Original Article

INFLUENCE ON MYOELECTRIC DISCHARGES OF ANTEROPOSTERIOR DISPLACEMENT OF THE MANDIBULAR POSITION NEAR THE TAPPING POINT

TAKEHIRO TEZUKA, TETSUYA SUGIYAMA and KAORU SAKURAI

*Department of Complete Denture Prosthodontics, Tokyo Dental College,
1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan*

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Abstract

The purpose of this study was to examine the influence that the anteroposterior mandibular displacement near the tapping point exerts on the myoelectric activity of masseter and temporal muscles at a specific occluding force and to clarify the possibility of judging the mandibular position by measuring the amount of myoelectric discharge. Eight edentulous subjects were selected for the study. Surface electrodes were placed over the anterior, middle and posterior regions of the masseter muscle and over the anterior, middle and posterior bundles of the temporal muscle. Independently of the measurement region, the changes in the masseter and temporal muscle myoelectric activity which accompanied the anteroposterior mandibular displacement, were low. Moreover, when the mandible was displaced anteroposteriorly, the total amount of the myoelectrical discharge from all the recorded places, as well as the amounts of myoelectrical discharge over the middle part of the masseter muscle and the anterior bundle of the temporal muscle reached their lowest values in those mandibular positions which included the tapping point in less than half of the subjects. Therefore, this study indicates that the possibility of judging anteroposterior mandibular displacement by masseter and temporal muscle electromyography is quite low.

Key words: Anteroposterior mandibular position—Myoelectric discharge—
Masseter muscle—Temporal muscle—Registration of interocclusal
relation

INTRODUCTION

Studies reporting the alterations in myoelectric activity of masticatory muscles during horizontal mandibular displacement are nec-

essary in order to understand the relationships between mandibular positions and masticatory muscles^{3-5,8)}. In clinical practice, to determine horizontal mandibular positions in edentulous patients, the tapping point

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Fig. 1 Gothic arch and the tapping point

Table 1 Anteroposterior length of the tapping point for each subject

Sub.	Anteroposterior length of the tapping point (mm)
1	0.13
2	0.21
3	0.41
4	0.25
5	0.21
6	0.46
7	0.96
8	1.02
Mean	0.51

recorded with Gothic arch tracer has been used^{1,6,7)}. However, we examined the differences in myoelectric discharges from the masseter and temporal muscles when the mandibular position was shifted anteroposteriorly near the tapping point and compared these values with those at the tapping point. In this study, we examined not only a possible relationship between a tendency for changes in myoelectric activity during anteroposterior mandibular displacement near the tapping point and the position of the tapping point, but also whether it was possible to clarify whether masticatory muscles' myoelectric discharges might be useful as a method for judging mandibular position.

MATERIALS AND METHODS

1. Subjects

In this study, eight dentulous men showing proper occlusion at the intercuspal position were selected. Their ages ranged from 21 to 26 years (mean age, 23.8 years). The relationship between the Gothic arch and the tapping point of each subject is described in Fig. 1. Table 1 shows the anteroposterior length of the tapping point for each subject.

2. Experimental device

A mandibular positioning unit consisting of a fixing plate and stylus were made of a cobalt chrome alloy to measure the occlusal

forces in mandibular positions (Fig. 2). Measurement of myoelectric discharges was carried out for the mandibular position with an anteroposterior shift against the tapping point. A position-fixing plate was attached to the upper dentition in order to regulate the mandibular position during electromyographic measurement. A stylus was attached to the mandible so that the mandibular position could be set by inserting its tip into a hole on the fixing plate. In order to measure the occlusal force, a strain gauge was attached to the stylus.

3. Mandibular position during electromyographic (EMG) recordings and occlusal force

Measurements of myoelectric discharges were carried out for mandibular positions involving anteroposterior movement from the tapping point. When the mandibular position was in maximal protrusion, it was located 1.2 mm from the tapping point, and, when in maximal retrusion, it reached the apex. The distance between the two marginal positions was divided into 0.2 mm intervals in which the measurements were performed. Fig. 3 shows the relationships of the anteroposterior length of the tapping points and measurement positions for each subject. Two occlusal force levels were selected for a specific occlusal force of the masticatory muscles, namely 10% and 20% of the maximal occlusal force at the center of the tapping point.

Fig. 2 Experimental device

Fig. 3 Measured mandibular positions and distribution of the tapping points

4. Myoelectric discharge registration conditions

1) Myoelectric discharge measurement device and electrode positions

Bipolar surface electrodes were used to record myoelectric discharges. The electrodes, 12 in total, were placed bilaterally over the anterior, middle, and posterior regions of the masseter muscles and over the anterior, middle and posterior bundles of the temporal muscles.

2) EMG recording method and analysis of EMG data

Myoelectric potentials obtained from each electrode were rectified in an integral unit (Nihon Kodensha, EI-601G) and the levels of myoelectric discharges for each mandibular position was calculated. Integration of signals was carried out at 1 second-intervals using the "time-reset" method, and the average value of recorded discharge amounts from five consecutive measurements was calculated for each mandibular position.

