Original Article

The main occluding area in normal occlusion and mandibular prognathism

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ABSTRACT

Objective: To clarify whether the concept of main occluding area, where hard food is initially crushed, exists in patients who have a jaw deformity.

Materials and Methods: Nineteen subjects with normal occlusion, 18 patients with mandibular prognathism, and 11 patients with mandibular prognathism who had undergone orthognathic surgery participated in this study. The main occluding area was identified by clenching Temporary Stopping. The coincidence, location of the main occluding area, and distance from the first molars to main occluding area were examined.

Results: High coincidence of the main occluding area was obtained in all groups, signifying that the main occluding area exists even in these patients. Mandibular main occluding area was located on the first molar in all groups. Maxillary main occluding area in subjects with normal occlusion was located on the first molar. However, it was located on the second premolar and first molar in patients with mandibular prognathism, and on the first and second molars in patients with mandibular prognathism who had undergone orthognathic surgery. There was a statistically significant difference in distance from the maxillary first molar to the main occluding area among groups, but there was no difference in the distance from the mandibular first molar among groups.

Conclusion: The main occluding area is more stable on the mandibular first molar than the maxilla in all groups. (*Angle Orthod.* 2016;86:87–93.)

KEY WORDS: Main occluding area; Mandibular prognathism; Orthognathic surgery; Occlusion; Mastication

INTRODUCTION

Mastication is an important function of the stomatognathic system.[1] Masticatory function has been evaluated in terms of masticatory efficiency,[2] electromyographic analysis,[3] masticatory movement,[4] and occlusal force.[5] However, the process of hard food crushing by molars during mastication has not been clarified.

Kato et al.[6] first described an occlusal area where hard foods are initially crushed in the early step of mastication and named the area, the "main occluding area." He found that the main occluding area plays an important role in the initial step of mastication, and is usually located on the maxillary and mandibular first molars in most of the subjects. This concept of the main occluding area has been based on research in subjects with normal occlusion. However, no study has yet confirmed the existence of such an area or location in patients with mandibular prognathism who have a large anteroposterior discrepancy between maxillary and mandibular molars as compared to that of subjects

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Accepted: January 2015. Submitted: November 2014.
Published Online: April 15, 2015

with normal occlusion. In addition, there is no report about the detailed process of mastication in such patients. Despite the large discrepancy in molars, these patients can crush hard food, signifying these patients would have a main occluding area too.

Therefore, we hypothesized that patients with mandibular prognathism also have a stable main occluding area. Research on the main occluding area in patients with mandibular prognathism will help to elucidate the masticatory mechanism.

The objective of this study, therefore, was to examine the main occluding area in patients with mandibular prognathism before and after surgical orthodontic treatment.

MATERIALS AND METHODS

The authors have no conflicts of interest. The present study was approved by the Ethics Committee of Tsurumi University Hospital and conformed to the principles of the Declaration of Helsinki. All subjects provided informed consent, and written consent forms were obtained before this study.

Subjects with normal occlusion (NORM), patients with mandibular prognathism (MP), and patients with mandibular prognathism who had undergone orthognathic surgery (MPOS) were included in the present study.

The NORM group (n = 19) met the following inclusion criteria:

- no missing teeth other than the third molar,
- no major restoration covering the cusp,
- appropriate overjet and overbite,
- midline deviation of 1.0 mm or less,
- no functional symptoms such as temporomandibular joint disorder,
- no history of orthodontic treatment,
- Angle Class I molar relationship (Figure 1a), and
- normal intermaxillary relationship identified or classified by ANB angle and Wits analysis (Figure 1b).

The MP group comprising 18 patients with mandibular prognathism who required orthognathic surgery at the Department of Orthodontics, School of Dental Medicine, Tsurumi University, met the following inclusion criteria:

- no congenital abnormalities,
- no missing teeth other than the third molar,
- no major restoration covering the cusp,
- overbite of 1.0 mm or more,
- overjet of less than 0 mm,
- no notable mandibular asymmetry,
- severe Angle Class III molar relationship with the occlusion between the maxillary second premolar and mandibular first molar (Figure 1a), and
- skeletal Class III intermaxillary relationship in ANB angle and Wits analysis (Figure 1b).

