

# Influence of anterior buccolingual crown inclination on the esthetic perception of the frontal smile by dentists, orthodontists, and laypersons: the importance of connector parallelism

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## ABSTRACT

**Objectives:** To assess the perception of smile esthetics, variations in buccolingual crown inclination of the upper anterior teeth were introduced, disrupting the parallelism of these connectors from a frontal view.

**Materials and Methods:** In this descriptive cross-sectional study, a close-up smile image was modified using Adobe Photoshop to adjust the angulation of connectors, affecting either the six upper anterior teeth (C/C group) or the four upper anterior teeth (LI/LI group). Orthodontists (ORs), general dentists (GDs), and laypersons (LPs) then evaluated the attractiveness of the modified smiles.

**Results:** A total of 79 LPs, 65 ORs, and 89 GDs participated in the evaluation. LPs gave the highest scores, followed by GDs and ORs, in both the C/C and LI/LI groups. The  $-6^\circ$  deviated image was the least favored in the C/C group, while the  $-9^\circ$  image received the lowest scores in the LI/LI group.

**Conclusions:** In this study, we highlight the importance of proper buccolingual crown inclination and parallelism of connectors during treatment. The OR group showed the most critical assessment of smile esthetics related to buccolingual crown inclination variations. Lower scores were noted for greater deformations and negative inclinations in both the LI/LI and C/C groups. (*Angle Orthod.* 0000;00:000–000.)

**KEY WORDS:** Orthodontists; Esthetic evaluation; Connectors; Esthetic perception; Smile; General dentists

## INTRODUCTION

Facial appearance is significantly influenced by an attractive smile. Authors of studies have indicated that perceptions of smile esthetics differed among orthodontists (ORs), general dentists (GDs), and laypersons (LPs), with LPs' opinions reflecting societal values. It is important to consider the views of both LPs and health care professionals when planning orthodontic treatment.<sup>1,2</sup>

Extensive studies have been conducted on various aspects of smile attractiveness.<sup>1,3–9</sup> Clinically, it was often noted that changes in a smile were more noticeable near the dental midline. The maxillary canines, along with the lateral and central incisors, are the primary teeth visible in a smile.<sup>10</sup>

The concept of regressive progressiveness focuses on the importance of parallel vertical lines, similar to connectors, in determining the esthetics of a smile.<sup>11,12</sup> Ideally, these connectors should be parallel, including those of the anterior front, which leads to a certain buccolingual inclination.<sup>11–13</sup> Variations in this inclination can impact smile esthetics, but it is unclear how ORs, GDs, or LPs perceive these variations. In some cases, anatomical contours may prevent achieving parallel connectors, necessitating alternative treatment.

Authors of most studies have analyzed the smile from a frontal perspective, but research on the esthetic impact of anterior buccolingual inclination from this viewpoint is limited.<sup>14–18</sup> This may be due to the challenge of referencing buccolingual crown inclination using a frontal image of the smile.<sup>2</sup>

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**Figure 1.** A photograph was taken of a female volunteer's smile under standard conditions.

The aim of this study was to evaluate how the buccolin-gual inclination of maxillary incisors and canines, viewed from the front, affects smile esthetics as perceived by ORs, GDs, and LPs. It was hypothesized that changes in connector parallelism could impact the harmony of the maxillary anterior teeth and influence the perception of smile esthetics.

## MATERIALS AND METHODS

This observational, cross-sectional, descriptive study was approved by the Ethics Committee at the University of Valencia, Spain (Approval 2724006) and followed the Declaration of Helsinki and STROBE guidelines for research involving human subjects.<sup>19</sup>

Three groups of examiners were defined for the study: ORs, GDs, and LPs with no dental background. OR participants were selected from Dr. Vela's Orthodontic Program and University of Valencia professors, GD participants were former postgraduate residents from Mississippi University Institution in Madrid and University of Valencia, and LP participants were relatives of patients from the University of Valencia and Dr. Vela's dental office. Questionnaires, completed anonymously between March and May 2023, were filled out by consenting participants.

Inclusion criteria were OR with at least 3 years of postgraduate orthodontics and 1 year of experience; GD with a minimum of 1 year of experience; and LP who had completed undergraduate studies, had no orthodontic treatment or dental training, and were aged 26 to 70. Both men and women were included in all groups.

