Influence of Midline Position and Incisal Inclination on Esthetic Evaluation of Complete Denture Wearers

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Clinical significance
The present study was designed to investigate how differences in the midline position and incisal inclination of complete dentures can affect the facial esthetics. An esthetically acceptable range of midline deviation and incisal inclination is suggested.

Abstract
Purpose: This study was conducted to determine the esthetically acceptable range of deviation of the midline position and incisal inclination of complete dentures, based on the results of esthetic evaluation conducted under various midline positions and degrees of incisal inclination in complete denture wearers. In addition, the influence of anatomic landmarks of the face in the evaluation of the midline position was also examined.

Methods: Frontal pictures of each of 10 complete maxillomandibular denture wearers were taken, with the lips opened in the intercuspal position. Each image was processed to yield 21 images with varying midline positions (±2.5 mm at 0.5-mm intervals) and varying degrees of incisal inclination (±2.5 degrees at 0.5-degree intervals) for evaluation. These images were presented to the examiners (20 dentists and 20 dental students), who gave a score of 0 to the images that appeared esthetically unacceptable, 1 to those that appeared neutral, and 2 to those that appeared esthetically acceptable. The scores of each image were totalled to yield the natural appearance score. We checked for significant differences in the natural appearance score between control images and each of the images evaluated in this study.

Results: No significant difference in the natural appearance score was noted when the midline deviation was within ±1 mm (in the evaluation by dentists) or ±1.5 mm (in the evaluation by students) (P>0.05). In addition, no significant difference in the score was noted when the incisal inclination was between −2 and +1.5 degrees (in the evaluation by dentists) or between −2.5 and +2 degrees (in the evaluation by students) (P>0.05).

Conclusion: The results suggest that in complete denture wearers, midline deviation within ±1 mm and incisal inclination within ±1.5 degrees are esthetically acceptable.

Key words: complete denture, esthetic evaluation, facial appearance, midline, teeth arrangement

Introduction
Satisfactory facial appearance is one of the important goals of prosthetic treatment. Dental factors determining the facial appearance include the vertical tooth dimensions and anterior tooth arrangement, and the morphology and color of the teeth. The midline position and inclination of the tooth axis are also important. It has been shown that harmonization of the midline position and tooth axis inclination with horizontal factors (that is, interpupillary, ophriac and lip lines) and vertical factors (that is, facial midline, columella nasi, and philtrum) is essential for obtaining an esthetic facial appearance. For this reason, particular care is needed when designing the arrangement of the maxillary central incisors in complete dentures.

It is important that the long axis of central incisors is not inclined and remains parallel and harmonized to the long axis of the face. From these points of view, studies have been conducted to morphologically analyze the relationship of the features of the surrounding tissues (such as the lip, philtrum, midpalatal suture and incisive papilla) to the position of the maxillary central incisors in individuals with natural dentition, and to incorporate these findings into the arrangement of artificial teeth. Indeed, data obtained from
the analyses of natural dentitions are useful, but it seems more important clinically to determine how patients and the people around them perceive the arrangement of the teeth. The midline is usually not exactly in the middle of the natural dentition, but deviation of the denture midline is often unacceptable to denture wearers.\(^8\) Brisman\(^9\) reported that people usually feel that their teeth look natural only if the denture is symmetrical. However, it has been pointed out that precise evaluation of the facial midline is more difficult for people, in general, than dentists.\(^10\)

Esthetic judgment is subjective in nature and depends greatly on individual esthetic sense; the esthetically acceptable range of objects varies among different individuals. To date, however, few studies have been conducted to precisely characterize such variation of judgment. The purpose of this study was to investigate the range perceived by individuals as esthetically acceptable by evaluation the effects of a range of midline positions and incisal angles in denture wearers. In addition, the influence of the anatomic landmarks of the face and imaginary lines drawn from them on the evaluation of the midline position.

