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Author(s)	Yotsuya, M; Sato, T; Kawamura, S; Furuya, E; Saito, F; Hisanaga, R; Onodera, K
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Original Article

Electromyographic Response in Inferior Head of Human Lateral Pterygoid Muscle to Anteroposterior Postural Change during Opening and Closing of Mouth

Mamoru Yotsuya, Toru Sato, Sadayuki Kawamura*, Eiji Furuya, Fumiaki Saito, Ryuichi Hisanaga and Kozue Onodera**

Department of Crown and Bridge Prosthodontics, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan

* *Kawamura Dental Clinic, Kyoto Takashimaya 6F, Nisiiru, Sijyodouri, Kawaramachi, Shimogyo-ku, Kyoto 600-8520, Japan*

** *Tokyo Therapeutic Institute, 3 San-ei-cho, Shinjuku-ku, Tokyo 160-0008, Japan*

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Abstract

The purpose of this study was to investigate the influence of anteroposterior postural change on electromyography (EMG) activity in the lateral pterygoid muscle. Subjects consisted of 7 patients attending this hospital for close examination. The inferior heads of the lateral pterygoid and masseter muscles were chosen as evaluation sites. For the EMG recordings, the test movement was opening and closing of the mouth; postural conditions were the upright and supine positions. The mean value of EMG activity in the inferior head of the lateral pterygoid muscle was calculated. During mouth-opening in 5 out of the 7 patients, and during mouth-closing in 2 out of the 7 patients, mean value of EMG activity differed significantly with body position. Mean value of EMG activity was reduced in the supine position. The results revealed that anteroposterior postural change affected mean value of EMG activity in this muscle.

Key words: Lateral pterygoid muscle—EMG—Postural change—Jaw movement

Introduction

Jaw movement is controlled by the masticatory and suprahyoid muscles. The lateral pterygoid muscle, a masticatory muscle, works with the digastric muscle to facilitate mouth-opening. Electromyographic studies have shown that the lower head of the lateral pterygoid muscle pulls the mandibular condyle anteriorly during mouth-opening[15,16]. It has also been reported that this muscle is actively involved in maintaining horizontal jaw position[4,11]. These reports suggest that the lower head of the lateral pterygoid muscle plays an

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important role in the occlusal relationship.

Many studies have also investigated the relationship between mandibular movement and posture. Hayashi and Mizokami[5] has reported that small mouth-opening and -closing movements and anteroposterior posture affect tooth contact. However, to our knowledge, no studies have investigated the relationship between lateral pterygoid muscle activity and anteroposterior posture during opening and closing of the mouth.

Since the lateral pterygoid muscle lies deep inside the body, there are many problems associated with investigating this muscle, such as how to apply electrodes. However, recent advances in diagnostic imaging tool technology have resulted in improvement in the accuracy of electromyography (EMG)[8,12], this technique now allowing electrodes to be positioned with greater accuracy than before.

The present study investigated the influence of changes in anteroposterior posture on EMG-recorded activity in the inferior head of the lateral pterygoid muscle.

Materials and Methods

1. Subjects and evaluation sites

1) Subjects

Subjects consisted of 7 patients (all men, aged 28–54 years) attending Tokyo Dental College Chiba Hospital for close examination. All patients complained of discomfort in the temporomandibular joint (TMJ). The patients were evaluated by verbal examination and diagnostic imaging prior to the study. It was confirmed that the patients showed no organic changes in the TMJ, and were capable of moving the jaw without pain, discomfort, or articular crepitus. The study was approved by the Ethics Committee of Tokyo Dental College (Ethics Clearance Number: 150). The aims and potential risks of the study were fully explained and informed consent obtained from each patient.

2) Evaluation sites

The inferior head of the lateral pterygoid and central area of the masseter muscles were chosen as evaluation sites. Masseter muscle activity was used as an indicator of mouth-closing movement.

2. Placement of electrode

1) Structure of electrode and insertion method

The electrode consisted of 2 insulator-coated platinum wires (UNW-2000, ϕ0.1 mm, Unique Medical, Tokyo, Japan) threaded through a 23G, 60-mm guide needle. At the insertion end, the tips of the two wires were exposed by 0.5 mm and bent back, one by 2 mm and the other by 3.5 mm. These were then inserted into the inferior head of the lateral pterygoid muscle according to the bipolar lead method.

