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Analysis of chewing pattern according to the types of lateral occlusal guidance

조선대학교 대학원

치의학과

김 오 영

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측방교합유도 형태에 따른 저작형태의 분석

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하악의 측방운동은 측두하악관절의 해부학적인 형태와 기능보다는 전방유도가 더 많은 영향을 끼치며, 전방유도는 견치유도와 군기능유도로 나눌 수 있다.

본 연구에서는 측방운동시 교합유도 형태에 따른 저작시 하악운동의 양상을 컴퓨터화된 하악운동 추적조사 장치인 JT-3(BioPAK system®, Bioresearch Inc., Milwaukee, USA)를 사용하여, 19명의 견치유도와 21명의 군기능유도를 가진 대상자를 전두면과 시상면에서 분석하였다.

이상의 실험에서 다음과 같은 결과를 얻게 되었다.

1. 견치유도군은 전두면에서 저작양상이 비교적 한 가지 형태로 일정하며 작업측으로의 측방운동 양상이 일정하게 반복되는 양상을 보였으나, 군기능유도군은 저작주기가 일정한 한 형태를 보이지 않고 다양한 양상을 보였으며, 작업측 및 비작업측으로의 측방운동 양상이 불규칙적인 것을 볼 수 있었다.
2. 시상면에서 견치유도군은 전환점이 중심교합위 후방에 존재하고 개구운동 양상이 곡선적인 경우가 많았으며, 군기능유도군에서는 전환점이 중심교합위 후방에 존재하고 개폐구로가 직선적인 양상이 가장 많았다. 두 그룹 모두에서 전환점이 중심교합위 근처에 존재하고 개폐구 양상이 곡선적인 경우는 가장 적었다.

이번 연구를 통해, 측방운동시 교합유도 형태에 따라 저작운동양상에 차이가 있음을 알 수 있었다.

I. INTRODUCTION

The mandibular movement which performs various functions at stomatognathic system is the motion of mandibular bone which is dependent on masticatory muscle and controlled by signal from sensory receptors in the central nervous system or oro-facial system. This movement is a complicated motion based on the rotation of condyle and sliding movement at a 3-dimensional space, and classified as the border movement showing relatively high reproducibility and the functional movement that are related with mastication, swallowing and pronunciation. All types of functional movement involving mastication consist sequence of highly complex physiologic function. This movement is derived not only in the muscles, teeth, and periodontal tissue but lips, cheeks, tongue, palate, salivary gland that coordinated with the reflex action for an appropriate function or muscle activity. The masticatory system is therefore consist of the complex nerve control system which controls and coordinates bones, articulations, ligaments, teeth, muscles and all those factors.

Researches about mastication had difficulty in analyzing the accurate movement because of its complexity. Recently the development of the precise measurement device with a computer program that records 3-dimensional border movement have made the reproduction of mandibular movement to be easier and more specific. The device also allows one to measure and reproduce the 3-dimensional movement very easily.

Mastication is the opening and closing movement that are rythmically occur and is well-controlled by the teeth of upper and lower jaw. As the most common mode of chewing soft food, Gibbs et al.[1-3] have indicated a drop-shaped pattern of opening tracings that are more or less vertically directed. It consists of opening and closing movement, where the closing

movement is subdivided into crushing phase and grinding phase. Thus, masticatory movement has not only vertical movement but also lateral movement.

It is generally agreed that 2 guidance systems act on excursive mandibular movement: the anterior teeth and the 2 temporomandibular joints(TMJs)[4] in the posterior. It has been shown that the anterior guidance has greater influence on mandibular movement in comparison to the anatomy and the function of the TMJs. Anterior guidance during a lateral movement may be provided only by canines(canine-protected articulation) or more working-side teeth, which may include the canines(group function)[5-9].

In The Glossary of Prosthodontic Terms[10], canine protection is defined as "a form of mutually protected articulation in which the vertical and horizontal overlap of the canine teeth disengage the posterior teeth in the excursive movements of the mandible." Group function is defined as "multiple contact relations between the maxillary and mandibular teeth in lateral movements on the working side whereby simultaneous contact of several teeth acts as a group to distribute occlusal forces."

The purpose of this study is to investigate the differences of mandibular movement according to the lateral guidance pattern during mastication.

