# **Original Article**

# Effect of occlusal plane on smile attractiveness

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# ABSTRACT

**Objective:** To determine the influence of the occlusal plane angle on smile attractiveness as perceived by a group of adult orthodontic patients and dentists.

**Materials and Methods:** The first stage utilized a laboratory approach to record changes in vertical tooth position at different occlusal plane angles using a maxillary model mounted on an articulator. In the second stage, photographic manipulation was undertaken, using data from stage 1, to produce a computerized prediction of the appearance of the smile at differing occlusal plane angles (0, 5, 10, 15, and 20 degrees). Finally, the five developed photographs were assessed by participants.

**Results:** Alterations in the occlusal plane angle did affect relative smile attractiveness for both patients (n = 66) and dentists (n = 66). For patients, the 10 degree smile was rated better than the 0 and 20 degree smiles (P < .01); for dentists, the 15 degree smile was rated better than the 0 and 20 degree smiles (P < .01). The 5, 10, and 15 degree smiles were indistinguishable for patients, and the 10 and 15 degree smiles were indistinguishable for dentists.

**Conclusion:** Changing the occlusal plane angle does affect relative smile attractiveness. However, patients were more tolerant of these changes than dentists. This suggests that large changes in the occlusal plane angle would affect relative smile attractiveness, and small changes are unlikely to affect smile attractiveness. (*Angle Orthod.* 2012;82:218–223.)

**KEY WORDS:** Occlusal plane; Smile; Esthetics

## INTRODUCTION

Personality development and social interaction are significantly affected by facial esthetics in both males and females. In social interaction, attention is usually directed toward the mouth and eyes of the speaker's face, suggesting that the smile is an important feature of facial appearance.<sup>1,2</sup> It is important that orthodon-tists are familiar with examining the various components that constitute a smile, and that these are

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Accepted: July 2011. Submitted: May 2011.

Published Online: September 20, 2011

considered during diagnosis, treatment planning, and delivery of treatment mechanics. One important component is the smile arc. The smile arc has been defined as the relationship of the curvature of the maxillary incisal and canine edges to the curvature of the lower lip during the posed smile.<sup>3</sup> Factors that contribute to an ideal smile arc relationship may include the lengths of the maxillary teeth, the inclination of the maxillary incisors, arch width, the curvature of the lower lip, and the occlusal plane angle.<sup>4</sup> The literature shows that orthodontic treatment can affect the angle of the occlusal plane,5 which in turn may affect the smile arc.6 Surgical treatment in particular can have a large influence on the occlusal plane angle.7 Research within the literature is lacking regarding the influence of the occlusal plane angle on smile attractiveness.<sup>8</sup> The purpose of this study was to investigate the effects of changes in the occlusal plane angle on perceived smile attractiveness.

Aims of this investigation included the following:

- Determine whether alteration of the occlusal plane angle can affect perceived attractiveness of the smile.
- Determine the most and least attractive smiles and their corresponding occlusal plane angles as assessed by patients and dentists.

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Figure 1. The maxillary model was held by the model-repositioning instrument, which was mounted on the articulator.

• Determine whether dentists and patients agree on the effect of the occlusal plane angle on smile attractiveness.

## MATERIALS AND METHODS

This study was carried out in three stages. The first stage utilized a laboratory approach to record changes in vertical tooth position at different occlusal plane angles using a mounted maxillary model. In the second stage, photographic manipulation was undertaken, using data from the first stage, to produce a computerized prediction of the appearance of the smile at differing occlusal plane angles. Finally for the third stage, the five developed photographs were assessed and rated by a group of dentists and adult orthodontic patients.

