered to be appropriate candidates for this study, similar to subjects in the previous study.

The present study revealed the EMG activities of Ment and Dig at MVO and MVC. The EMG activities of Ment and Dig at MVO were significantly higher than those at MVC. These findings may indicate that the activity of Ment during jaw opening may be capable of dislodging mandibular dentures. EMG activities of not only the Dig, but also Mm were observed during MVO. This phenomenon seems to be responsible for the mandibular stretch reflex. Furthermore, a strong positive correlation of the EMG activities was found between Ment and Mm during MVO, and between Ment and Dig during MVC. These findings may indicate the relation of Mm activity to wide unrestricted opening of the jaw during MVO, and that of Ment and the Dig along with the Mm activity during MVO and MVC.

Masticatory function is known to be influenced by various proprioceptors and inputs from the central nervous system. During mastication, contraction of the jaw opening muscles extends the mandible, and the tongue carries food into the interocclusal space. Moreover, contraction of the jaw closing muscles elevates the mandible to crush or grind the food. The masticatory process is structured by the regular jaw opening and closing muscle activities. In regard to the EMG activities during the mastication of peanuts, the activity of Ment was synchronous with that of Dig, and reciprocal to that of Mm.

The labial flanges of mandibular dentures occupy a potential space bounded by the labial aspect of the residual ridge, the mucolabial fold, and the orbicular oris muscle. If the labial flange of the mandibular denture does not have an appropriate shape, it is thought that the EMG activity of Ment might change during jaw function. Therefore, it is necessary to consider the influence of the labial flange of mandibular dentures on the activity of Ment during jaw functions. From our results, we propose that the Ment may be one of the responsible muscles for the dislodging of mandibular dentures. Clinical application of these findings must await further study to evaluate the effects of the labial flange of mandibular dentures on the activity of Ment.

**Conclusion**

1. The EMG activities of Ment and Dig at MVO
were significantly greater than those at MVC. A strong correlation was found between the activities of Ment and Mm at MVO, and Ment and Dig at MVC.

2. It was observed that the EMG activity of Ment was synchronous to that of Dig and reciprocal to that of Mm during mastication of the peanuts. These results indicate that the Ment acts in coordination with the actions of Dig and Mm during various jaw functions.

References