The MPOS group, consisting of 11 patients with mandibular prognathism who had undergone orthognathic surgery, met the following inclusion criteria:

- no missing teeth other than the third molar at the first visit,
- no major restoration covering the cusp,
- appropriate overjet and overbite,
- midline deviation of 1.0 mm or less,
- preoperative occlusion between the maxillary second premolar and mandibular first molar,
- at least 1 year since orthognathic surgery,
- Angle Class II molar relationship due to the extraction of the maxillary bilateral first premolars in orthodontic treatment and mandibular setback (Figure 1a), and
- normal intermaxillary relationship identified or classified by ANB angle and Wits analysis (Figure 1b).

Table 1 shows the morphologic characteristics of the subjects in the NORM, MP, and MPOS groups in terms of ANB angle and Wits appraisal on the lateral cephalometric radiograph.

Test Material

Dental stopping (Temporary Stopping, GC, Tokyo, Japan; 3.4 mm in diameter), which is commonly used for dental temporary filling in Japan, was used as the test material in this study. The material was cut to 4.0 mm in length at room temperature, and one piece was used for each examination.

Identification of the Main Occluding Area

The main occluding area was identified in accordance with the method of Kato et al.[6] Briefly, one piece of dental stopping was placed on the center of the dorsal surface of the tongue in each subject as test food, and the subject was instructed to clench it once on the particular occluding area that was preferably used during mastication (Figure 2). The subjects were trained to clench dental stopping several times on the left and right side respectively. Then the subjects were instructed to clench it on their preferable side. After that, the dental stopping was carefully taken out from the oral cavity and subsequently transferred onto a prepared dental stone model for analysis. The location of the dental stopping on the dental arch was defined as the main occluding area. The same procedure was repeated three times for each subject.

Evaluation Method

Coincidence of the main occluding area. We examined the location of the main occluding area in three trials to confirm the reproducibility of the method.