II. MATERIAL AND METHODS

1. Subjects

According to clinical and occlusal examination, we selected dental college students who have a natural dentition and do not have symptoms of TMD except for the simple TMJ noises as an object of study. During a lateral movement, there are canine protection or group function guidance on both sides. Therefore we chose 40 students who have the Angle's classification I occlusal relation. The age range of the subjects is between 23 to 33. The subjects consist of 31 males and 9 females.

After letting the subjects sit on dental chairs is an upright position, we tested the lateral guidance pattern by 13μm-occlusal film(AccuFilm II® , PARKELL Co.,U.S.A). Then we classified group I into those with only lateral movement depending on maxillary and mandibular canine protection while the group II were led by the guidance of two or more teeth at both sides.

Table 1. The classification of subjects groups.

Group I	Canine protection	19 persons
Group II	Group function	21 persons

2. Electrognathograph

In this study, JT-3 device in the BioPAK® system(Bioresearch Inc., Milwaukee, USA) was used. The BioPAK® system is highly accurate in measuring both speech patterns and masticatory movements. The three experiments were carried out after an accurate set-up of the device was

checked. The subjects were first instructed in border movement to reduce the possibility of error which could be arise from the device itself. Then the subjects were instructed to make reproducible movement.

3. Measurement

Firstly, we inserted the name, birth and sex of the subjects into the computer as data. The magnet was attached to the labial surface of mandibular incisors of the subjects in order to bring the midline of the magnet with the labial frenum and to locate the groove of the magnet to the left side of the subjects. It was important to locate the magnet parallel with interpupillary line because otherwise the data can be recorded inaccurately.

If the subjects tend to have deep bite therefore it is impossible to attach the magnet to the labial surface, the labial gingival surface or the lingual tooth surface can be replaced as an attachment site. The JT-3 device was the set to the subjects. Once the horizontal and vertical standard point were set, we controlled them to fit into the subjects' head. It must be confirmed that the bar of the front side is parallel with the interauditory axis, and the bar of the lateral side is parallel with the Frankfort Horizontal plane while the lateral line is parallel with the floor. The magnet positional bar is for approaching to the magnet that is fixed temporally to set the exact midline. During the measurement of the orbit of mandibular movement, the JT device is supported by the nose prop. The subjects were able to hold the bilateral side of the JT-3 for convenience. (Fig. 1)

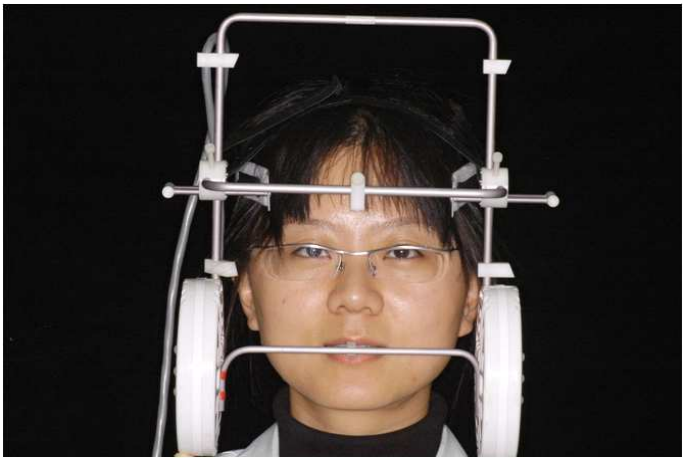


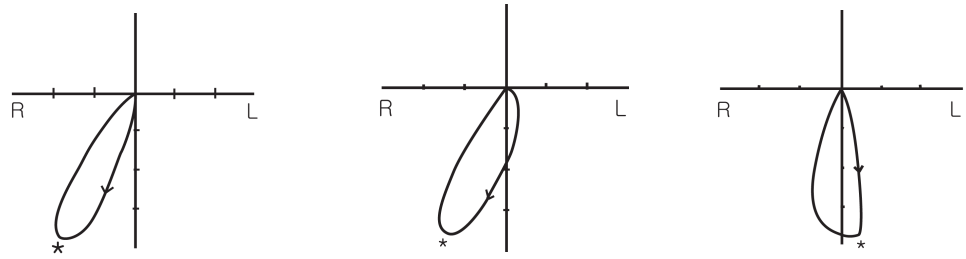
Fig.1. JT-3 device (BioPAK® system) placed on the subjects.