RESULTS

1. Myoelectric activity of the masseter muscles

The EMG records obtained from masseter muscles on each mandibular position are shown in Fig. 4.

In subjects 1 to 7, the amounts of myoelectric discharge of the masseter muscles

reached their highest levels at the maximal or almost maximal protruded mandibular positions in all electrode placement regions. When the mandibular position was shifted posteriorly from the maximal protruded position, the amounts of myoelectric discharge dropped, and reached their lowest levels in mandibular positions included in the apex or in the apex area.

In Subject 8, all the electrodes placed over the masseter muscle in maximal protruded mandibular positions recorded the highest myoelectric discharges. The discharges decreased as the mandible retruded but increased again near the apex.

2. Myoelectric activity of the temporal muscles

The EMG records obtained from temporal muscles for each of the mandibular position are shown in Fig. 5. In the majority of subjects, the number of myoelectric discharges from the temporal muscle decreased from maximal protrusion until the mandibular position of the tapping point, and increased in mandibular positions posterior to the tapping point. However, depending on the subject, the pattern of alterations in EMG potentials varied, and three different patterns of myoelectric activity change could be defined: 1) the "decrease" pattern: Myoelectric discharges increased with protrusion and decreased from maximal protrusion until the mandibular positions of tapping point,

Fig. 4 Myoelectric discharge from masseter muscles on each mandibular position

Fig. 5 Myoelectric discharge from temporal muscles on each mandibular position

Fig. 6-1 The total amounts of myoelectric activity of masseter and temporal muscles (10% of the maximal occlusal force)

★ : The mandibular positions at lowest levels activity
 ↔ : Anteroposterior length of the tapping point $p < 0.05$

Fig. 6-2 The total amounts of myoelectric activity of masseter and temporal muscles (20% of the maximal occlusal force)

Table 2 Patterns of changes in the temporal muscles

Subjects and occluding force		Patterns of changes
			Decrease pattern	Increase pattern	Irregular pattern
1	10%	A M P			
	20%	A M P			
2	10%	A		M P	
	20%	A		M P	
3	10%			A M P	
	20%			A M P	
4	10%			A M P	
	20%			A M P	
5	10%	A		M P	
	20%	A		M P	
6	10%			A M P	
	20%			A M P	
7	10%			M	A P
	20%			A M	P
8	10%			A M P	
	20%			A M P	

A: Anterior bundle, M: Middle bundle
P: Posterior bundle

reaching the lowest value in the apex or its vicinity; 2) the “increase” pattern: Myoelectric discharges decreased with protrusion and increased from maximal protrusion until the mandibular positions of tapping point, reaching the highest value in the apex or its vicinity, 3) the “irregular” pattern: The frequency of change in the amount of myoelectric discharges was high in all mandibular positions from the maximal protrusion to the apex. All the patterns of changes in the temporal muscles myoelectric activity of each of the subjects are shown in Table 2.

In Subjects 2, 3, 4, 5, 6, 7 and 8, the “increase” pattern was observed in more than half of the electrode placement regions. In all the examined temporal muscle regions in

Subject 1 and in some of the electrode placement regions of Subjects 2 and 5, the “decrease” pattern could be determined. Subject 7 showed the “irregular” pattern in some of the electrode placement regions.

3. The amount of myoelectric discharges

1) The total amount of myoelectric activity of masseter and temporal muscles

No correlation between masseter and temporal muscle myoelectric activities and the tapping points could be found in any of the subjects examined. Therefore, the total amount of myoelectric activity, represented by the total amount of the rectified EMG signals from all regions of both the masseter and temporal muscles, was calculated for each mandibular position. This was based on the assumption that the total amount of myoelectric discharge recorded from both masseter and temporal muscles, after exerting an equal occlusal force, would reach its lowest level in the tapping point.

The total amounts of myoelectric activity of masseter and temporal muscles for each of the mandibular positions are presented in Figs. 6-1 and 6-2 at 10% and 20% of the maximal occlusal force, respectively. In this figure, a star (★) indicates the position of the mandible at lowest levels of activity. An asterisk (*) indicates those mandibular positions showing a significant difference from the lowest levels of activity. Fig. 7 shows the relationship between the total amount of discharge and mandibular position. An open circle (○) indicates those mandibular positions showing no significant difference from the lowest levels of activity.

Mandibular positions with the lowest total amount myoelectric activity that were included in the tapping point, were found the 4 subjects (Subjects 2, 4, 6 and 8) at 10% of the maximal occlusal force and 5 subjects (Subjects 1, 2, 3, 6 and 8) with this correlation at 20% of the maximal occlusal force. However, the area enclosed by those mandibular positions marked with open circles (○) in Fig. 7 were larger than the tapping points in all subjects.