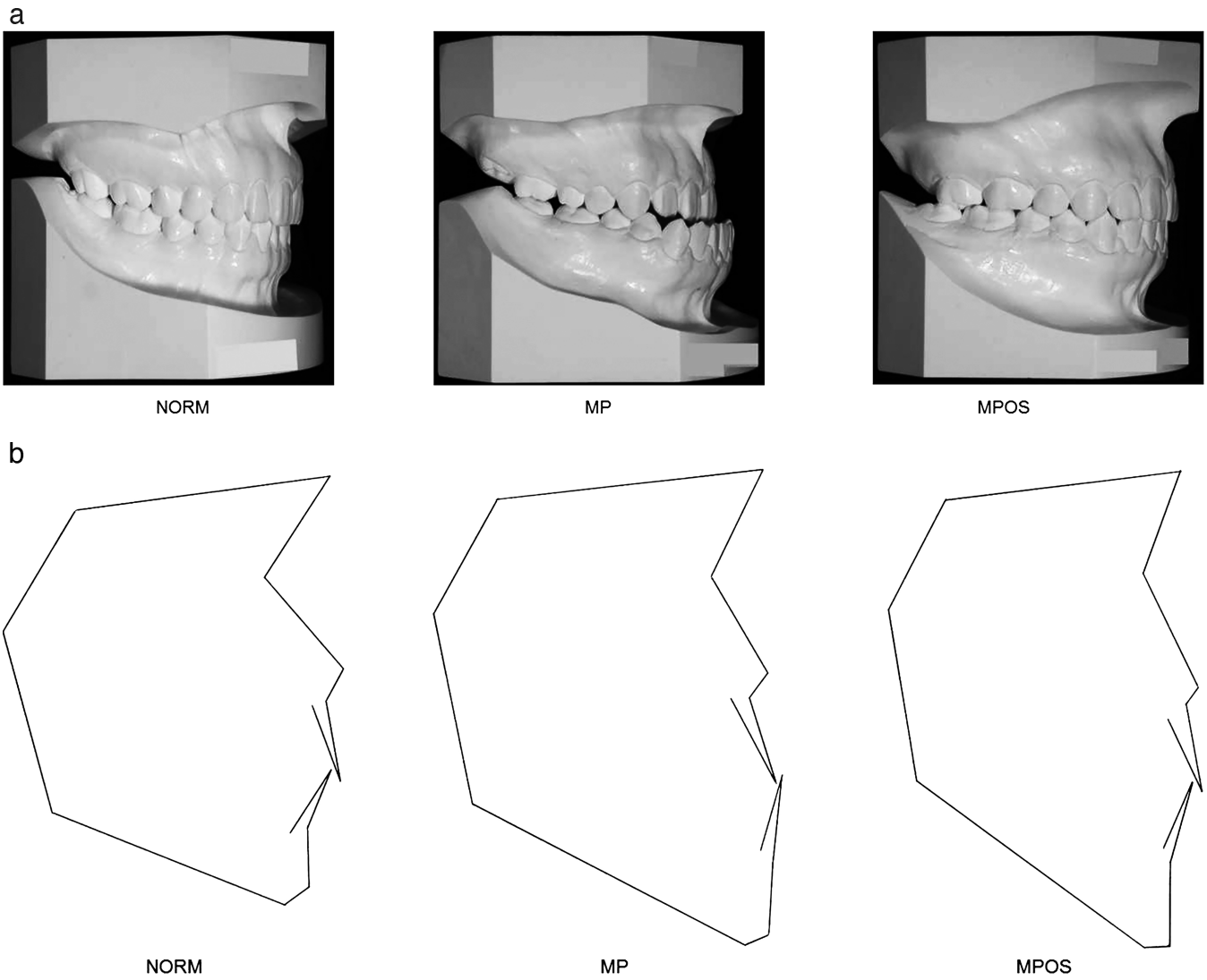

Figure 1. Representative photographs of the dental stone models and cephalometric diagrams of each group. (a) Representative photographs of dental stone models of subjects in the NORM, MP, and MPOS groups are shown. Photographs are of dental stone models of the subject closest to the characteristics of each group. (b) Representative cephalometric diagrams of subjects in the NORM, MP, and MPOS groups are shown. Figure tracing of lateral cephalometric radiographs of the subject closest to the average of the skeletal characteristics of each group.

The dental stopping was examined from the point of whether the site includes the same cusp or interdental region.

Table 1. Cephalometric Characteristics of the Subjects[a]

	Groups[b]		
Parameter	NORM	MP	MPOS
ANB, (degrees)	3.2 ± 2.0; NS	−4.2 ± 2.9*	2.0 ± 1.5; NS
(Wits mm)	−0.9 ± 1.9*	−12.8 ± 3.5*	−2.7 ± 1.4*

[a] NORM indicates subjects with normal occlusion; MP, patients with mandibular prognathism; and MPOS, patients with mandibular prognathism who had undergone orthognathic surgery.

* The Mann-Whitney *U*-test (comparison among groups); $P < .05$. NS indicates no significant difference. Statistically significant difference was observed among groups, except for the ANB between NORM and MPOS.

Location of the main occluding area. The location of the maxillary and mandibular main occluding areas in subjects of the NORM, MP, and MPOS groups was compared.

Distance from the first molars to the midpoint of the main occluding area. The distances from the mesiobuccal cusp tip of the maxillary first molar, or the mesiobuccal groove of the mandibular first molar to the mesiodistal midpoint of the dental stopping were measured by calipers. The mesiobuccal cusp tip of the maxillary first molar or the mesiobuccal groove of the mandibular first molar served as the reference point. Mesial distances were regarded as positive value, and distal distances as negative value (Figure 2). These measurements were performed by a single investigator.