A female volunteer's smile was photographed under standard conditions, featuring characteristics deemed highly attractive according to ideal smile principles from the literature<sup>20–22</sup> (Figure 1). The photograph was taken with the subject in a natural head position and the interpupillary line parallel to the horizon. It was digitally edited with Adobe Photoshop 6.0 (Adobe Systems, San Jose, Calif), removing the nose and chin to reduce confounding variables. All edits were made by the same operator.<sup>23</sup>

The photograph was edited to modify the angulation of connectors between central incisors and lateral incisors (CI-LI), lateral incisors and canines (LI-C), and canines and premolars (C-PM). Two series of images were created: one altering only the incisors in 3° increments, and another affecting both incisors and canines in 2° increments. After these changes, 13 photographs were available for evaluation. The alterations were (Figure 2):

- Lateral incisor to lateral incisor (LI/LI) group:  $-9^\circ$ ,  $-6^\circ$ ,  $-3^\circ$ ,  $0^\circ$ ,  $+3^\circ$ ,  $+6^\circ$ ,  $+9^\circ$
- Canine to canine (C/C) group:  $-6^\circ$ ,  $-4^\circ$ ,  $-2^\circ$ ,  $0^\circ$ ,  $+2^\circ$ ,  $+4^\circ$ ,  $+6^\circ$

Angulation changes were measured from the middle of the papilla in its most gingival position to the embrasure in the control photo. To maintain vertical alignment and prevent changes in incisor exposure, horizontal tangents were drawn to the incisal edges of both incisors (Figure 3).

The 13 images were randomized and presented using PowerPoint (version 12.0; Microsoft, Redmond, Wash) for 10 seconds each, with a 5-second dark interval between images to minimize distractions.<sup>24</sup> Each photo was shown twice in random order to assess intraexaminer reproducibility, and the examiners were unaware of the gender of the model. Each image was coded for later analysis.

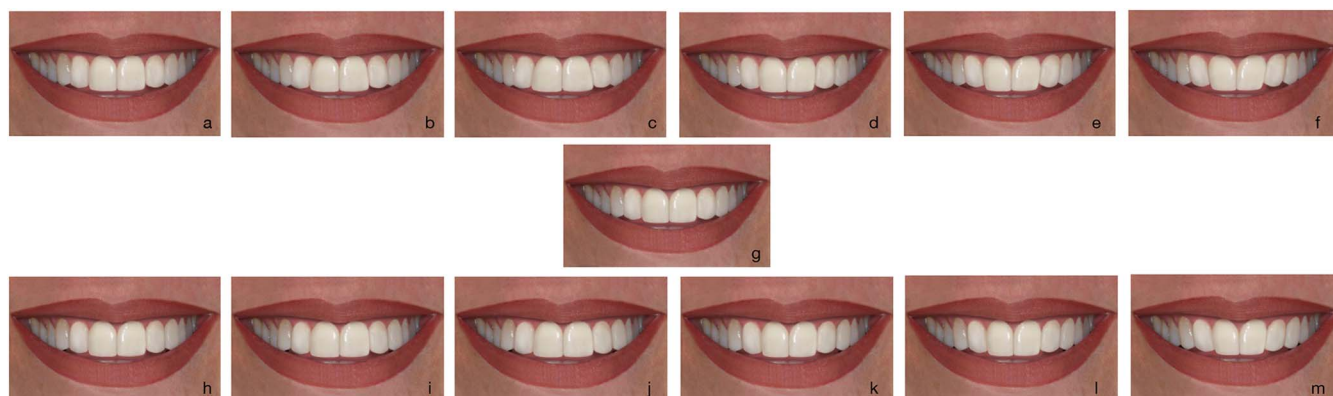
A visual analog scale from 0 (*least attractive*) to 10 (*most attractive*) was used to evaluate smile attractiveness.<sup>9,25,26</sup> Examiners marked their score without conferring or discussing their ratings with others.

A minimum of 200 participants was needed to achieve 80% power for detecting a small effect size ( $f = 0.1$ ) in the interaction between professional group and degree of deformation, with a 95% confidence level and a correlation between repeated measures of  $r = 0.2$ .