2) Magnetic resonance imaging

Magnetic resonance imaging (MRI) was performed to determine the site, direction, and depth of electrode insertion on a 1.5 Tesla MR imager (Magnetom Symphony, Siemens, Erlangen, Germany). T2-weighted images were obtained with a fast spin echo sequence (TE = 100 ms, TR = 3,500 ms, slice thickness = 3 mm, and field of view = 230 mm × 230 mm). The Camper's plane was set as the reference site.

3) Determination of insertion site

Insertion site was determined on an axial MR image at a location perpendicular to the skin surface and toward the center of the muscle belly. Distance between the center of the auditory canal and the insertion site was measured in order to set the lateral view of the subject (Fig. 1). The actual insertion site was 10 mm inferior to the Camper's plane (Fig. 2).

4) Determination of direction of insertion

Direction of insertion to the inferior head of the lateral pterygoid muscle was determined to be perpendicular to the skin surface and parallel to the Camper's plane.

5) Determination of insertion distance

Distance between the insertion site and the center of the muscle belly was measured on an axial MR image and defined as the insertion distance (Fig. 1).

6) Electrode insertion

Electrode insertion was achieved by refer-

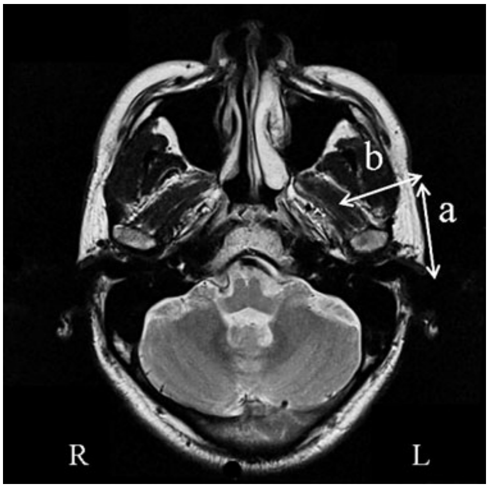

Fig. 1 Determination of site, direction, and depth of electrode insertion on MR image
Lower-case letters represent distance from center of auditory canal to insertion site (a), distance from insertion site to target site (b).

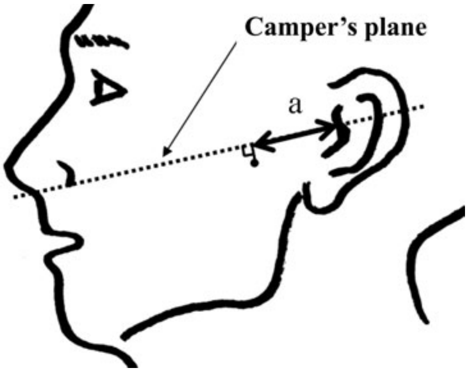

Fig. 2 Determination of site of electrode insertion by lateral view of subject
Lower-case *a* represents distance from center of auditory canal to insertion site (a). ●: insertion site

ring to measurements. During electrode insertion, the subjects were instructed to keep the mouth slightly open. Attention was paid to not allowing muscle rigidity to occur due to nervousness, as this would affect insertion of the guide needle, and preventing the coronoid process from blocking the needle.

7) Computed tomography

After electrode insertion, CT (Somatom, Siemens) was performed with a tube voltage of 120 kV, tube current of 200 mA and slice thickness of 0.5 mm. The guide needle was kept in the body during imaging. It was confirmed that the electrode tip was centrally positioned between the infratemporal fossa and the mandibular condyle on an axial image, with the lower one-third between the infratemporal fossa of the sphenoid bone and the pterygoid process of the sphenoid bone on a reconstructed coronal image (Fig. 3-a, b). Accurate positioning of the anteroposterior insertion angle was confirmed on a reconstructed sagittal image (Fig. 3-c). The guide needle was then removed without changing the position of the position of the electrode. The tip of the electrode was folded back to prevent it shifting.

In the present study, electrodes were inserted into the lower head of the lateral pterygoid muscle, and EMGs obtained from the lower electrode were identified as muscle activity in the inferior head.