**Materials and methods**

1. **Subjects**

The subjects of the study were 10 edentulous patients (four females and six males with a mean age of 76.4 years) for whom new complete maxillomandibular dentures were prepared at the Tokyo Medical and Dental University Dental Hospital, who consented to participate in this study. The maxillomandibular relation was rated as class I in all the subjects, and there was no significant abnormality of the stomatognathic system in any. For seven of the 10 patients, the previous dentures had also been prepared at the same hospital. The reason for preparing new complete maxillomandibular dentures for the patients was either excessive mobility of the existing dentures or occlusal disharmony; esthetic improvement was not a major motivation for any of these patients.

Tapering and Combination resin teeth (Real Crown, Shofu, Kyoto, Japan) served as the anterior artificial teeth; the arrangement of the anterior artificial teeth was determined by the operator and two prosthodontists. After not less than 3 months of the delivery of the new dentures, the faces of those patients in whom the esthetic and functional outcomes were judged to be favorable, both according to the patients themselves and their dentists, were photographed.

2. **Examiners**

The examiners were 20 dentists working at the outpatient denture clinic of our university hospital, and 20 students of our dental school. The dentists had a mean clinical career length of 3.1 years, and all the students were from the third grade of college. They had complete theoretical knowledge of denture prosthetics, but were yet to put their training to practical use. All the examiners understood the purposes of this study and promised not to disclose any information collected during the study to any third party.

This study was carried out after obtaining the approval of the Ethics Committee of the Tokyo Medical and Dental University School of Dentistry (Application Receipt #95).

3. **Photographs**

Each subject sat on a chair with a solid blue screen as the backdrop, with the Frankfort horizontal plane of the head kept parallel to the floor. The new denture was fitted, and the subject was instructed to smile while biting at the intercuspal position and exposing the teeth as much as possible. Each subject’s face was then photographed from the front, with a digital camera (EOS D60, Canon, Tokyo, Japan) fixed at a certain location.

The images were processed with an image processing program (Photoshop 7.0, Adobe, San Jose, USA) to obtain control images in which the background and the clothes were black (Fig. 1). Using computer software, the upper and lower dentitions were removed from the images, followed by image processing to yield images of varying midline positions and incisal inclination of the dentures for evaluation. With the left serving as the positive side, the midline was moved in parallel lines within the range of ±2.5 mm at intervals of 0.5 mm to yield images with 10 different midline positions (Fig. 2). With the counter-clockwise direction serving as the positive direction, the incisal inclination was changed within the range of ±2.5 degrees at intervals of 0.5 degrees to yield images with 10 different incisal inclinations (Fig. 3). For each subject, the 21 images, including the control image, obtained thus were printed on glossy paper (127×178 mm). The size of the print-
ed images was two-thirds of the actual size.

4. Esthetic evaluation
Prior to the start of the study, each examiner was informed that the dentures of the patients had been changed. No further details (e.g., change of the midline position or incisal inclination) were given to the examiners before the evaluation. The 21 images of each subject were presented at random, one after the other, to the examiner, who then gave a score of 0 to the images that appeared esthetically unacceptable, 1 to those that appeared neutral, and 2 to those that appeared esthetically acceptable. The scores of each image were totalled to yield the natural appearance score.

5. Facial measurement
The relationship of the denture midline to three imaginary lines parallel to the denture midline drawn from the midpoint between the medial angles of the eyes, the tip of the nose and the center of the philtrum was evaluated. The nose was rated as being curved in cases having at least one point at which the line connecting the midpoint between the medial angles of the eyes and the dorsal and tip of the nose was separated by ≥1 mm from the imaginary line parallel to the denture midline drawn from the midpoint between the medial angles of the eyes (Fig. 4).

6. Analysis
All the images were evaluated for significant differences in the natural appearance score as compared to that of the control image. In the analysis of midline deviation, all the images other than the control image were divided into minus and plus zones, and the natural appearance scores for
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Table 1: Mean ± (standard deviation) natural appearance score for midline deviation for each examiner.