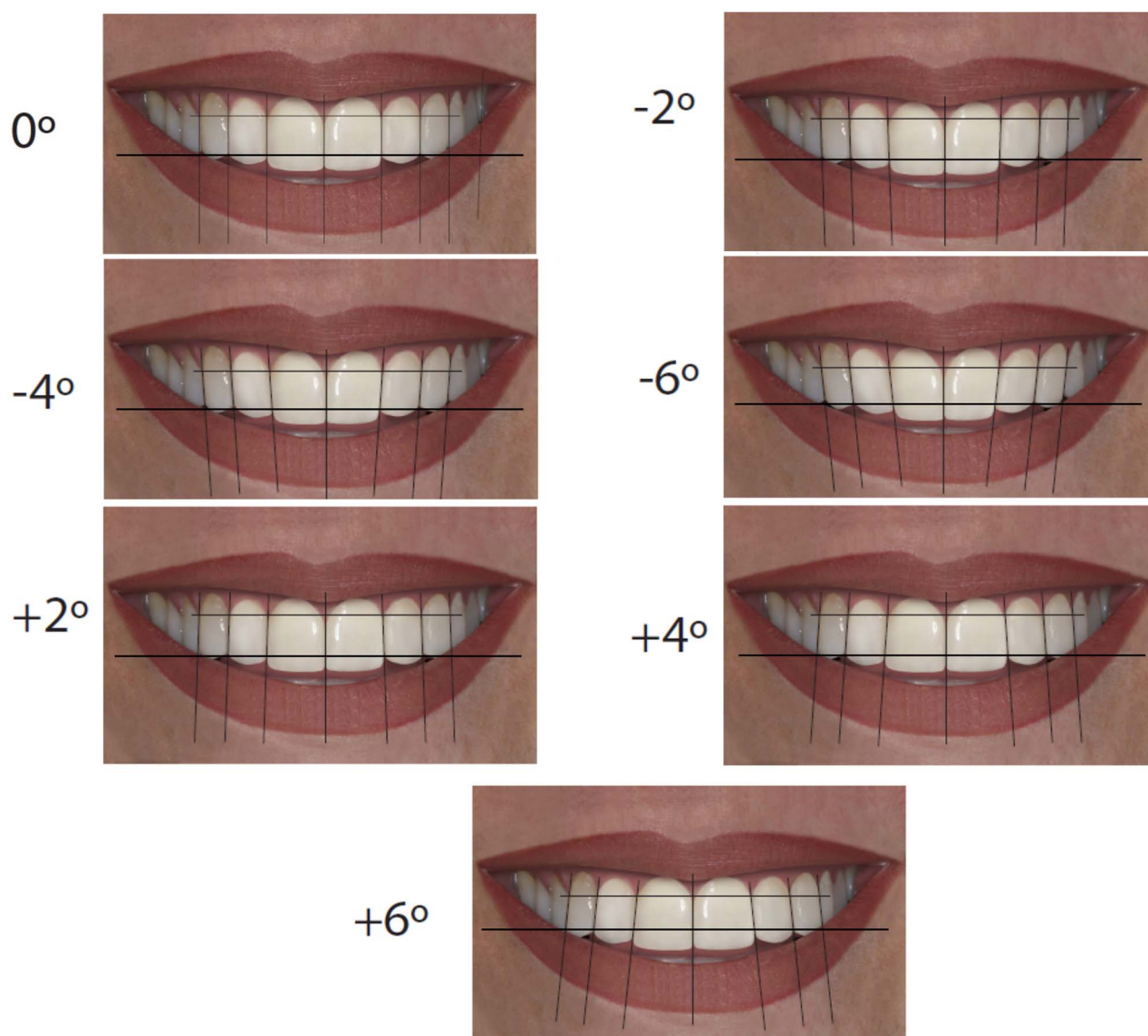
Descriptive statistics included mean and standard deviation. Parametric analysis was used due to the large sample size. Inferential analysis examined significant differences in esthetic perception among groups as well as by sex and age, using a univariate repeated measures analysis of variance. The professional group was the between-subjects factor, and the degree of image alteration was the within-subjects factor, with separate models for sex and age. Intraobserver reproducibility was assessed with the intraclass correlation coefficient (ICC) and 95% confidence intervals.

## RESULTS

A total of 238 participants agreed to participate in the study. After applying the inclusion and exclusion criteria, five questionnaires were excluded due to failure to respond or incomplete tests (2%), resulting in a sample of 233 questionnaires. The sample consisted of 105 males and 128 females with a mean age of  $36.1 \pm 12.1$  years.



**Figure 2.** Modification of the connector's angulation. (a) +3° (LI/LI group); (b) +6° (LI/LI group); (c) +9° (LI/LI group); (d) -3° (LI/LI group); (e) -6° (LI/LI group); (f) -9° (LI/LI group); (g) control image without variation; (h) +2° (C/C group); (i) +4° (C/C group); (j) +6° (C/C group); (k) -2° (C/C group); (l) -4° (C/C group); and (m) -6° (C/C group).



**Figure 3.** Angulation changes were measured in the control photo from the middle of the papilla in its most gingival position to the embrasure.