3. EMG

1) Test movement

The test movement was opening and closing of the mouth. The mouth was opened by 2 finger breadths. Seven strokes each of mouth-opening and -closing movement were performed at a frequency of 0.5 Hz. The patients were instructed to assume a resting position before and after the end of each cycle of 7 strokes until the electromyograph settled. Subjects were allowed to freely determine their own occlusal force on closing the mouth.

2) Postural conditions

Two postural conditions were imposed: 1. an upright position, and 2. a supine position. The upright position was defined as the position in which the angle between the floor and Frankfort horizontal plane was 0°. The supine position was defined as the position in which the angle between the floor and Frankfort horizontal plane was 90°. The head was supported with a head rest in both positions.

3) EMG recording

EMGs were obtained by the bipolar lead

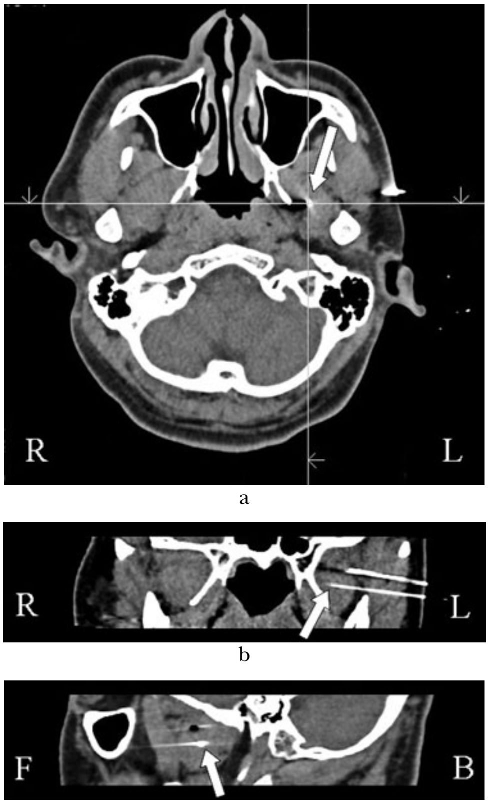

Fig. 3 Verification of electrode placement on CT image
Positions of electrodes (arrows) were checked on axial (a), reconstructed coronal (b) and reconstructed sagittal (c) images.

method using platinum wire electrodes inserted in the inferior head of the lateral pterygoid muscle, and surface electrodes for the masseter muscle, with a distance between electrodes of 20 mm. Surface electrodes were placed on the center of the masseter muscle, parallel to the muscle belly. A reference electrode was placed on the earlobe.

EMGs were recorded using an electromyograph (MEB-9104, Nihon Kohden, Tokyo, Japan) with a high-pass filter of 1 kHz, low-pass filter of 5 Hz, and sampling frequency of 5 kHz.

4. Analysis methods

1) Evaluation of EMG activity wave

Values exceeding 50 μV were defined as muscle activity. Points exceeding or falling below this amplitude were regarded as the starting and ending points, respectively. Any segment falling between the starting and ending points was regarded as an EMG activity wave.

2) Mouth-opening and -closing segment setting of EMG of lateral pterygoid muscle

EMG activity waves synchronizing with those of the masseter muscle were identified as mouth-closing, and EMG waves in other segments were identified as mouth-opening.

3) Calculation of mean value of EMG activity in inferior head of lateral pterygoid

Lateral pterygoid EMG activity per unit time was calculated from the integration of EMG activity waves in the lateral pterygoid muscle. The cumulative mean of 7 mouth-opening and -closing movements was regarded as the representative value of mean EMG activity.

5. Statistical analysis

Mean EMG activity in the lateral pterygoid muscle for each body position was determined using the Student's *t*-test at a 5% significance level (Microsoft® Office Excel 2003 Ver. 11).

Results

1. EMG activity in lateral pterygoid muscle

EMG activity was noted in all patients during mouth-opening in the upright and supine positions. During mouth-closing, EMG activity was observed in 4 out of the 7 patients in the upright position, and 3 out of the 7 patients in the supine position.

