Experimental Study of the Differences in the Mandibular Condyle Position Between the Activator and the Inclined Bite Plane

Kunihiro Nokita, Kunihiko Fujita, Etsuo Nodai and Sunao Ohki
Department of Orthodontics (Chief: Prof. Michiyasu Sato)
Kyushu Dental College, Kitakyushu, Japan

Received on December 22, 1989.

Key words: Activator/Inclined bite plane/Mandibular condyle/Transcranial lateral oblique projection/Photographic subtraction

Introduction

Maxillary protrusions are often caused by a discrepancy in the size or position of the maxilla or the mandible. Various appliances have been developed to correct specific cases of maxillary protrusions\(^1\)\(^-\)\(^4\)\). Since tooth eruptions and jaw growth can be utilized advantageously during the period of the mixed dentition when tissue adaptability is particularly high, an activator or an inclined bite plane is used to advance the mandible for the cases of maxillary protrusion accompanied by mandibular retrusion (Figs. 1 and 2).

Both appliances are similar in the respect that they change mandibular position and make use of the muscular functions. Their structures, however, are different and the effects of treatment are expected to be different.

Moss stated in his functional matrix theory\(^5\)\) that both the maxilla and the mandible, as well as the other facial bones, grow in some sort of coordinated fashion. It is no more difficult for us to imagine the facial bones, essentially surrounding facial spaces,
to be passively and secondarily expanding outward, downward and forward within a functional matrix here termed the oro-nasal capsule, than it is to visualize the expansion of the neutral vault as a homologous response to the growth of neutral viscera. The growth of bone at the facial sutures, as at the mandibular condyle and at the neurocranial sutures, represents secondary, compensatory events.

This subject has been investigated clinically. Fujita and associates\(^6\) in our department compared the effects of the activators and the inclined bite planes on the temporomandibular joints in treating maxillary protrusions complicated by a deep mandibular distal bite. They reported that the activator moved the mandible in a bilaterally parallel anteroinferior direction, while the inclined bite plane rotated the mandible clockwise.

Sato\(^3\) used the activator to treat patients with maxillary protrusions and compared patients who underwent removal of the biting surfaces of the molars with those who did not. According to his report, the former group developed clockwise rotation of the mandible similar to that caused by the inclined bite plane and showed no advance of the Pogonion. In the latter group, the lower edge of the mandible moved in a bilaterally parallel anteroinferior direction, accompanied by markedly advanced Pogonion. Thus, Sato's report was consistent with the results of Fujita et al.\(^6\)

Masumoto et al.\(^7\) histopathologically investigated the effects of elevated bite planes applied to both front and molar teeth and to the molars on the temporomandibular joints of dogs. They observed slight differences in the mandibular condyle position and in the response of the cartilage layer between the two elevated planes.

It is believed that these appliances affect maxillary and mandibular growth differently. There have been few studies on this subject, so the difference is not yet clear.

The purpose of this study was to examine the different treatment effects caused by the activators and the inclined bite planes. The positional changes of the mandibular condyle when each appliance was applied were recorded radiographically, and some facts have been proved.

**Materials and Methods**

The subjects studied were thirteen adults, eleven males and two females with \(\angle ANB\) 4 to 7.5\(^\circ\), an average of 5.2\(^\circ\); 5.0 to 7.0 mm of overjet, an average of 5.3 mm; and 2.5 to 6.0 mm of overbite, an average of 4.2 mm. They were cases of so-called maxillary protrusion, and no dysfunctions were found in the temporomandibular joint. Selected cephalometric findings are shown in Table 1.

Experimental devices were activators and inclined bite planes which are used in clinical orthodontics. The fabrication process of these devices was as follows: Construction bite impressions were taken with the mandible opened 5 mm, from centric occlusion, perpendicular to the occlusal plane and then advanced 5 mm parallel to the occlusal plane and the median palatine suture. Dental paraffin wax was used.
Diff. in the Mandibular Condyle Position (Nokita, et al.)