**Table 1.** Description of the Scores and Score Symmetry Assigned to the C/C Group Based on the Different Buccolingual Crown Inclination Variations<sup>a</sup>

	Mean $\pm$ SD		
	OR (n = 65)	GD (n = 89)	LP (n = 79)
-6° C/C	3.3 $\pm$ 1.8	3.6 $\pm$ 1.8	4.8 $\pm$ 1.8
-4° C/C	4.8 $\pm$ 1.5	6.3 $\pm$ 1.6	6.8 $\pm$ 1.6
-2° C/C	6.6 $\pm$ 1.2	6.8 $\pm$ 1.6	7.0 $\pm$ 1.6
0°	7.8 $\pm$ 1.1	7.6 $\pm$ 1.4	8.0 $\pm$ 1.2
+2° C/C	7.1 $\pm$ 1.3	7.2 $\pm$ 1.6	7.5 $\pm$ 1.3
+4° C/C	5.8 $\pm$ 1.6	7.0 $\pm$ 1.5	7.2 $\pm$ 1.3
+6° C/C	4.9 $\pm$ 1.9	5.9 $\pm$ 1.7	6.6 $\pm$ 1.7
Score symmetry			
-2/+2° C/C	6.8 $\pm$ 1.0 $P = .029^*$	7.0 $\pm$ 1.4 $P = .017^*$	7.3 $\pm$ 1.3 $P = .035^*$
-4/+4° C/C	5.3 $\pm$ 1.5 $P < .001^{**}$	6.6 $\pm$ 1.3 $P < .001^{**}$	7.0 $\pm$ 1.3 $P < .001^{**}$
-6/+6° C/C	4.1 $\pm$ 1.6 $P < .001^{**}$	4.8 $\pm$ 1.4 $P < .001^{**}$	5.7 $\pm$ 1.6 $P < .001^{**}$

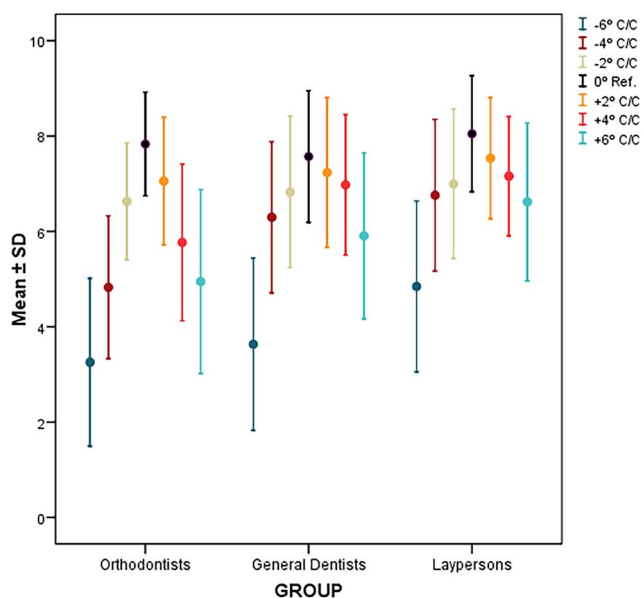
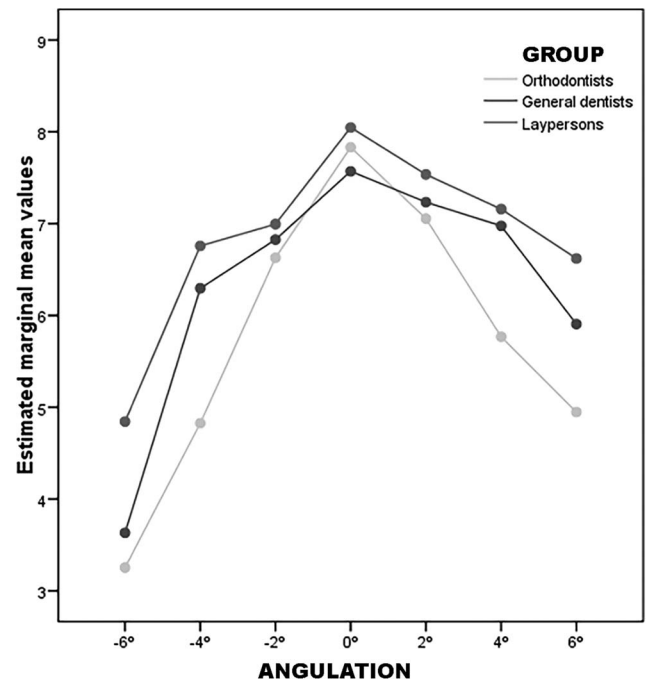
<sup>a</sup> C/C indicates canine-canine group; OR, orthodontists; GD, general dentists; and LP, laypersons; \*  $P < .05$ ; \*\*  $P < .001$ .

Of the participants, 79 (33.9%) were LPs, 65 (27.9%) were ORs, and 89 (38.2%) were GDs. The mean experience for ORs was 9.4 years, while for GDs it was 7.9 years. The sample distribution was homogenous according to sex, age, experience, and group.

The reproducibility values obtained with the ICC were close to 1.0. According to Fleiss's guidelines,<sup>27</sup> this level of correlation is considered very high, as an ICC greater than 0.75 denotes excellent agreement.