<table>
<thead>
<tr>
<th>Examiner</th>
<th>−2.5 mm</th>
<th>−2.0 mm</th>
<th>−1.5 mm</th>
<th>−1.0 mm</th>
<th>−0.5 mm</th>
<th>0 mm</th>
<th>+0.5 mm</th>
<th>+1.0 mm</th>
<th>+1.5 mm</th>
<th>+2.0 mm</th>
<th>+2.5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentists</td>
<td>2.3±4.4*</td>
<td>6.8±8.3*</td>
<td>9.9±9.8*</td>
<td>19.4±11.9</td>
<td>26.0±7.2</td>
<td>28.3±4.5</td>
<td>27.2±4.1</td>
<td>20.6±6.0</td>
<td>13.7±10.0*</td>
<td>9.0±9.0*</td>
<td>4.3±7.0*</td>
</tr>
<tr>
<td>Students</td>
<td>9.9±7.2*</td>
<td>14.3±6.7*</td>
<td>20.9±9.3</td>
<td>25.4±4.0</td>
<td>28.9±4.6</td>
<td>30.0±2.1</td>
<td>29.9±4.5</td>
<td>28.3±4.7</td>
<td>19.3±10.5</td>
<td>13.9±8.4*</td>
<td>12.5±6.7*</td>
</tr>
</tbody>
</table>

*P<0.05, the values inside the frame are not significant

Table 2: Mean ± (standard deviation) natural appearance score for incisal inclination for each examiner.

<table>
<thead>
<tr>
<th>Examiner</th>
<th>−2.5°</th>
<th>−2.0°</th>
<th>−1.5°</th>
<th>−1.0°</th>
<th>−0.5°</th>
<th>0°</th>
<th>+0.5°</th>
<th>+1.0°</th>
<th>+1.5°</th>
<th>+2.0°</th>
<th>+2.5°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentists</td>
<td>18.0±5.5*</td>
<td>23.9±8.1</td>
<td>27.2±6.5</td>
<td>29.9±6.9</td>
<td>32.2±3.5</td>
<td>32.5±4.2</td>
<td>31.7±3.6</td>
<td>26.8±5.1</td>
<td>23.6±4.9</td>
<td>18.6±4.3*</td>
<td>15.8±5.4*</td>
</tr>
<tr>
<td>Students</td>
<td>25.4±7.3</td>
<td>26.4±6.6</td>
<td>26.3±6.0</td>
<td>25.9±6.1</td>
<td>28.4±7.0</td>
<td>29.6±1.9</td>
<td>31.0±4.8</td>
<td>26.3±5.7</td>
<td>21.9±6.7</td>
<td>22.3±6.1</td>
<td>22.7±3.6*</td>
</tr>
</tbody>
</table>

*P<0.05, the values inside the frame are not significant

Table 3: Mean ± (standard deviation) absolute difference between the denture midline and each imaginary line.

<table>
<thead>
<tr>
<th>Difference (mm)</th>
<th>midpoint of medial angles of eye</th>
<th>tip of the nose</th>
<th>center of the philtrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1±0.2</td>
<td>0.5±0.4</td>
<td>0.9±0.8</td>
<td></td>
</tr>
</tbody>
</table>

Results

1. Midline deviation

In both the evaluation by dentists and that by the dental students, the natural appearance score was the highest for the control images (0 mm). In the evaluation conducted by dentists, the score did not change significantly when the midline position deviated within ±1 mm. However, for a midline deviation was ≥1.5 mm or more, the score decreased significantly (Table 1). In the evaluation conducted by the dental students, while there was no significant change in the score as compared to that of the control image when the midline deviation was within ±1.5 mm, the score decreased significantly for a midline deviation of over ±2 mm.

2. Incisal inclination

The natural appearance score was the highest for an inclination of 0 degrees (control image) in the evaluation conducted by dentists, while it was the highest for an inclination of +0.5 degrees in the evaluation conducted by the dental students. In the evaluation conducted by the dentists, the score did not change significantly for inclinations between −2 and +1.5 degrees, whereas it became significantly lower for inclinations of +2 and +2.5 degrees (Table 2). In the evaluation conducted by the dental students, while the score showed no significant change for inclinations between −2.5 and +2 degrees, it became significantly lower for inclination angles of +2.5 degrees or more.

3. Relationship to the imaginary facial lines

The absolute separation between the denture midline and each of the imaginary lines on the face was as follows: line drawn from the midpoint between the medial angles of the eyes, 0.1 mm on average and 0.5 mm at maximum; line drawn from the tip of the nose, 0.5 mm on average and 1.5 mm at maximum; line drawn from the center of the philtrum, 0.9 mm on average and 2.5 mm at maximum (Table 3).