Fig. 7 Relationship between mandibular positions of the lowest total amount of myoelectric discharge and tapping point

- 2) The amounts of myoelectric discharge over the middle part of the masseter muscle and the anterior bundle of the temporal muscle

The amounts of myoelectric discharge recorded by electrodes placed over the middle part of the masseter muscles and the anterior bundle of the temporal muscles was calculated in consideration of clinical applicability and measuring convenience. This amount for each of the mandibular positions at 10% and 20% of the maximal occlusal force is shown in Figs. 8-1 and 8-2, respectively. The relationship between the mandibular positions during the lowest amounts of myoelectric discharge and the tapping points is described in Fig. 9. In two subjects (Subjects 2 and 8) at both 10% and 20% of the maximal occlusal force, the amounts of myoelectric discharge over the middle part of the masseter muscle and the anterior bundle of the temporal muscle, was the lowest at the mandibular positions included in the tapping points. However, in both subjects, the positions assigned with the open circle (o) were outside the tapping point areas.

DISCUSSION

1. Changes in the myoelectric discharge amount

- 1) Changes in myoelectric activity of the masseter muscle

In 7 out of the 8 subjects, when the mandibular positions were completely or almost completely protruded, the myoelectric activity reached its highest level and, in maximal retrusion, that is in the apex or its vicinity, the level of myoelectric discharges was at its lowest. Those data were in agreement with those in previous reports^{3,4,8)} that the number of myoelectric discharges over the masseter muscle increases in anterior mandibular positions, which was considered reasonable because the masseter muscle elevates the mandible and supports its movements in the anterior direction²⁾.

In Subject 8, the myoelectric discharge of the masseter muscle dropped from its highest level in the most protruded mandibular position to become lower during posterior displacement of the mandible from the most protruded position, and increased again in the apex. This was considered to be due to cooperation between masseter and temporal muscles in shifting the mandible backward. However, in all of the subjects, during anteroposterior displacement of the mandible, variations in the amounts of myoelectric discharge between the mandibular positions were relatively small; therefore, the level of anteroposterior mandibular displacement cannot be estimated on the basis of the masseter muscle myoelectric discharge measurement.

- 2) Changes in the myoelectric activity of the temporal muscle

★ : The mandibular positions at lowest levels activity
 ↔ : Anteroposterior length of the tapping point p<0.05

Fig. 8-1 The amount of myoelectric activity of middle part of masseter muscle and anterior bundle of temporal muscle (10% of the maximal occlusal force)

Fig. 8-2 The amount of myoelectric activity of middle part of masseter muscle and anterior bundle of temporal muscle (20% of the maximal occlusal force)

Fig. 9 Relationship between the mandibular positions of the lowest amounts of myoelectric discharge and the tapping points

The changes in the number of temporal muscle myoelectric discharges varied and depended on the relationships between the tapping point, apex, and electrode placement region. In Subjects 1 and 2, the tapping point coincided with the apex, but this positive relationship was not observed in Subjects 3 to 8. The coincidence of the tapping point and apex in Subject 1, who showed the "decrease" pattern of myoelectric activity changes, was probably due to the inability of the temporal muscle to deviate the mandible posteriorly. In subjects without a positive tapping point-apex relationship, the "increase" pattern of myoelectric activity changes was usually observed; this was probably due to an increase in temporal muscle myoelectric activity when the muscle held the mandible in position in the apex.

The different patterns of myoelectric activity change observed in different electrode placement regions could be related to different directions of temporal muscle fibers in these regions. In Subjects 2 and 5, who showed the "decrease" pattern of myoelectric activity changes over the anterior bundle of the temporal muscle, the direction of muscle fibers was similar to that of the masseter muscle fibers; therefore, the amounts of myoelectric discharge increased in the anterior mandibular positions. However, in all subjects, during anteroposterior displacement of the mandible, the changes in the amounts of

myoelectric discharge between the successive mandibular positions were relatively small; therefore considered that anteroposterior displacement of the mandible cannot be estimated using the temporal muscle myoelectric discharge measurements.

2. Possibility of judging mandibular position by measuring the myoelectric discharge

In only half or less than half of the subjects, the mandibular positions whose total amount of myoelectric activity or the amount of myoelectric activity reached their lowest levels in locations that included the tapping points. Since mandibular movements are controlled by a great number of muscles, measurement of the masseter and temporal muscle EMGs alone is very limited if recognition of mandibular movements is to be properly understood. Moreover, some mandibular positions with total amounts of myoelectric activity or amounts of myoelectric discharges at their lowest levels and in which no statistically significant difference in myoelectric potentials could be found did not include the tapping points. Because of these results, we concluded that changes in myoelectric activity relating to mandibular displacement are very subtle and that mandibular displacement in the small area of the tapping point vicinity cannot be judged by measuring the amount of myoelectric discharge.

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Reprint requests to:

Dr. Kaoru Sakurai
 Department of Complete Denture
 Prosthodontics,
 Tokyo Dental College,
 1-2-2 Masago, Mihama-Ku,
 Chiba 261-8502, Japan