### C/C Group

Table 1 presents the scores, with the highest in LPs, followed by GDs, and finally ORs, who were the most

**Figure 4.** Description of the scores assigned to the C/C group based on the different variations.**Figure 5.** Representation of average scores in the C/C group.

critical. The impact of altering the image at one level was greater among ORs. Additionally, the asymmetry observed in the scores based on variations in buccolingual crown inclination, whether increased or decreased, added an intriguing aspect to the findings. In general, the -6° deviated image was clearly the least valued by all groups (Figure 4).

### Score Symmetry

When analyzing whether deviations with positive or negative buccolingual inclination had the same impact on the ratings, it was found that, at the maximum magnitude of deformation (6°), the scores for the image with negative buccolingual inclination were significantly lower than those of the positive buccolingual inclination for all groups. For deformations of  $\pm 4^\circ$  and  $\pm 2^\circ$ , the differences were statistically significant for all groups except LP, where the differences were relatively weaker in magnitude at  $\pm 2^\circ$ .

The esthetic assessment was significantly dependent on the group ( $P < .001$ , group effect). ORs appeared to

**Table 2.** C/C Scores by Group and Torque Variation Grade: Results of the F-Test From the One-Way Repeated Measures Analysis of Variance Model

	F	P Value
Group	22.8	< .001*
Grade	165.9	< .001*
Group $\times$ grade	7.04	< .001*

\*  $P < .001$ .

**Table 3.** C/C Scores by Group and Torque Variation Grade: Multiple Comparisons Results Using Bonferroni Correction for Variation in the Buccolingual Crown Inclination Effect

	-6°	-4°	-2°	0°	+2°	+4°	+6°
-6°							
-4°	<.001*						
-2°	<.001*	<.001*					
0°	<.001*	<.001*	<.001*				
+2°	<.001*	<.001*	<.001*	<.001*			
+4°	<.001*	<.001*	<.001*	<.001*	<.001*		
+6°	<.001*	<.001*	.654	<.001*	<.001*	<.001*	

\*  $P < .001$ .

be the most discerning, followed by GDs, with LPs being the least critical. Additionally, the differences between the groups were not constant but also depended on the degree of image deformation ( $P < .001$ ). Thus, as the degree of variation increased, the likability scores decreased across all three groups (Figure 5; Table 2).

**Differences by Group**

Differences existed among the three groups, with the LP group assigning higher scores to the images, followed by the GD group and, finally, the OR group. Statistical analysis revealed significant differences between ORs and GDs ( $P = .003$ ), ORs and LPs ( $P < .001$ ), and GDs and LPs ( $P = .008$ ). When examining the differences by degree of deformation in detail, even a single level of deformation caused statistically significant differences (Table 3). When evaluating the effect of sex and age within each group separately, no significant differences in esthetic evaluation were found (Table 4).

**LI/LI Group**

Table 5 presents the scores, with the highest being in LPs, followed by GDs, and finally, the most critical in ORs. The impact of altering the image at one level was greater in ORs. Overall, the image deviated by  $-9^\circ$  was clearly the least favored by all groups (Figure 6).

**Table 5.** Description of the Scores and Score Symmetry Assigned to the LI/LI Group Based on the Different Buccolingual Crown Inclination Variations<sup>a</sup>

	Mean $\pm$ SD		
	OR (n = 65)	GD (n = 89)	LP (n = 79)
-9° LI/LI	2.3 $\pm$ 1.4	3.6 $\pm$ 1.8	4.5 $\pm$ 1.9
-6° LI/LI	3.4 $\pm$ 1.6	4.1 $\pm$ 1.7	5.5 $\pm$ 1.8
-3° LI/LI	5.8 $\pm$ 1.4	5.9 $\pm$ 1.9	6.8 $\pm$ 1.5
0°	7.8 $\pm$ 1.1	7.6 $\pm$ 1.4	8.0 $\pm$ 1.2
+3° LI/LI	7.1 $\pm$ 1.3	7.6 $\pm$ 1.5	7.6 $\pm$ 1.4
+6° LI/LI	4.2 $\pm$ 2.0	4.9 $\pm$ 1.9	6.0 $\pm$ 1.8
+9° LI/LI	3.2 $\pm$ 1.9	3.0 $\pm$ 1.7	5.0 $\pm$ 1.7
Score symmetry			
-3/+3° LI/LI	6.4 $\pm$ 1.1	6.7 $\pm$ 1.4	7.2 $\pm$ 1.3
	$P < .001^{**}$	$P < .001^{**}$	$P < .001^{**}$
-6/+6° LI/LI	3.8 $\pm$ 1.6	4.5 $\pm$ 1.5	5.8 $\pm$ 1.5
	$P < .001^{**}$	$P < .001^{**}$	$P = .011^*$
-9/+9° LI/LI	2.8 $\pm$ 1.5	3.3 $\pm$ 1.5	4.8 $\pm$ 1.6
	$P < .001^{**}$	$P = .007^*$	$P = .014^*$

<sup>a</sup> LI/LI, lateral incisor-lateral incisor group; OR, orthodontists; GD, general dentists; and LP, laypersons; \*  $P < .05$ ; \*\*  $P < .001$ .