2. Mean value of EMG activity in lateral pterygoid muscle and change in body position

During mouth-opening, mean value of EMG activity differed significantly with body position in 5 out of the 7 patients (Fig. 4). The mean value of EMG activity was reduced in the supine position. During mouth-closing, mean value of EMG activity differed significantly with body position in 2 out of the 7

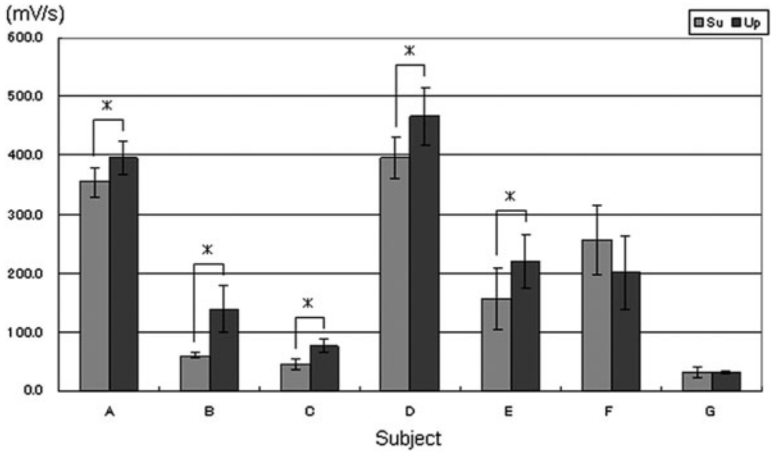

Fig. 4 Mean value of EMG activity in lateral pterygoid muscle during mouth-opening
Su: supine position, Up: upright position, ⁎: $p<0.05$

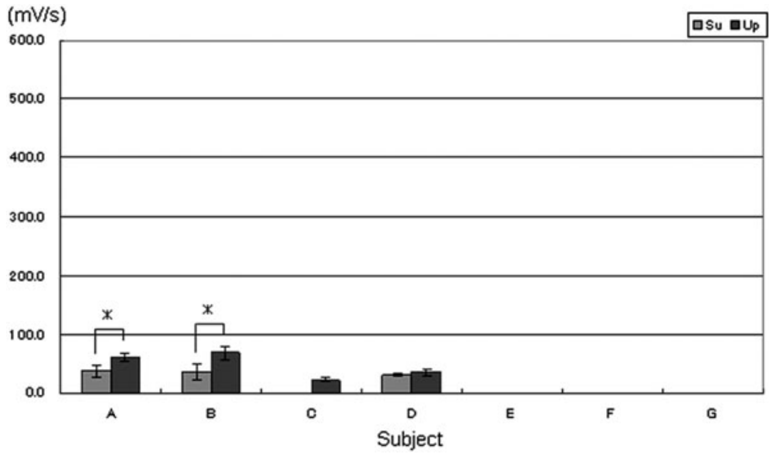

Fig. 5 Mean value of EMG activity in lateral pterygoid muscle during mouth-closing
Su: supine position, Up: upright position, ⁎: $p<0.05$

patients (Fig. 5). The mean value of EMG activity was reduced in the supine position.

Discussion

1. Methods

The lateral pterygoid muscle is divided into superior and inferior heads. The superior head originates in the infratemporal fossa of the greater wing of the sphenoid bone, and inserts into the articular disk and pterygoid fovea in the cervical area of the mandibular condyle. The inferior head originates in the lateral pterygoid plate of the sphenoid bone and inserts into the pterygoid fovea in the cervical area of the mandibular condyle. It has been reported that the superior head is thin, with a flat, oval-shaped cross-section and a long axis in the horizontal direction, and that the inferior head is thick, with an oval-shaped cross-section and a long axis in the vertical direction[9]. It has also been reported that the cross-sectional area of the superior head is half of that of the inferior head[13]. The inferior head of the lateral pterygoid muscle affects horizontal jaw position. Therefore, in the present study, the inferior head of the lateral pterygoid muscle, which affects occlusal position, was chosen as the test site as it is easier to identify due to its greater size and thickness, and the relationship between the inferior head and body position was investigated.