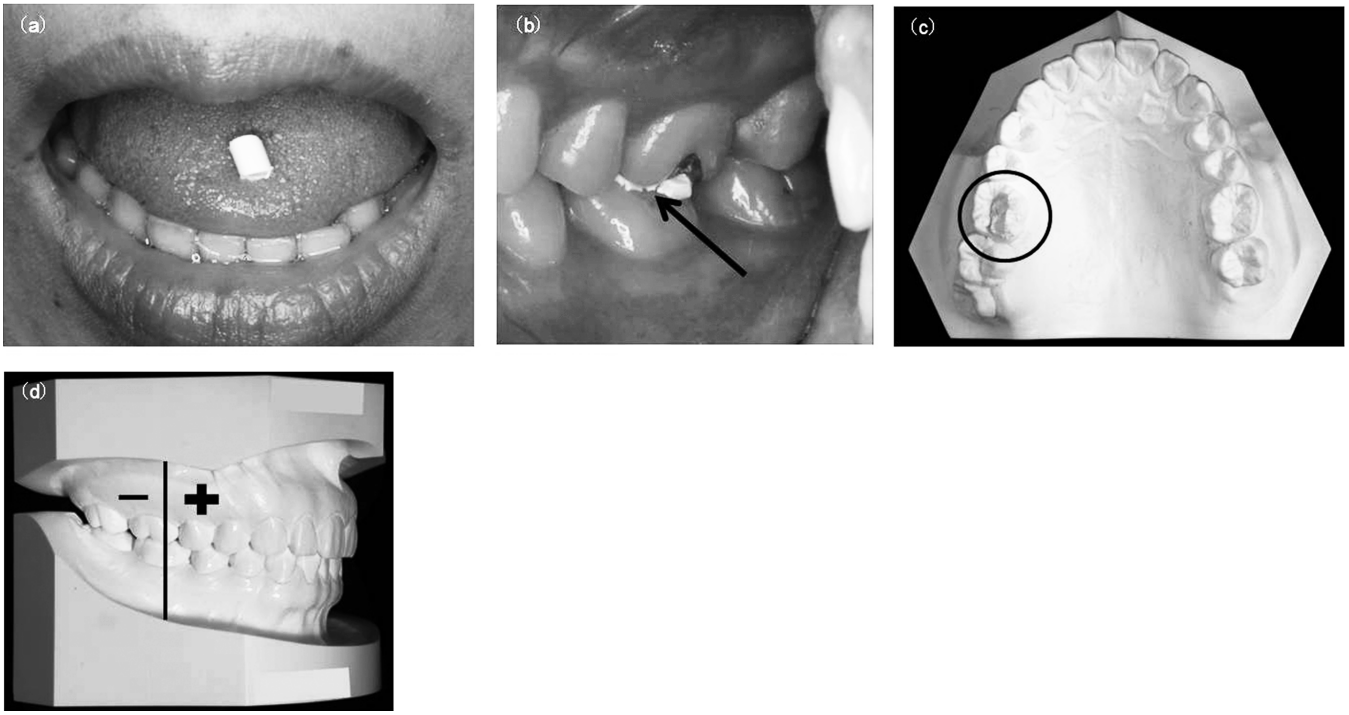

Figure 2. Identification of the main occluding area using a piece of dental stopping. (a) Placement of the stopping on the tongue. (b) Chewing the stopping (arrow). (c) Image of a dental stone model with the stopping indicating the main occluding area (circle). (d) Distance from the first molars to the midpoint of the main occluding area. Mesial distances from molar were regarded as positive value, and distal distances as negative value.

Statistical Analysis

The coincidence of locations within each group was analyzed using the chi-square test. The Fisher exact test was used to compare the percentage of the coincidence among the three groups. The Mann-Whitney *U*-test for between-group comparisons with Bonferroni correction was used for multiple comparisons of the mean distance from the midpoint of the main occluding area to the first molars.