**Score Symmetry**

For all degrees of alteration, the evaluations were worse for negative buccolingual inclination in all three groups, although the significance was weaker in the LP group. As the degree of variation increased, the likability scores decreased across all three groups (Table 6; Figure 7).

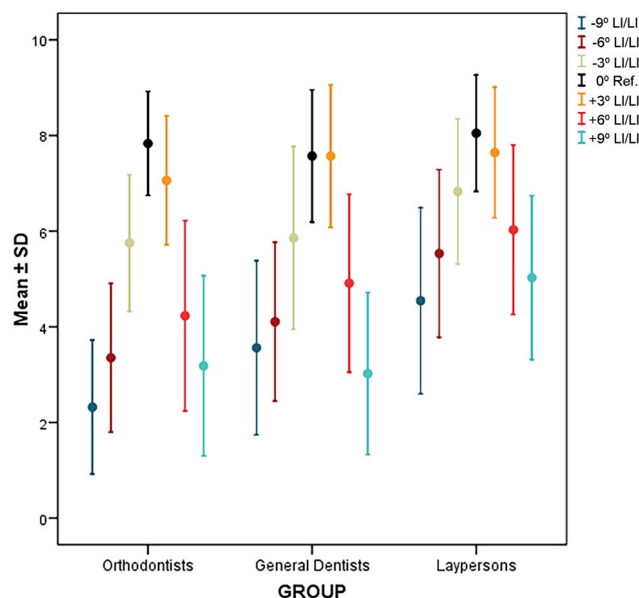
**Differences by Group**

Statistically significant differences were observed between the OR and GD groups as well as between these groups and the LP group (OR versus GD  $P = .001$ , OR versus LP  $P < .001$ , and GD versus LP  $P = .001$ ). When examining the differences by degree of deformation in detail, it was observed that even a single level change caused statistically significant differences (Table 7). Evaluation of the effect of sex and age in each group separately showed no significant differences in esthetic evaluation (Table 8). A comprehensive summary of the results can be seen in Figure 8.

**Table 4.** C/C Scores by Gender and Age in Orthodontists (OR), General Dentists (GD), and Laypersons (LP): Results of the *F*-Test From the One-Way Repeated Measures Analysis of Variance Model

	OR		GD		LP	
	<i>F</i>	<i>P</i> Value	<i>F</i>	<i>P</i> Value	<i>F</i>	<i>P</i> Value
Grade	6.55	<.001*	6.42	<.01*	6.12	<.001*
Gender	0.87	.354	0.44	.508	0.83	.365
Age	1.82	.182	0.26	.615	3.37	.070
Grade $\times$ gender	1.68	.121	0.76	.387	0.78	.587
Grade $\times$ age	3.45	.155	0.27	.910	2.20	.053
Gender $\times$ age	0.93	.338	1.90	.171	1.09	.300
Grade $\times$ gender $\times$ age	1.65	.130	0.90	.469	1.32	.254

\*  $P < .001$ .



**Figure 6.** Description of the scores assigned to the LI/LI group based on the different variations.

## DISCUSSION

Connectors tend to be parallel<sup>11–13</sup> and, as a result, buccolingual crown inclination may influence perception of the connectors and overall esthetics of the smile. Authors of only one previous study have evaluated buccolingual inclinations in the frontal view, solely in canines and premolars, among ORs and LPs.<sup>26</sup> Authors of other studies have evaluated the labiolingual inclination of incisors in a profile projection.<sup>14–18</sup> This study is the first to evaluate the relationship between smile esthetics and buccolingual inclination variation in the upper anterior six teeth from the perspective of GDs, ORs, and LPs in the frontal view.