# Stage 1: Changes in Vertical Tooth Position at Different Occlusal Plane Angles

An alginate impression of the maxillary dentition of an individual considered to have an esthetic smile, with well-aligned teeth and a Class I incisor relationship, was obtained and cast to create a study model (Crystacal R special plaster, British Gypsum Limited, Loughborough, Leicestershire, UK). The model was mounted onto a model-repositioning instrument and was held in position through plastic sleeves (anteriorly between the central incisors at the dental papilla level and two lateral holes at the middle of the first premolar buccal surfaces). The repositioning instrument was then mounted on an articulator (Der SAM 3 articulator, Prazisionstechnik GmbH, Munich, Germany) (Figure 1). The model was positioned so that the occlusal plane was parallel to the true horizontal. This was achieved using an Ericson model block and platform (Model 190-044, Great Lakes Orthodontics Ltd, Tonawanda, NY) with a mounted digital caliper in position. The occlusal plane was adjusted parallel to the base of the platform. The



Figure 2. Caliper was reset to 0 at the central incisor level.

digital caliper was then reset to 0 at the central incisor edge level (Figure 2). This level was used as a reference point. Any changes in the vertical position of the teeth would therefore be relative to the central incisor position. The first position of the occlusal plane angle was at 0 degrees, where the occlusal plane was parallel to the true horizontal. The vertical position of the lateral incisor, canine, and premolar was measured relative to the central incisor position. The occlusal plane was then changed by 5 degree intervals between 0 and 20 degrees (relative to true horizontal). The measurements were repeated and the average of the two readings taken.

#### **Photograph Construction**

A photograph of the smile of the same individual from whom we had taken the alginate impression was manipulated using Adobe Photoshop Elements software (version 6.0, Adobe Systems Incorporated, San Jose, Calif). The image was obtained by capturing a photograph of the lower one-third of the face (using Canon EOS 40D digital camera, 10 megapixels, Canon Japan, Tokyo, Japan). Next, the image was uploaded into Adobe Photoshop software. The image scale was adjusted to counter any magnification by reproducing the same lateral incisor length from the model and the image. The more esthetic half of the photograph was selected (left side). Photoshop was used to produce changes in the vertical position of the teeth of the smile photograph corresponding with changes recorded at different occlusal plane angles during stage 1 (Figure 3). The photograph was duplicated as a mirror image of the left side to produce a perfectly symmetric image. Five life-size photographs representing five different occlusal planes were produced (Figure 4) and color coded to enable photograph recognition and later analysis.



Figure 3. Photograph construction.

#### **Photograph Assessment**

The Joint Research and Ethics Committee granted ethical approval for the study. Sixty-six dentists and orthodontic patients (aged 25 years or older) were recruited from the Dental Hospital. After signed consent was obtained, the researcher shuffled the five photographs and presented each smile image individually. Participants were allowed to view each photograph for as long as they found necessary. Participants rated the attractiveness of each smile image in a quiet, nonclinical environment with good lighting conditions using a seven-point Likert scale: Awful, Bad, Fairly Bad, Okay, Good, Great, or Perfect. To assess participant repeatability, a second set of the same photos (white color coded) was shuffled, and a single photograph was picked at random and assessed by the participant.

#### **Statistical Methods**

Sample size. A sample size calculation estimated that to detect a difference of 30% of smile ratings, 66 patients were required in each group (patients and dentists) for a significance level of .01 and a power of 85%.



Figure 4. Five constructed smiles with altered occlusal plane angles.



**Figure 5.** Smile ratings as perceived by dentists and patients after attractive (Good, Great, and Perfect) and unattractive (Fairly Bad, Bad, and Awful) ratings were combined.

#### **Analytical Statistics**

The chi-square test was used to analyze the data. To satisfy the requirement of the test that at least 80% of expected frequencies in the contingency table were greater than or equal to five, the seven smile ratings were combined into three (Good, Great, and Perfect ratings were combined and described as *attractive*. Likewise, Awful, Bad, and Fairly Bad ratings were combined and were described as *unattractive*. The Okay rating was not combined). The weighted kappa test was undertaken to check patients' and dentists' repeatability.

## RESULTS

About 60% of patients and 40% of dentists were female. Figure 5 shows the global smile ratings for both groups, and Figure 6 shows the smile rankings. These figures demonstrate the following:

- More patients rated the 10 degree smile than any other smile as the most attractive.
- Patients ranked smiles, from best to worst, as follows: 10 degrees, 5 degrees, 15 degrees, 20 degrees, and 0 degrees (Figure 6).
- More dentists rated the 15 degree smile than any other smile as the most attractive.
- Dentists ranked the smiles from best to worst as follows: 15 degrees, 10 degrees, 5 degrees, 20 degrees, and 0 degrees (Figure 6).
- Dentists and patients rated the 0 degree smile as the most unattractive, and more dentists than patients rated the 0 degree smile as unattractive.