A *P* value less than .05 was considered statistically significant. Statistical analyses mentioned above were performed with SPSS for Windows (Chicago, Ill).

RESULTS

Coincidence of the Main Occluding Area

Most of the subjects showed high coincidence of the main occluding area in the three trials (Table 2). In the NORM group, chewing was seen at the same location in all three trials in 16/19 subjects (84.2%), and two trials in 3/19 subjects (15.8%). In the MP group, chewing was seen at the same location in all three trials in 17/18 subjects (94.4%), and two trials in 1/18 subjects (5.6%). Interestingly, 11/11 subjects (100%) in the MPOS group chewed in the same location in all three trials. The percentage of subjects who chewed in the same location in all three trials was significantly higher than those who chewed in the same location twice within all groups. There was no statistically significant difference in the percentage of the subjects who chewed in the same location in all three trials among three groups. These results suggest that the main occluding area in all three groups seems reproducible, even in the MP group.

Table 2. The Coincidence of the Main Occluding Area[a]

Groups[b]	Three of Three Times (%) (A)	Two of Three Times (%) (B)	Significance Between (A) and (B)
NORM (n = 19)	16 (84.2); NS	3 (15.8)	*
MP (n = 18)	17 (94.4); NS	1 (5.6)	*
MPOS (n = 11)	11 (100); NS	0 (0)	*

[a] Chi-square test (comparison within group). Fisher exact test (comparison among groups).

[b] NORM indicates subjects with normal occlusion; MP, patients with mandibular prognathism; and MPOS, patients with mandibular prognathism who had undergone orthognathic surgery.

* $P < .05$. NS indicates no significant difference in three of the three times (%) between groups.

Table 3. Location of the Main Occluding Area (n = 48)

Groups[a]		Location of the Main Occluding Area		
		Second Premolar (%)	First Molar (%)	Second Molar (%)
NORM (n = 19)	Maxillary		19 (100)	
	Mandibular		19 (100)	
MP (n = 18)	Maxillary	13 (72.2)	5 (27.8)	
	Mandibular		13 (72.2)	5 (27.8)
MPOS (n = 11)	Maxillary		8 (72.7)	3 (27.3)
	Mandibular		11 (100)	

[a] NORM indicates subjects with normal occlusion; MP, patients with mandibular prognathism; and MPOS, patients with mandibular prognathism who had undergone orthognathic surgery.

Location of the Main Occluding Area

We then analyzed the location of the main occluding area in each group (Table 3). The main occluding area was located on the maxillary and mandibular first molars in the NORM group. However, the main occluding areas in the MP and MPOS groups were somewhat different from that in the NORM group. The maxillary main occluding area was located on the second premolar in 13/18 subjects (72.2%) and first molar in 5/18 subjects (27.8%) in the MP group. The mandibular main occluding area was located on the first molar in 13/18 subjects (72.2%) and on the second molar in 5/18 subjects (27.8%) in the MP group. Interestingly, in the MPOS group, the maxillary main occluding area was located on the first molar in 8/11 subjects (72.7%) and second molar in 3/11 subjects (27.3%); but in the mandible, it was located on the first molar in 11/11 subjects (100%) (ie, the main occluding area was converged to the first molar). The location of the main occluding area was more stable on the mandibular first molar than maxillary first molar in the MP group.

Mesiodistal Distance From the Reference Points to the Main Occluding Area

Finally, we measured the distance from the reference points to the midpoint of the main occluding area in both the maxilla and mandible (Figure 3). The mean distance from the reference points in maxillary first molar was −3.3, +2.1, and −5.9 mm in the NORM, MP, and MPOS groups, respectively (Figure 3a). There were statistically significant differences among the groups. On the other hand, the distance from the reference points in mandibular first molar was −3.2, −4.1, and −1.2 mm, respectively (Figure 3b), and no significant difference was observed. Compared to the mean distance based on the maxillary molar as reference, the mean distance based on the mandibular molar as reference was more stable among groups, signifying that the main occluding area of the mandible seems more stable than that of the maxilla.