After completing the set up of JT devices, subjects chewed the gum on the right side, allowing one to continuously maintain the feature of food. When they showed mastication cycle with reproducibility, we recorded masticatory movements three times for 30 seconds on the Mastication mode. We found movement pattern at sagittal, frontal and horizontal planes.

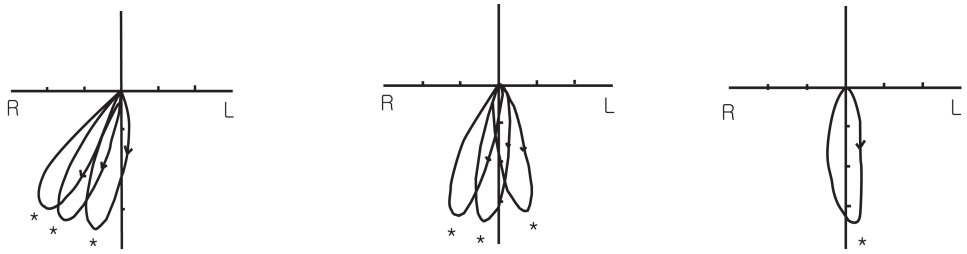
III. RESULTS

1. Analysis according to pattern of mastication cycle at frontal plane

We classified 6 patterns according to the curvature direction of opening path and consistency of shape. Frontal patterns of chewing(FP) 1 show a consistent pattern presenting a regular mastication cycle and a lateral deviation pattern. According to the direction of opening path and location of turning point, FP1 is divided into FP1-1, FP1-2, FP1-3. FP1-1 represents a case that all gliding patterns of mastication cycle and turning points occur at the working side. FP1-2 represents a case that most gliding patterns occur at the working side but they also occur at the non-working side in the early opening. The turning point is at the working side. FP1-3 is the case where the gliding patterns of mastication cycle occur around median line and the turning point is at the non-working side. Frontal patterns of chewing(FP) 2 show irregular mastication cycle and various patterns. FP2-1 is the case that the turning point is at the working side. FP2-2 is the case that the turning point is at both sides. Frontal patterns of chewing(FP) 3 show continuous cycle of regular mastication. Its turning point is at median line and it has a similar lateral movement(Fig.2). The result are shown below. (Fig.3)



(a) FP 1-1 (b) FP 1-2 (c) FP 1-3



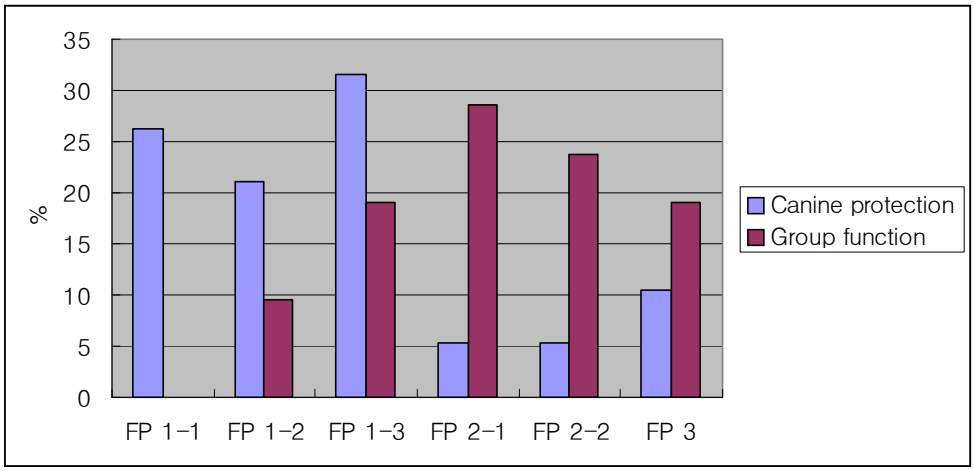
(d) FP 2-1 (e) FP 2-2 (f) FP 3

FP: Frontal patterns of chewing

R: Right, L: Left

* : Point of transition from opening to closing

Fig.2. Classification of morphological chewing patterns on the frontal plane. (a), All movement occurs at the working side, the turning point is at the working side. (b), Most movement not only occurs at the working side but also occurs at the non-working side in the early opening, the turning point is at the working side. (c), Movement occurs around median line, the turning point is at the non-working side. (d), Irregular and various mastication patterns, the turning point is at the working side. (e), Irregular and various mastication patterns, the turning point is at both sides. (f), Consistent cycle of mastication, the turning point is at median line.