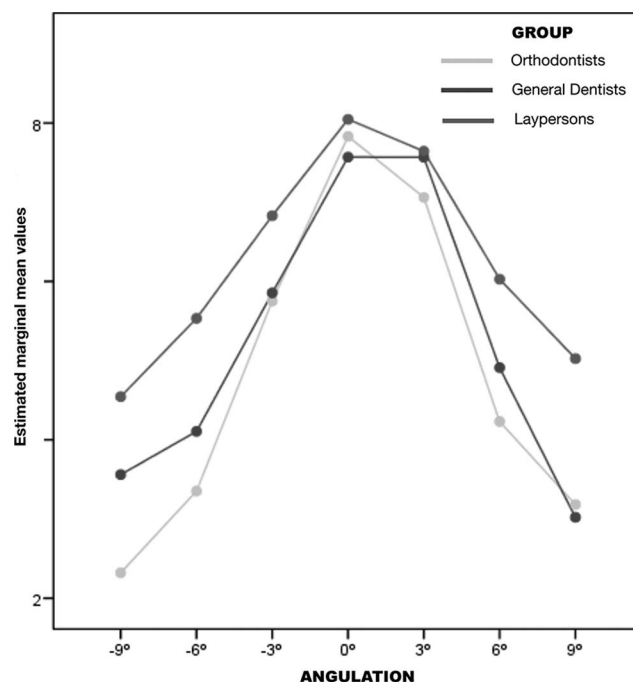
In this study, we demonstrated that images with a buccolingual crown inclination defect received lower scores than those with excess inclination across all three groups. Likability scores decreased with greater variation. Excluding the canine from the variation resulted in more negative evaluations due to disruption of the regressive proportion and failure to achieve parallel connectors.

In this study, it was found that LPs rated buccolingual inclination alterations most favorably, followed by GDs, with ORs giving the lowest scores.

**Table 6.** LI/LI Scores by Group and Torque Variation Grade: Results of the *F*-Test From the One-Way Repeated Measures Analysis of Variance Model

	<i>F</i>	<i>P</i> Value
Group	30.1	<.001*
Grade	227.7	<.001*
Group × grade	8.78	<.001*

\* *P* < .001.



**Figure 7.** Representation of average scores in LI/LI group.

Comparing this study with others is challenging, as it is the first to evaluate all three groups. Previous researchers have examined the effect of canine inclination on smile perception among various groups, such as ORs and LPs<sup>27</sup>; and ORs, GDs, and LPs.<sup>1,4</sup> Lemos et al.<sup>8</sup> reported that increased buccolingual crown inclination in canines could decrease attractiveness by hiding the premolars. Conversely, Haerian et al.<sup>1</sup> noted a slight increase in attractiveness with a 10° inclination. These differences may have been due to varying beauty standards across regions, as the studies were conducted in different countries.

In this study, we found significant differences among the three groups, with ORs being the most critical. These results were in agreement with previous research on other aspects of dental esthetics.<sup>1,26,28,29</sup>

When devising treatment strategies, the interincisal angle is greater in Class III malocclusions, and the treatment mechanics tend to incline the upper incisors labially,

**Table 7.** C/C Scores by Group and Torque Variation Grade: Multiple Comparisons Results Using Bonferroni Correction for Variation in the Buccolingual Crown Inclination Effect

	-9°	-6°	-3°	0°	+3°	+6°	+9°
-9°							
-6°	<.001*						
-3°	<.001*	<.001*					
0°	<.001*	<.001*	<.001*				
+3°	<.001*	<.001*	<.001*	<.001*			
+6°	<.001*	<.001*	<.001*	<.001*	<.001*		
+9°	.294	<.001*	<.001*	<.001*	<.001*	<.001*	

\* *P* < .001.

**Table 8.** LI/LI Scores by Gender and Age in Orthodontists (OR), General Dentists (GD), and Laypersons (LP): Results of the *F*-Test From the One-Way Repeated Measures Analysis of Variance Model