DISCUSSION

The present study using the cross-sectional samples demonstrated that the concept of the main occluding area is applicable to patients with mandibular prognathism. Furthermore, by comparing mandibular prognathism with normal occlusion, we revealed that the mandibular first molar plays a more important role as the main occluding area than the maxillary first molar, irrespective of the anteroposterior jaw relationship.

This study was the first to examine the presence of a main occluding area in both the maxilla and mandible in patients with mandibular prognathism. Kato et al.[6] had reported that the main occluding area in normal occlusion was located on the maxillary and mandibular first molars in most subjects, and concluded that the maximal biting force might be exerted in the first molar region. Nakata et al.[7] reported the change of the main occluding area with dental age. In the deciduous dentition, the main occluding area is located on the second deciduous molars and then it shifts to the permanent first molar with eruption of the first molar and exfoliation of the second deciduous molar. Furthermore, Tsuchiya et al.[8] reported that the main occluding area in adults located on the permanent first molar tends to be more stable than on the second deciduous molar. These results, however, were all derived from the data of the subjects with normal occlusion. No previous study has examined the patients with anteroposterior discrepancy in the maxillomandibular jaw relationship, such as mandibular prognathism, or those who have experienced a remarkable change in the maxillomandibular jaw relationship by orthognathic surgery. Therefore, we examined the main occluding area in the patients with mandibular prognathism and mandibular prognathism who had undergone orthognathic surgery.

As for the coincidence of the main occluding area, Kato et al.[6] reported that the percentage of the subjects who showed the coincidence in five trials was 67%. In the present study, the coincidence in all three trials was over 80% in all groups and higher than that in the report by Kato et al.[6] This high coincidence