In the evaluation conducted by the dentists, the tip of the nose was found to be deviated by ≥0.5 mm from the denture midline. The natural appearance score was larger on the deviated side than on the opposite side in all seven subjects. Of the eight subjects in whom the philtrum was deviated by ≥0.5 mm from the denture midline, six had a significantly higher natural appearance score on the biased side. In the evaluation conducted by the dental students, there was no significant difference in the natural appearance score when the deviation was ≤0.5 mm. In the
four subjects showing a deviation of the denture midline of ≥1.5 mm from the tip of the nose or the philtrum, the natural appearance score was higher on the deviated side.

The nose was curved in three of the 10 subjects. For these three subjects, the variance in the natural appearance score depending on the incisal inclination was marked, even according to the evaluation conducted by the dentists.

### Results

1. **Examiners**

In esthetic evaluation, which involves subjective judgments, the perception by a third party is important. However, adopting subjects from the general population as examiners poses a problem from the viewpoint of protection of subject privacy. For this reason, the examiners in the present study were confined to members of our dental school who were in a position to easily understand the purpose of the study.

Frush et al\(^ {11}\) reported that evaluations differed significantly between dentists and third parties not consisting of dentists, and that the evaluations by the dental students fell into an intermediate group between these two groups of examiners. In the present study, the zone without a significant difference in the natural appearance score was wider in the evaluation conducted by the students than in that conducted by the dentists. This zone is expected to be even wider when the evaluation is conducted by third parties not concerned with dentistry. We consider the arrangement of the anterior teeth not being perceived as unnatural by the dentists in the present study to probably mean that it is within the esthetically acceptable range for the general public.

2. **Denture designing conditions**

In the present study, it was relatively easy to determine the denture midline for the following reasons: (1) the previously used dentures in many of the patients had been prepared at our school of dentistry, (2) the maxillomandibular relation in all the subjects was rated as class I, and (3) there was no significant abnormality of maxillomandibular function. The arrangement of the new dentures was determined by multiple prosthodontists. Each new denture was followed up for at least 3 months after its delivery, and no problems were found during the follow-up period. Furthermore, the natural appearance score evaluated by dentists in relation to the midline position and incisal inclination was highest for the control image. These results indicate that the arrangement of the artificial teeth in the present study was esthetically appropriate.

3. **Effects of midline deviation on the esthetic evaluation**

Lombardi\(^ {12,13}\) reported that if the midline is improperly located, the balance of the elements constituting the right and left half of the face is lost and, for this reason, it is essential to keep the mesial surfaces of the maxillary central incisors coincident with the facial midline for the purpose of achieving a more esthetically desirable appearance.

However, Chiche et al\(^ {14}\) state that, logically, the maxillary central incisal midline should coincide with the midline of the face. However, observations have revealed that a lack of coincidence between the location and direction of the two midlines is not an esthetic liability, unless the dental midline is conspicuously oblique or distinctly deviated to one side. Golub\(^ {15}\) cautions against achieving a perfectly centered dental midline with the face because it creates too much uniformity. Conversely, a vertical and centered dental midline may also be used to avert attention from asymmetrical facial features. Minor asymmetries are allowed in natural dentition, and bilateral asymmetry between the maxillary central incisors have been reported to not exceed 0.3–0.4 mm in terms of the mesiodistal width.\(^ {16,17}\)