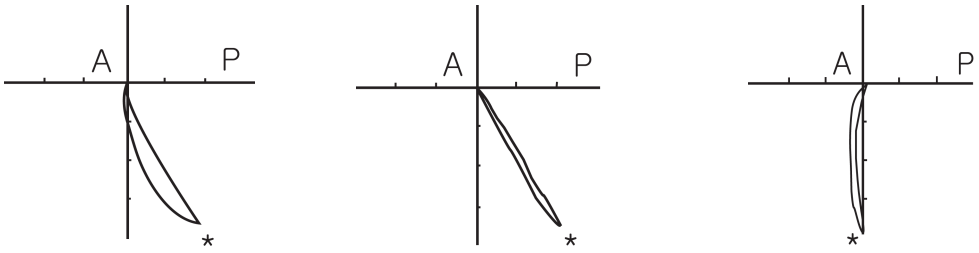


FP: Frontal patterns of chewing

Fig.3. Distribution of chewing patterns on the frontal plane in both groups.

2. Analysis according to pattern of mastication cycle at sagittal plane

We classified three patterns according to the location of the turning point and the presence curvature of opening and closing path. Sagittal pattern of chewing(SP) 1 is the case where the turning point is on the posterior from the centric occlusion and the pattern being curved. SP2 is the case that the turning point is on posterior from the centric occlusion and the pattern is straight. SP3 is the case that the turning point is around the centric occlusion and the pattern is curved (Fig.4). The results are shown below (Fig.5).



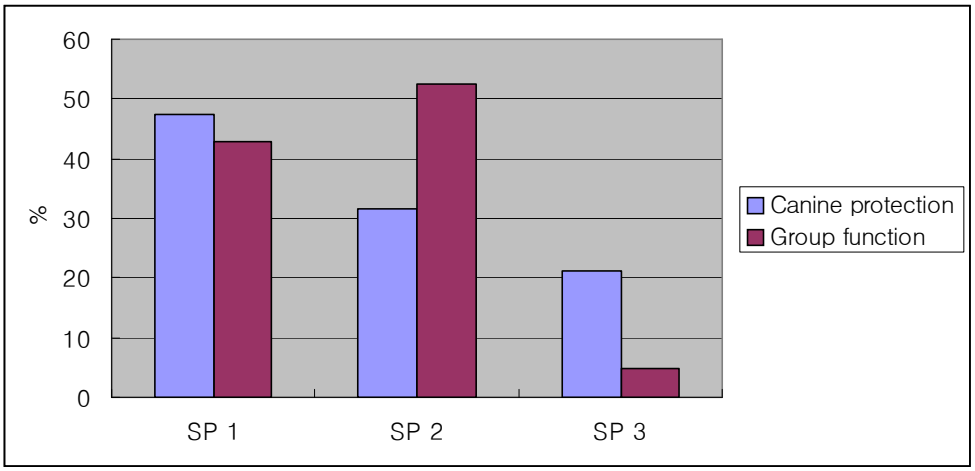
(a) SP 1 (b) SP 2 (c) SP 3

SP: Sagittal pattern of chewing

A: Anterior, P: Posterior

* : Point of transition from opening to closing

Fig.4. Classification of morphological chewing patterns on the sagittal plane. (a), The turning point is on posterior from the centric occlusion, the chewing pattern is curved. (b), The turning point is on posterior from the centric occlusion, the chewing pattern is straight. (c), The turning point is around the centric occlusion, the chewing pattern is curved.



SP: Sagittal pattern of chewing

Fig.5. Distribution of chewing patterns on the sagittal plane in both groups.