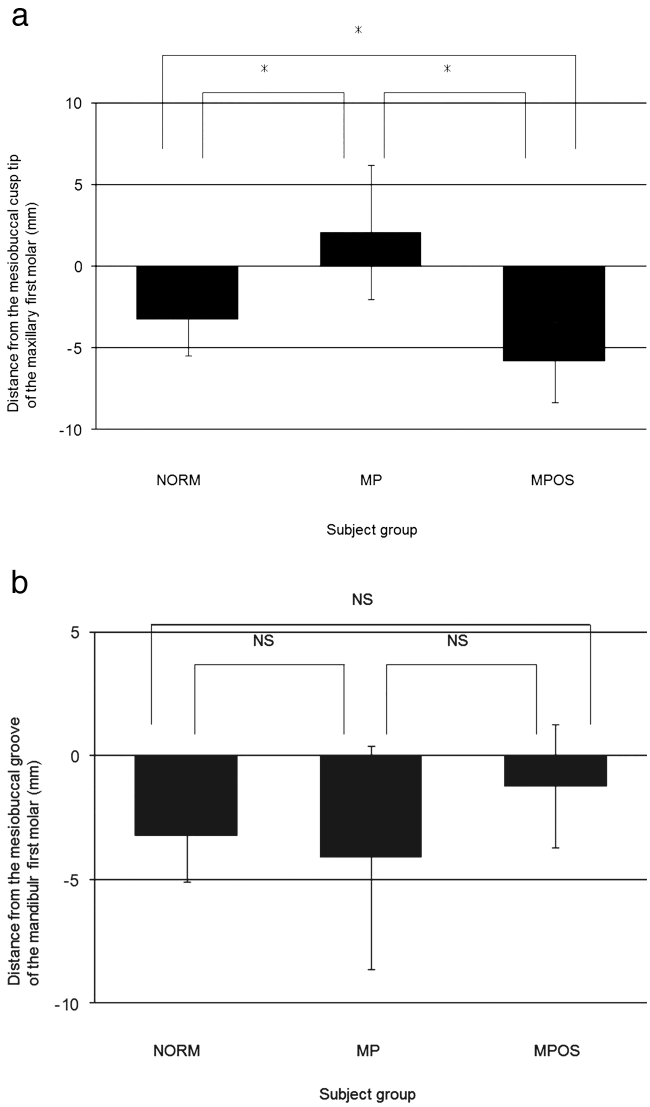

Figure 3. Distance from the first molars to the midpoint of the main occluding area. (a) Distance from the mesiobuccal cusp tip of the maxillary first molar to the midpoint of the main occluding area are shown. *$P < .05$ between groups. (b) Distance from the mesiobuccal groove of the mandibular first molar to the midpoint of the main occluding area. NS indicates no significant difference between groups.

suggests that our experimental method is reliable and reproducible even though we examined just three trials. In addition, the high coincidence in the patients with mandibular prognathism as compared to the subjects with normal occlusion indicates that the concept of the main occluding area exists in patients with mandibular prognathism.

The percentage of the location of the main occluding area on the first molars in both the maxilla and mandible in our study is somewhat different from the others. In our study, the first molar was the main occluding area in both the maxilla and mandible in all subjects with normal occlusion, with a very high frequency, as compared with the data of other studies where the main occluding area was located on the maxillary and mandibular first molar in 55.0%[6] and 55.6% of cases.[9] This might be due to the strict selection criteria of the subjects in this study. Our inclusion criteria for normal occlusion included not only Angle Class I molar relationship, but also intermaxillary relationship judged by lateral cephalometric radiographs.

In most of the patients with mandibular prognathism and mandibular prognathism who had undergone orthognathic surgery, the main occluding area was also located on the mandibular first molar, which was the same as that in the subjects with normal occlusion. However, the percentage of patients with maxillary occluding area on the first molar was only 27.8%, which is considerably different from that in the subjects with normal occlusion. This is due to the difference in molar relationship between normal occlusion and mandibular prognathism (Angle Class I and severe Angle Class III). These results indicate that the main occluding area on the mandibular first molar is stable, irrespective of molar relationship.

The main occluding area on the mandibular first molar remained unchanged during the treatment consisting of extraction of first premolars and mandibular setback. It was located on the mandibular first molar in all patients with mandibular prognathism who had undergone orthognathic surgery. However, the maxillary main occluding area changed from the second premolar and first molar (severe Angle Class III molar relationship) to first and second molars (Angle Class II molar relationship), both with which the mandibular first molar occludes. These results strongly indicate that teeth with the main occluding area in the maxilla are the antagonists to mandibular first molar. Because these results were obtained from patients with extraction of the maxillary bilateral first molars in orthodontic treatment and mandibular setback in orthognathic surgery, it is necessary to examine the main occluding area in patients with only extraction of the maxillary bilateral first molar in a future study.

The results in this study indicate the importance of the mandibular first molar in occlusion and mastication. In food bolus transport, a food bolus on the occlusal surface of the mandibular molars is very stable and easily crushed by occlusion with the antagonists. The mandibular first molar has the largest coronal diameter among teeth, both mesiodistally and buccolingually,[10–14] which makes it easier for the tongue to carry a food bolus on the occlusal surface as compared with those of the incisors and premolars.[15] The mandibular first molar is located anterior to the second molar, which makes the tongue smoothly carry a food bolus onto the surface.

In summary, we found that the concept of the main occluding area is applicable to patients with mandib-

ular prognathism, and the mandibular first molar plays a more important role as the main occluding area than the maxillary first molar, irrespective of anteroposterior jaw relationship.

CONCLUSIONS

- The concept of main occluding area is also applicable to patients with mandibular prognathism.
- In the case of patients with mandibular prognathism and patients with mandibular prognathism who had undergone orthognathic surgery, the main occluding area is dependent on the mandibular first molar.

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