Table 1 shows that, except for 5 degree and 15 degree smiles, a significantly greater percentage of patients rated the 10 degree smile as the most



Figure 6. The attractive smile ranking.

attractive compared with each of the other smiles. On the other hand, a significantly greater percentage of dentists rated the 15 degree smile as the most attractive compared with each of the other smiles, except the 10 degree smile. Moreover, Table 1 shows that a significantly greater proportion of both patients and dentists ranked the 0 degree smile as the most unattractive smile when compared with each of the other smiles. A significant difference (P < .01) was noted only between patients and dentists in their rating of the 0 degree occlusal plane angle, with more dentists finding the smile unattractive.

The weighted kappa test was undertaken to check patients' and dentists' repeatability. All 132 participants were asked to reassess one of the smiles selected at random. The frequency of the presented photos is shown in Table 2. Patients showed good agreement (0.830 kappa score), and dentists showed substantial agreement (0.749 kappa score).<sup>9</sup>

#### DISCUSSION

The occlusal plane angle was measured to the true horizontal in this study rather than to the sella-nasion line (SN). The true horizontal was the only reference that could be used in the first stage of this study. The occlusal plane range that was investigated in this study was 0–20 degrees to the true horizontal. Lundström and Lundström<sup>10</sup> showed that the SN on average was 4 degrees to the true horizontal. Studies indicate that the mean angle between the SN line and the occlusal

 Table 2.
 Frequency of Photos Presented Randomly to Participants to Assess Their Reliability

	Dentist	Patients	Total
0 degrees	16	12	28
5 degrees	11	10	21
10 degrees	12	16	28
15 degrees	18	12	30
20 degrees	9	16	25
Total	66	66	132

plane angle is 14  $\pm$  2.5 degrees.<sup>11</sup> This equates to a norm of 10  $\pm$  2.5 degrees for the occlusal plane angle to the true horizontal. The range of the occlusal plane angle covered in this study was therefore 5–15 degrees, to ensure that 2 standard deviations were included on either side of the mean. For completeness, 0 and 20 degrees were added to cover 100% of the occlusal plane range, although this would occur in less than 5% of the population.

Life size digitally altered smile photographs were used in this study. Digitally altered photographs allow the investigator to develop an extremely realistic image. Moreover, such altered smile photographs allow the investigator to change one or multiple features of the smile. This method was used because it is widely adopted in the literature.<sup>12–16</sup> The modified photographs used in this study were of an attractive white female smile; this limits our findings to this group. Ideally, two photographs should have been assessed—a male smile and a female smile; even then, standardization of skin color and lip shapes would be difficult to achieve and would affect participant judgment.<sup>17</sup>

The occlusal plane angle was altered by rotating the occlusal plane around the maxillary incisal edges. This helped to keep the incisor show consistent between smiling photos. It is believed that this was important because incisor show is a major factor in determining smile esthetics. Tooth and gingival positions changed in three dimensions (horizontal, anteroposterior, and vertical) as the occlusal plane angle was altered on the model. It was not possible to mimic such changes three-dimensionally on the photographs.

Patients' concerns about smile esthetics are affected not just by their perception, but also by the

Table 1. Chi-Square Test Used to Determine the Most Attractive and Unattractive Smiles<sup>a</sup>

The most attractive smile	Patients	10° vs 0° .001	10° vs 5° .203	10° vs 15° .203	10° vs 20° .005
	Dentists	15 <sup>°</sup> vs 0° <u>.001</u>	15° vs 5° <u>.002</u>	15° vs 10° .203	15° vs 20° .001
The most unattractive smile		$0^\circ$ vs $5^\circ$	$0^\circ$ vs $10^\circ$	$0^\circ$ vs $15^\circ$	$0^\circ$ vs $20^\circ$
	Patients	.001	.001	.001	.002
	Dentists	.001	<u>.001</u>	.001	.001

<sup>a</sup> Underlined figures represent significant values (P < .01).

reactions of other people such as orthodontists and parents. The literature shows that dentists, particularly orthodontists, are more sensitive than lay people to a number of dental conditions.<sup>18–20</sup> For this reason, both dentist and patient groups were used in this study.