Cardash et al\(^ {18}\) carried out a study in which dentists and the general public checked for deviation of the maxillary anterior tooth midline and a vertical line drawn from the midpoint between the medial angles of the eyes using facial photographs of dentate patients. Although an explanation regarding the midline had been given to the examiners in advance, the midline deviation detection rate by both the dentists and the general public was markedly low when the deviation was ≤2 mm. In the present study, there was no significant difference in the natural appearance score when the midline deviation was within ±1 mm (in the evaluation by dentists) or within ±1.5 mm (in the evaluation by dental students). This result suggests that a midline deviation within ±1.5 mm is esthetically acceptable to the general population.
4. Effects of incisal inclination on the esthetic evaluation
With fixed prostheses, it is rare that horizontal deviation causes any significant problems. Inclusion of the dentition midline may more frequently cause major problems with a fixed prosthesis. In the present study, however, the variance in the natural appearance score as reported by the dentists, was greater than we had anticipated, and we found that the assessment of the tooth axis inclination tended to be unsatisfactory, even by dentists. In regard to the mesiodistal inclination of the tooth axis, it has been reported that the inclination detection rate tends to decrease in the order of central incisors > lateral incisors > canines. In our patients, the right and left central incisors had been arranged symmetrically, but the locations and inclinations of the lateral incisors and canines differed slightly between the right and left sides in most cases. These differences between the right and left sides probably made it difficult for the examiner to detect the overall inclination of the entire dentition. Tooth axis is easily observed in cases where the lip line is high and the artificial teeth are exposed to the cervical level. However, in elderly patients with reduced lip tension, the entire coronal portion is seldom exposed, even during an intense smile, possibly leading to the difficulty in assessment. In the present study, the natural appearance score, as evaluated by dental students, did not differ significantly in the inclination range between –2.5 and +2 degrees. We, however, believe that if an evaluation is conducted more strictly and the values on the positive side are also adopted, an incisal inclination within ±2 degrees would be esthetically acceptable.

5. Relationship between the facial imaginary lines and the natural appearance score
It is considered that the most important requirement for ensuring that the external face is attractive is making the midline of the dentition perpendicular to the interpupillary line. This relationship contributes to improving the facial appearance while smiling. Bolender et al reported that the anterior teeth midline can be determined on an imaginary vertical line drawn from the center of the interpupillary line. Therefore, the interpupillary line is regarded as an important landmark in the evaluation of dentitions. In the present study, however, the midpoint between the medial angles of the eyes was used instead of the center of the interpupillary line because the pupilla was not identifiable on the photographs in some cases. The denture midline was closest to the imaginary line drawn from the midpoint between the medial angles of the eyes. This result indicates that the midpoint between the medial angles of the eyes can also serve as a useful facial landmark for determining the denture midline.

The tip of the nose and the center of the philtrum are also considered as important landmarks for determining the denture midline. Miller et al contend that the center of the philtrum is the most reliable guide to determine the facial midline. They reported that the midline of the maxillary teeth in 75% of the 500 subjects examined in their series coincided with the median line of the philtrum. Tjan et al suggested that, because patients tend to relate the midline to the upper lip rather than to other facial landmarks farther from the mouth, an imaginary line dividing the midline lobe of the philtrum can be used to establish the midline. In the present study, many subjects showed slight deviation of the imaginary line (with the deviation being greater for the tip of the nose than for the philtrum), as compared to that in the control denture. However, since the total natural appearance score on the biased side was larger in the presence of deviation of the philtrum or the tip of the nose, it seems likely that the philtrum and the tip of the nose may contribute significantly to evaluation of the midline. We may therefore say that the denture midline can be designed in a clinically satisfactory manner if the imaginary line from the midpoint between the medial angles of the eyes is used as a landmark, and the midline is arranged in the zone containing the imaginary line drawn vertically from the tip of the nose and the philtrum.

None of the 10 subjects in our study showed any marked differences in the pupillary level between the right and left sides. However, in three subjects, the dorsum of the nose was deviated either to the right or to the left side. In these cases, determination of the incisal inclination seemed to be difficult, even for the dentists. An additional study involving a larger number of subjects would be desirable for esthetic evaluation of individuals whose faces are less symmetric.
Conclusion
1. The variance in the results of esthetic evaluation was greater among dental students than among dentists.
2. According to the evaluation conducted by the dentists, midline deviation within ±1.0 mm is acceptable from the viewpoint of natural appearance.
3. According to the evaluation conducted by the dentists, incisal inclination within ±1.5 degrees is acceptable from the viewpoint of natural appearance.
4. The imaginary line parallel to the denture midline drawn from the midpoint between the medial angles of the eyes seems be a useful indicator for determining the denture midline.

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References