Table 1  Some cephalometric measurements of the subjects

<table>
<thead>
<tr>
<th>Case No.</th>
<th>sex</th>
<th>overjet</th>
<th>overbite</th>
<th>(\angle)SNA</th>
<th>(\angle)SNB</th>
<th>(\angle)ANB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>♂</td>
<td>6.0mm</td>
<td>4.5mm</td>
<td>84.0°</td>
<td>80.0°</td>
<td>4.0°</td>
</tr>
<tr>
<td>2</td>
<td>♂</td>
<td>5.0mm</td>
<td>4.5mm</td>
<td>82.5°</td>
<td>76.5°</td>
<td>6.0°</td>
</tr>
<tr>
<td>3</td>
<td>♀</td>
<td>7.0mm</td>
<td>6.0mm</td>
<td>78.5°</td>
<td>72.0°</td>
<td>6.5°</td>
</tr>
<tr>
<td>4</td>
<td>♂</td>
<td>5.0mm</td>
<td>2.5mm</td>
<td>82.5°</td>
<td>76.5°</td>
<td>6.0°</td>
</tr>
<tr>
<td>5</td>
<td>♂</td>
<td>5.0mm</td>
<td>4.5mm</td>
<td>80.5°</td>
<td>75.0°</td>
<td>5.5°</td>
</tr>
<tr>
<td>6</td>
<td>♂</td>
<td>5.0mm</td>
<td>4.5mm</td>
<td>75.5°</td>
<td>71.5°</td>
<td>4.0°</td>
</tr>
<tr>
<td>7</td>
<td>♂</td>
<td>5.5mm</td>
<td>3.5mm</td>
<td>82.0°</td>
<td>77.5°</td>
<td>4.5°</td>
</tr>
<tr>
<td>8</td>
<td>♂</td>
<td>5.0mm</td>
<td>5.0mm</td>
<td>81.0°</td>
<td>76.5°</td>
<td>4.5°</td>
</tr>
<tr>
<td>9</td>
<td>♂</td>
<td>5.0mm</td>
<td>4.5mm</td>
<td>83.0°</td>
<td>78.5°</td>
<td>4.5°</td>
</tr>
<tr>
<td>10</td>
<td>♂</td>
<td>5.0mm</td>
<td>5.5mm</td>
<td>83.0°</td>
<td>78.5°</td>
<td>4.5°</td>
</tr>
<tr>
<td>11</td>
<td>♂</td>
<td>5.5mm</td>
<td>4.5mm</td>
<td>81.0°</td>
<td>75.5°</td>
<td>5.5°</td>
</tr>
<tr>
<td>12</td>
<td>♂</td>
<td>5.0mm</td>
<td>3.0mm</td>
<td>78.5°</td>
<td>74.0°</td>
<td>4.5°</td>
</tr>
<tr>
<td>13</td>
<td>♀</td>
<td>5.0mm</td>
<td>2.5mm</td>
<td>83.0°</td>
<td>75.5°</td>
<td>7.5°</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>5.3mm</td>
<td>4.2mm</td>
<td>81.2°</td>
<td>76.0°</td>
<td>5.2°</td>
</tr>
</tbody>
</table>

The occlusal plane was decided as the plane that contained the mandibular incisal point and the distobuccal cusps of the mandibular second molars.

This mandibular position was controlled by an anterior bite indicator attached to the incisors of the maxilla and the mandible (Fig. 3 a and b). After placing the plaster casts together with the construction wax bite in a fixator, the appliances were made using orthodontic acrylic resin (Figs. 4 and 5).

In accordance with Ohba's method\(^8\), standardized transcranial lateral oblique radiographs of the temporomandibular joint were taken with the activator applied and with the inclined bite plane applied.

Fig. 3  The anterior bite indicator attached to the incisors of the maxilla and mandible.

a. The centric occlusion.

b. The mandibular position that the upper front teeth were raised 5 mm vertically and displaced 5 mm forward.
Fig. 4 The activator used in this experiment.

Fig. 5 The inclined bite plane used in this experiment.

The cranio-stat for the standardized radiography consisted of an acrylic plate inclined 20° upward and 0° horizontally and acrylic ear rods (Fig. 6). A central ray was directed 13 mm anterior to the external auditory meatus of the radiation side.

Radiographs were taken under the following conditions:
three-phase rotating anode,
focal spot: 0.8×0.8 mm,
tube current: 100 mA,
tube potential: 80 kVp,
exposure time: 3/10 second,
focus-film-distance: 85 cm,
filter: 2.0 mm equivalent aluminum filtration,
intensifying screen: hige-speed.

Ipsilateral radiographs were taken serially in the fixed head position at centric occlusion, and with activator and inclined bite plane applied for the right and left sides. The reproducibility was kept high because ipsilateral x-rays were taken with the head fixed.

The so-called photographic subtraction technique was applied to the lateral radiograph. The positional changes of the mandibular condyles were then closely observed.
Results

Based on the FH plane, the positional changes of the mandibular condyle when wearing the inclined bite plane and when wearing the activator are summarized in Table 2. Examination of changes was made for each side.

On the left side, 7 cases were in the posterosuperior position, 4 were in the posterior position, 1 was in the anterior position and 1 was unchanged. Eleven of the 13 cases were in the posterior and posterosuperior positions, and 7 were in the posterior positions.

On the right side, 8 cases were in the posterosuperior positions, 1 was in the posterior position, 1 was in the anterior position, and 3 were unchanged. Nine of the 13 cases were in the posterior and posterosuperior positions.