3. Analysis at Mastication sweep view

Mastication sweep view is the mode which analyzes mastication cycles and array through time serially. Therefore we are able to see the direction of mandibular movements more specifically on the centric occlusion. The mastication sweep view always appears with "Masking" of cycles already done by the program. The program calculates the average cycle and compares each individual cycle with the average. Any cycle that falls more than two standards deviations from the average is marked with diagonal slashes. (Fig. 6, 7) In Group I, we can notice that the pattern of lateral movement to the working side is repeated regularly, but in Group II, we recognize that the directions of lateral movement to the working side and the non-working side are irregular.

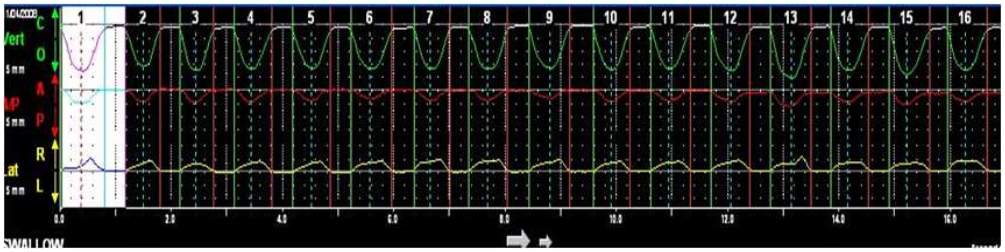


Fig.6. Mastication sweep of subject on canine protection.

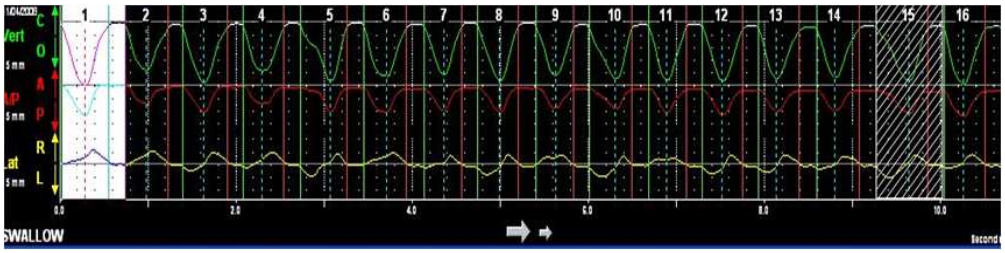


Fig.7. Mastication sweep of subject on group function.

IV. DISCUSSION

The researches on mandibular movement at masticating have been conducted for a long time, but the results are diverse according to the recording method and the types of food used. For recording the border movement of mandible, pantograph has been used for a long time but, as high-level recording devices have developed, we have shifted our attention to tracing and recording not only the border movement but also functional movement.

In the researches on mastication patterns using a mandibular movement recorder, a possibility of mechanical errors exists and the recorder is also affected by whether subjects can masticate in reproducibility or not.

Balkhi et al.[13] insisted that an mechanical error at the border movement could occur. Movements recorded on incisors are inappropriate to present the movement of molars and condyle or maximum mandibular movement. Santos et al.[14] insisted that for all that discipline, subjects could not reproduce consistent functional movement of mandible. However, Furuya[15] asserted that the measurement at incisors has several advantages, 1. one point of incisors part can be a reference point, 2. incisor point gives easy measurement thanks to its wide range of movement, 3. movements of incisor point are usually distinct, 4. incisor point can be easily affected by abnormal muscle because of its wide range of movement, 5. it is easy to anchor the measurement device.

Electrognathograph (BioPAK® system, Bioresearch Inc., Milwaukee, USA) which was used in this research is a device that measures mandibular movement at mandibular incisor. It measures a range of movement and velocity at frontal, sagittal and horizontal plane for the first record. It measures data processed to diagnostic information on a computer too. It is able to adjust to numerous subjects easily. Also, it gives a good chance to be combined with the devices for analyzing

electromyogram and TMJ sounds.