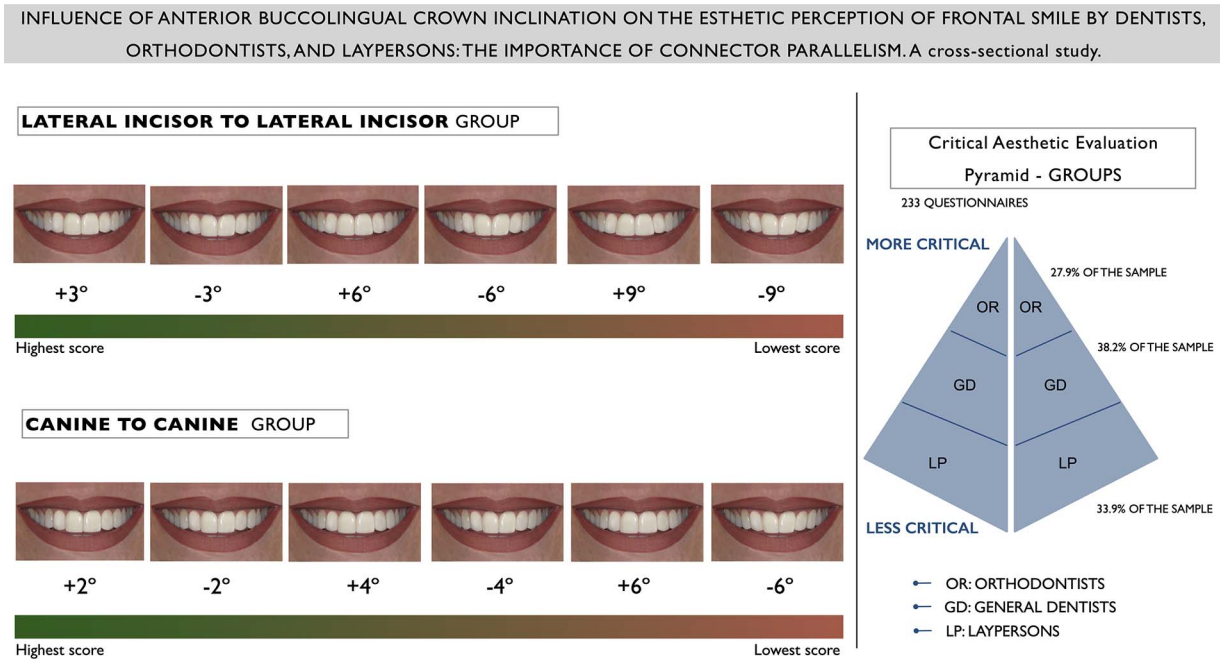
	OR		GD		LP	
	<i>F</i>	<i>P</i> Value	<i>F</i>	<i>P</i> Value	<i>F</i>	<i>P</i> Value
Grade	5.52	< .001*	5.78	< .001*	11.2	< .001*
Gender	0.9	.486	0.22	.639	0.30	.587
Age	3.63	.092	1.11	.295	0.88	.352
Grade × gender	1.14	.353	0.74	.616	0.73	.626
Grade × age	0.72	.632	0.27	.948	1.89	.094
Gender × age	0.72	.399	0.06	.803	0.91	.344
Grade × gender × age	1.73	1.32	0.71	.402	0.98	.44

\* *P* < .001.

resulting in excessive buccolingual inclination and more divergent connectors.<sup>11,20</sup> Based on the findings of the current study, to compensate for this situation esthetically, the treatment objective should be to avoid excessive buccolingual inclination of the upper incisors. Additionally, proinclination of the upper incisors would result in reduced incisor exposure during a smile, further impacting smile esthetics.

On the contrary, in Class II malocclusions, the interincisal angle is smaller, and treatment mechanics tend to lingually incline the upper incisors. This results in deficient buccolingual inclination and more convergent connectors.<sup>11,20</sup> The results of this study showed that the lowest scores were given to the most negative buccolingual inclination variations in all three groups. To address this situation, the orthodontic objective should be to increase the buccolingual inclination of the upper incisors until achieving appropriate labiolingual inclination with parallel connectors.

One limitation of this study was that the link between connectors and buccolingual inclination may be influenced by variations in tooth morphology, such as triangular-shaped central incisors, and crown angulation (mesiodistal angulation). Additionally, the focus on frontal views of smile attractiveness may not fully capture the impact of buccolingual inclination. Authors of future studies could benefit from evaluating both frontal and lateral views to provide a more comprehensive assessment of smile esthetics. To mitigate the influence of confounding variables, a set of digitally modified artificial smiles derived from a single original female smile was used. However, while Correa et al.<sup>30</sup> observed no distinction in the comparison of smiles between males and females, it is important to note that this investigation was constrained by the use of only one female smile. Nevertheless, as a strength of the research, it is noteworthy that we are the first investigators to assess and compare the perception of smile esthetics among LPs, GDs, and



**Figure 8.** A comprehensive summary of the results.



ORs in a frontal view by introducing variations in buccolingual crown inclination in incisors (LI/LI) and in incisors and canines (C/C).

## CONCLUSIONS

- In this study, we underscore the importance of achieving proper buccolingual crown inclination and maintaining correct parallelism of connectors during treatment.
- The OR group was the most critical in assessing smile esthetics, compared with GDs and LPs, for buccolingual inclination variations in both LI/LI and C/C groups.
- Lower scores were observed for larger deformations and negative buccolingual inclinations in both groups. Also, even minor deformations were shown to affect the score.
- Evaluations for the C/C group showed significant differences among the three groups, with LP scoring the highest, followed by GD and OR.
- Assessments for the LI/LI group revealed significant differences between LPs and both groups of professionals as well as between the two professional groups.
- The results did not indicate any statistically significant differences based on age or gender.

## ACKNOWLEDGMENT

This article is dedicated to the memory of Maria José Bejarano.

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