The two sides showing an identical change were 7 cases in the posterosuperior positions, 1 was in the posterior position, 1 in the anterior position, and 1 unchanged.

Of the cases in which each side moved in different directions two subjects had the left side in the posterior position and the right side unchanged. There was also one case where the left side was in the posterior position and the right side was in the posterosuperior position.

Table 2 The positional change of the mandibular condyle when wearing the inclined bite plane to when wearing the activator (Superimposed by the FH plane)

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Left side</th>
<th>Right side</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>3</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>4</td>
<td>P</td>
<td>U</td>
</tr>
<tr>
<td>5</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>6</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>P S</td>
</tr>
<tr>
<td>8</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>9</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>10</td>
<td>P</td>
<td>U</td>
</tr>
<tr>
<td>11</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>12</td>
<td>P S</td>
<td>P S</td>
</tr>
<tr>
<td>13</td>
<td>P S</td>
<td>P S</td>
</tr>
</tbody>
</table>

A : Anterior position
P : Posterior position
S : Superior position
P S : Posterosuperior position
U : Unchanged

Discussion

1. Subtraction technique

Ever since Ziedes des Plantes\(^\text{10}\) introduced his subtraction technique in 1935 as a radiographic diagnostic tool, it has been applied to angiography\(^\text{11}\), particularly to cerebral angiography\(^\text{12}\). Dental applications of this technique have been expanded recently. For instance, standardized cranial subtraction radiography is used for evaluating orthodontic collections by comparing the sites before and after treatment\(^\text{13}\), observing changes in the alveolar bone\(^\text{14}\), and visualizing salivary glands\(^\text{15}\).

Standardized subtraction radiography on a paraoblique view of the temporomandibular joint has also been used to visualize the mandibular condyle. The subtraction technique eliminates unnecessary or interfering shadows, such as bone and soft tissue shadows,
from x-ray images by optic or electronic methods. Depending on the methods, subtraction is classified into the photographic, the color, or the digital techniques.

In this experiment, we applied the photographic subtraction technique that produces clear images to standardized radiograph on a paraoblique view of the temporomandibular joint. Subtraction radiographs were prepared according to the method of Sakurai et al. Based on radiographs of temporomandibular joints obtained with the activator applied, and radiographs obtained with the inclined bite plane applied, second subtraction images were produced (Fig. 7).

This technique enable us to clearly visualize differences in the mandibular condyle position caused by the two orthodontic appliances. We found this technique to be effective in identifying positional changes in bones. We therefore believe that it can be applied in many areas of dentistry in the future.

2. Differences in the mandibular condyle position caused by the activator and the inclined bite plane appliances.

Setting the construction bite in the correct position is very important in correcting maxillary protrusions with orthodontic appliances. Nevertheless, no consensus has been reached concerning the vertical, anteroposterior, and lateral directions of correct mandibular position. Using Ueyama’s report as a reference, we set the construction bite mandibular position so that the upper front teeth were raised 5 mm vertically and displaced 5 mm forward.

We postulated the following explanation for the differences in mandibular condyle position caused by the activator and the inclined bite plane. Generally, mandibular movement during mastication is believed to create a third lever phenomenon in which the vector of occlusal force operates between the upper and lower teeth on the masticating side at the fulcrum of the mandibular condyle.

There is a significant structural difference between the activator and the inclined bite plane. The difference involves resin on the biting surfaces of the molars. With the activator, the biting surfaces of the upper and lower teeth, including incisors and
molars, are covered with a single resin block. Therefore, even if a strong force is applied in closing the jaws, it is absorbed by all the teeth. The activator is worn and the position of the mandibular condyle is fixed.

In other words, when the activator is worn, a strong occlusal force transmitted to the mandible is absorbed primarily by the dental arch and only partially by the mandibular condyle. In this case, the entire mandibular dental arch acts as a fulcrum and the mandibular condyle as an acting point. As shown in Fig. 8, a third lever phenomenon is created in the teeth wearing the activator, in which the positions of the fulcrum and the acting point of the vector are reversed from that described above.

Fig. 8 A third lever phenomenon is created in the teeth wearing the activator.

In the case of the inclined bite plane, resins do not cover the biting surfaces of the molars. As a result, only the position of the lower front teeth is fixed. Fujimoto\(^1\) histopathologically examined the lower front teeth of dogs wearing elevated bite planes. He observed downward sloping of the lower front teeth in occlusion.

His study showed that the elevated bite plane caused a concentration of force in the lower front teeth. Consequently, while wearing the inclined bite plane, a strong occlusal force transmitted to the mandible is absorbed mostly by the front teeth and partially by the mandibular condyle (Fig. 9). At that time, a third lever phenomenon similar to that observed with the activator was observed, but here the site of the fulcrum is confined to the front teeth. This difference in the site of the fulcrum is believed to be the major cause of the difference in mandibular condyle position between teeth wearing the
activator and those wearing the inclined bite plane.