There are opening, lateral, closing movement factors in a mastication. Ahlgren[16] showed the evidence of tooth gliding in 62% of all chews of gum and 54% of all chews of carrot in 35 children's case. From all his children subjects, 95% showed some gliding of teeth during gum chewing. Their path patterns are different by the type of food and their nature, but cusp inclination and occlusal state are concerned around the path of occlusal contact.[25] Also, there is a report that the paths of mandibular border movement or mastication are changed when occlusion contact relation is changed at lateral occlusion.[25] When there is a canine protection occlusion by changing lingual shape of canine having molars contact at the balancing side, we recognize the change not only in the path of lateral gliding movement but also in the path of lateral boundary opening and the closing movement without occlusal contact. Furthermore, there are extension of movement range and changes at the path of mastication.[17]

We can tell the difference of chewing pattern according to occlusal guidance pattern at lateral movement. There is no unification method to show configuration of mastication cycle due to different individual characteristics. We classify it by a configuration of mastication recorded at frontal plane and sagittal plane. At frontal plane, we classify it as 6 patterns according to the curvature direction of opening path, the location of the turning point and the consistency of shape. At sagittal plane, we classify it into 3 patterns according to the location of turning point and whether it has curvature of opening and closing path. In Group I, the chewing pattern shows relatively regular form and typical shape of tear-drop. There are individual differences in angulation of mastication pattern with major axis at the initial stage of opening movement regardless of the occlusal pattern guided by lateral movement but because

of the difference of lingual inclination at individual maxillary canine.[17] At frontal plane, Group II, not similarly to Group I, shows various patterns of mastication cycle. At sagittal plane, Group I has lots of cases of turning points existing on the posterior from the centric occlusion and the pattern of opening movement being curved. In Group II, most of the cases are that the turning point exists on posterior from the centric occlusion and the pattern of opening and closing movement is straight. In both groups, the least frequent case is the turning point existing around the centric occlusion and opening and closing movement being curved. Paths of motion in the sagittal plane show that the central incisor usually closes in a retrusive movement and open in a protrusive movement.[18,19] During functional movement, the working side condyle is at its most superior, rear position during the closing stroke, and both condyles often move forward immediately upon opening, allowing the central incisor to move in a path in front of the path following when the jaws are closing.[20]

The patterns of mastication vary depending on the characteristics of food. In case of crushable food like peanut or resistant food like squid, we acknowledge the pounding movement has strong lateral factors on the path where tooth guidance relates with. There is a lot of up and down movement on cutting food like apples or carrots. We see that the harder the food, the wider the lateral closing jaw movement. As the food softens, the lateral and vertical extent of the jaw movement decreases.[21] Gibbs et al. compared each personal path with lateral gliding movement in 3-dimension and reported that about 60% on the average has the similar path around tooth contact.[22]

Kinesiologic and morphologic analyses by Ogawa[23]and Koyano[24] have shown that the width and length of the mandible, and the anterior and condylar guiding system differ between the genders. It is possible that a gender difference exists in the prevalence of the occlusal contact pattern.

Our study has the limitation that each group consists of different genders. Needed are more researches on mastication pattern between genders according to occlusal guidance type at lateral movement.

According to Ahlgren's report[16], when maxillomandibular function is normal, the mastication cycle of simple pattern is repeated regularly. In the case of abnormal occlusion, however, it shows a complex pattern and it tends to become irregular compared to normal occlusion. Thus it is considered that the study on the effect of articular function by irregular mastication pattern needs to be carried out more through a long term follow-up of the subjects who showed group guidance and had irregular guidance pattern that could lead to a symptom of articular disorder later on.

V. CONCLUSIONS

Within the limitations of this study, mandibular movement during gum chewing was analyzed in 19 subjects who have canine protected occlusion(Group I) and 21 subjects who have group function occlusion(Group II). The study investigate the effect of lateral guidance pattern on mandibular movement during mastication.

Results are summarized as following:

1. In Group I, chewing pattern shows a relatively regular form and patterns of lateral movement to the working side are repeated regularly. At a frontal plane, Group II, different from Group I, shows various patterns of mastication cycle, while the patterns of lateral movement to the working side and the non-working side are irregular.
2. At sagittal plane, Group I has plenty of cases where the turning point exists posterior from the centric occlusion and the patterns of opening movement are curved. In Group II, most of cases consist of the turning point existing posterior from the centric occlusion and the patterns of opening and closing movement being straight. For both groups, the least frequent case was where the turning point exists around the centric occlusion and the patterns of opening and closing movement are curved.

Based on the results above, one can detect differences in the patterns of mandibular movement according to lateral guidance pattern at mastication.

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