Many approaches have been adopted in EMG studies of the lateral pterygoid muscle. Due to its complex morphology and position deep inside the body, accurate positioning of the electrodes is important. In conventional methods, muscles have been identified by examining EMG activity waves after placement of electrodes[7]. However, Murray *et al.*[8] and Salame *et al.*[12] have reported that the positions of electrodes in the lateral pterygoid muscle could be determined on CT images. In the present study, MRI and CT were used to position electrodes and confirm their location. MRI was employed to obtain a guide for electrode insertion without having to expose subjects to radiation. Electrode positioning was performed accurately using diagnostic imaging devices.

In this study, wire electrodes were inserted into the lateral pterygoid muscle so as not to restrict its movement under test conditions. There have been concerns about muscle complications with the medial pterygoid muscle near the origin of the lower head of the lateral pterygoid muscle[2,9]. Also, the upper and lower muscle fiber bundles of the lateral pterygoid muscle may intermingle near the mandibular condyle, so the electrodes were placed near the center of the muscle fiber bundles. In this study, particular attention was directed to EMG activity with change in anteroposterior posture. The test movements were opening and closing of the mouth, and there was no lateral component in the postural conditions. Therefore, the test was performed unilaterally.

2. Results

All subjects showed EMG activity in the inferior head of the lateral pterygoid muscle during mouth-opening. This result is consistent with those of previous reports[1,2]. Nearly half of the patients showed no muscle activity in the present study. This result is considered to be consistent with those of previous reports showing that the superior head of the lateral pterygoid muscle is active during mouth-closing[6]. Some exhibited EMG activity in the lateral pterygoid muscle during mouth-closing. The lateral pterygoid muscle is believed to adjust the position of the articular disk relative to the mandibular condyle during such movement. Anatomically, it is believed that the muscle fibers of the lower head of the lateral pterygoid muscle are attached to the articular disk[1]. Bhutada *et al.*[3] have reported that the superior and inferior heads have the same functional characteristics, as the superior head of the lateral pterygoid muscle showed EMG activity during protrusive and lateral movements of the balancing side. These findings indicate that the lateral pterygoid muscle should be treated as a single muscle instead of functionally dividing it into superior and inferior heads during mandibular movement.

Mean value of EMG activity was lower during mouth-closing. This is believed to be due to differences in the functional roles of the lateral pterygoid muscle in different mandibular movements. It adjusts the whole mandible, including the mandibular condyle, during mouth-opening, and supports the articular disks during mouth-closing.

In terms of influence of postural change on mean value of EMG activity, Takahashi[14] has reported that EMG activity of the lateral pterygoid muscle shows a significant positive correlation with the distance moved by the mandibular condyle. In this study, during mouth-opening, the mean value of EMG activity decreased in the supine position. We believe this was due to the decrease in the distance moved by the mandibular condyle in the supine position. In the supine position, mandibular movement is mainly driven by axial movements of the mandibular condyle rather than by sliding movements. As one of the 7 patients showed EMG activity in the upright but not supine position during mouth-closing, the mean value of EMG activity decreased in the supine compared with the upright position in 3 out of the 7 patients. A similar tendency was observed during mouth-opening. The mandible significantly glides backward from its 45° backward inclination in the upright position[10]. This indicates that the lateral pterygoid muscle supports the articular disk at a forward position. However, 3 out of the 7 patients in this study showed no EMG activity, and one of the 7 showed no influence of postural change on mean value of EMG activity. The lateral pterygoid showed different activation patterns in different patients.

The results of the present study suggest that the mean value of EMG activity in the inferior head of the lateral pterygoid muscle changes depending on anteroposterior body position. Therefore, anteroposterior body position must be taken into consideration during treatment related to mandibular position or movement.

Conclusion

In the present study, we investigated the relationship between EMG activity in the lateral pterygoid muscle and anteroposterior postural change to identify factors affecting occlusal position. It was found that the inferior head of the lateral pterygoid muscle functions during mouth-opening. During mouth-closing, EMG activity differed among patients, but activity in the inferior head of the lateral pterygoid muscle was observed in approximately half of the patients. The results revealed that anteroposterior postural change did not affect the function of the lateral pterygoid muscle, but affected the mean value of EMG activity of this muscle.

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Reprint requests to:
Dr. Mamoru Yotsuya
Department of Crown and
Bridge Prosthodontics,
Tokyo Dental College,
1-2-2 Masago, Mihama-ku,
Chiba 261-8502, Japan
E-mail: yotsuyam@tdc.ac.jp