Patients and dentists distinguished between photographs; the differences in photograph ratings of the five smiles were significant. A greater percentage of patients rated the 10 degree smile as the most attractive compared with the 0 and 20 degree smiles. This may be attributed to the fact that the 10 degree smile represents a more consonant smile arc, while the 0 degree and 20 degree smiles represent a nonconsonant smile arc. A consonant smile arc was rated better than a flat smiles and a reverse smile arc within the literature.<sup>5,12,21,22</sup> However, the 10 degree smile (consonant smile) was not significantly different from the 5 degree smile (nonconsonant, slightly reversed smile arc) and the 15 degree smile (nonconsonant, slightly increased smile arc). This means that patients are willing to accept an occlusal plane range from 5-15 degree smiles within the smiling photograph used.

A greater percentage of dentists rated the 15 degree smile as the most attractive compared with the 0, 5, and 20 degree smiles. This was surprising, in that the 15 degree smile may not represent the most consonant smile arc. However, the 15 degree smile has a slightly increased smile arc and minimal gingival display, and the literature shows that dentists are less tolerant to gingival display.<sup>19</sup> So it could be that dentists were looking at the gingival display as well as the smile arc, and they could have rated the best mixture of these two features. Parekh et al.<sup>12</sup> mentioned that ideal and excessive smile arcs were acceptable 84%-95% of the time. This embraces the importance of gingival display and smile arc and shows the influence of occlusal plane changes on them.

The inability of participants to distinguish between small differences in the occlusal plane could be attributed to three reasons. The first reason is that detection of a 30% difference in ratings may have been too tight. The second reason is the number of smiles presented. Parekh et al.<sup>12</sup> presented three smile arcs rather than five (this study), which made it easier for participants to distinguish between. Finally, it is possible that patients could not really distinguish between small changes in the occlusal plane.

For patients and dentists, the 0 degree smile was rated significantly as the most unattractive. This may be because this has the least harmonious relationship between maxillary incisal edge curvature and the curvature of the lower lip. More dentists than patients thought that the 0 degree smile was less attractive, which supports the general perception that dentists are less tolerant than patients of deviations in smile norms.<sup>18–20</sup> However, this difference may be attributed to the fact that dentists were assessing other aspects of the smile such as gingival show.

Patients showed good agreement in their smile ratings, and dentists showed substantial agreement. This is difficult to explain because dentists should score a higher repeatability score, as they are thought to be less subjective and more objective in their assessment. However, their concentration on specific features might have deceived them because there are too many features to look for. This might jeopardize their overall assessment of the smile.

#### **Clinical Relevance**

Conventional orthodontic mechanics can induce small changes in the occlusal plane angle.<sup>5,23,24</sup> However, this study suggests that small changes in the occlusal plane angle do not affect smile attractiveness. Patients showed large tolerance to occlusal plane changes (accepting 5, 10, and 15 degree smiles); this may reflect their tolerance to changes in the smile arc. It is therefore unlikely that small changes in the occlusal plane angle will have a significant effect on the perception of smile esthetics.

On the other hand, larger change in the occlusal plane angle may be encountered during orthognathic surgical procedures, particularly if there is differential vertical maxillary movement. It has been shown that changes in the occlusal plane angle for patients who have been treated with orthognathic approaches vary from 3–12 degrees, depending on the proposed vertical maxillary movement, where such movement will cause a change in mandibular plane angle, chin position, and lower incisor position and angulation.<sup>7</sup> It is therefore important to consider such changes to the smile during treatment planning, and patients should be informed of such changes when informed consent is obtained.

# CONCLUSIONS

- According to dentists and patients, changing the occlusal plane angle does affect smile attractiveness.
- Patients tended to rate the 10 degree smile better than 0 and 20 degree smiles, and dentists tended to rate the 15 degree smile better than 0 and 20 degree smiles. This suggests that patients and dentists did not tolerate extreme deviations in the occlusal plane angle.
- Patients showed higher tolerance to occlusal plane changes (accepting 5, 10, and 15 degree smiles) than did dentists (accepting 10 and 15 degree smiles).
- This study suggested that large changes in the occlusal plane angle would affect relative smile

attractiveness, but small changes are unlikely to affect smile attractiveness.

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