In the 11 cases we examined in this experiment, the mandibular condyles remained within the temporomandibular joint when the activator and the inclined bite plane were worn. Also, the anterior edges of the mandibular condyle and the mandibular fossa did not touch each other.

In Case No. 11, there was no difference in the mandibular condyle position on both the left and right sides between wearing the activator and wearing the inclined bite plane. Since this patient had a long anteroposterior condyle distance accompanied by deep mandibular fossa, the anterior edges of the mandibular condyle and the mandibular fossa touched each other when the two appliances were worn. This seems to be the most likely explanation for the absence of any difference in the mandibular condyle in this patient.

Changes in the mandibular condyle position in patients wearing the inclined bite plane were assessed based on the condyle position of patients wearing the activator, as viewed on a FH plane. The left mandibular condyle position was shifted in a posterosuperior direction in 7 cases, in a posterior direction in 4 cases, in an anterior direction in 1 case, and remained unchanged in 1 case. Thus, posterior and posterosuperior shifts in the left condyle position were seen in 11 of the 13 cases.

The right mandibular condyle position was shifted in a posterosuperior direction in 8 cases, in a posterior or anterior direction in 1 case each, and remained unchanged in 3 cases. Posterior and posterosuperior shifts in the right condyle position were again high, 9 of the 13 cases. Furthermore, bilateral posterosuperior shifts were observed in 7 cases.

In short, comparison of the mandibular condyle position between subjects wearing the activator and subjects wearing the inclined bite plane revealed that the condyle position was slightly shifted in a posterosuperior direction while wearing the inclined bite plane in many cases. In other words, the inclined bite plane is more likely to cause a clockwise rotation of the mandible than the activator.

The results of this experiment are consistent with the differences noted during therapeutic application of these two orthodontic appliances in a series of studies conducted by our department.

**Summary**

1. Our application of a subtraction technique to standerdized radiography to observe structurally complex temporomandibular joints from the paraoblique view allowed us to visualize changes in bone position.

2. Comparison of the mandibular condyle positions between subjects wearing the activator and subjects wearing the inclined bite plane revealed a tendency for the latter appliance to cause a slight posterosuperior shift. This suggests that the inclined bite plane is more likely to cause a clockwise rotation of the mandible than is the activator.
Acknowledgements

We are deeply grateful to Prof. Takeshi Ohba and Dr. Toru Sakurai at the Department of Dental Radiology of Kyushu Dental College for assisting us in this experiment.

References


10) Ziedes dse Plamtes : quotation from 12).


16) Ueyama, H.: A study of occlusal contact duration and mandibular resting forces with


アクトパトールと前歯挙上板装着時の下顎頭の位置的相違に関する実験的研究

九州歯科学科歯科矯正学講座（主任：佐藤通泰教授）
野田：邦裕・藤田：邦彦・野代：悦生・大木：淳

組織の順応性が高い混合歯列期には、歯牙の萌出や顎の成長発育を効果的に利用できるなどの利点があることから、下顎後退を伴う顎前突には、下顎を前方へ移動する目的で、アクトパトールや咬合平面板がしばしば用いられている。これら両装置は、下顎の位置を変化させ筋の機能を利用して点に関しては同じであるが、装置の構造に相違があるため治療効果にも違いが生じてくることが考えられ、本教室ではこれまで臨床的研究や組織学的研究を行ってきた。

本研究では、アクトパトールと咬合平面板の治療効果の違いを明らかにするために、アクトパトールと前歯挙上板を各々装着した場合の下顎頭の位置的相違をX線学的に検索した。

被験者は、顎関節部に異常のない成人男子11名、女子2名、計13名のいわゆる上顎前突者が、実験装置であるアクトパトールおよび咬合平面板の咬合採得は、中心咬合位より下顎を咬合平面に垂直に5mm開口させ、さらに咬合平面および正中口蓋縫合に平行に下顎を5mm前進させた位置で行った。

被験者は両装置をそれぞれ装着させ、顎関節側斜位規格X線写真を撮影し、その読影にはいわゆる光学的サブトラクション法を応用して下顎頭の位置的相違を観察した。

その結果、1. 顎関節という複雑な骨構造を撮影した顎関節側斜位規格X線写真の読影に、サブトラクション法を応用した結果、顔の位置的変化を見るには有効な方法であったことがわかった。

2. アクトパトール装着時の下顎頭の位置と咬合平面板装着時の下顎頭の位置を比較すると、後者の方がやや前方上に位置する傾向があった。すなわち、アクトパトール装着に対して咬合平面板装着は、下顎が clockwise rotation を起こすことが示唆された。