

# Morphological Simulation of Different Incisal Embrasures: Perception of Laypersons, Orthodontic Patients, General Dentists and Orthodontists

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## ABSTRACT

**Objective:** This study aimed to evaluate how different forms of incisal embrasures influence the esthetic perception of the smile, the preferences of each group of evaluators, and the influence of gingival display.

**Material and Methods:** Two photographs of a broad male and female smiles were digitally manipulated to remove imperfections and asymmetries. A second manipulation was performed on the four maxillary incisors, creating 3 different forms of incisal embrasures: rounded, semi-rounded and squared. The lower region of the upper lip was shifted down to simulate a smile with and without gingival display, resulting in a total of 12 photos. A presentation in digital media was structured with instructions and the photos to be studied by 240 evaluators, who were divided into four groups: laypersons, patients undergoing orthodontic treatment, general dentists and orthodontists. The statistical analysis comprised the Multiple Factor ANOVA (SPANOVA), and the Tukey's post-test was applied at a 5% significance level.

**Results:** The semi-rounded form was generally preferred, with a score of 70.83 for the male smile, and 77.26 for the female smile. Gingival display generated a statistically significant influence on how the embrasures were perceived, with the semi-rounded being preferred when associated with gingival display. Orthodontists were the most stringent in their evaluations. Patients and laypersons exhibited different patterns of esthetic perception.

**Conclusions:** The form of the incisal embrasures associated with gingival display influenced the evaluators' esthetic perception. There was a statistically significant difference between the groups of patients and orthodontists.

## CLINICAL SIGNIFICANCE

Incisal embrasures play an important role in smile esthetics and influence the attractiveness perception. In general, the semi-rounded embrasure form is the most preferred. Different groups' perceptions on tooth morphology reinforce the importance of patient participation in treatment planning.

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## INTRODUCTION

Esthetic perception is a key concern among professionals. A pleasant smile not only mirrors a desired beauty pattern, but it is also a competitive edge that can determine a candidate's success in a job interview, and in social interaction.<sup>1</sup> It has been shown that malocclusions exert a negative impact on facial attractiveness as well as on the individual's quality of life.<sup>2-4</sup>

Furthermore, laypersons and dentists hold conflicting opinions within the realm of esthetics. It has been found that dentists are more stringent in their evaluations than laypersons.<sup>5,6</sup> In this context, some features of the smile were not easily perceived by laypersons. Moreover, they do not focus their attention on specific aspects of the smile, unlike dentists, who are trained through formal education to be more discerning.<sup>6</sup>

Matters pertaining to esthetics and to different dental and gingival features have been studied with the purpose of learning about the patient's general preferences regarding this subject, and so as to provide guidance towards better treatment planning in light of the patient's opinions.<sup>7,8</sup> Tooth shape is one of the factors that has had a great impact on smile esthetics, and it is influenced by the individuals' preferences, age, gender or cultural, and ethnic features.<sup>1,9-11</sup>

Some studies showed that certain patterns are related to the shape of anterior teeth, whereas female smiles were preferred when associated with more rounded and delicate teeth and male smiles were associated with squarer teeth.<sup>9,10,12</sup> Conversely, another study recommends that teeth with squared and straight incisal angles be rounded.<sup>1</sup>

There is evidence indicating that rounded incisal embrasures are considered more pleasing, and exhibit a more youthful smile. As for the squared form, it depicts a more senior or elderly smile.<sup>13,16</sup> In addition, in a harmonic smile, incisal embrasures must be narrower between central incisors and become gradually larger between central and lateral incisors, and between lateral incisor and cuspid.<sup>10,15,17</sup>

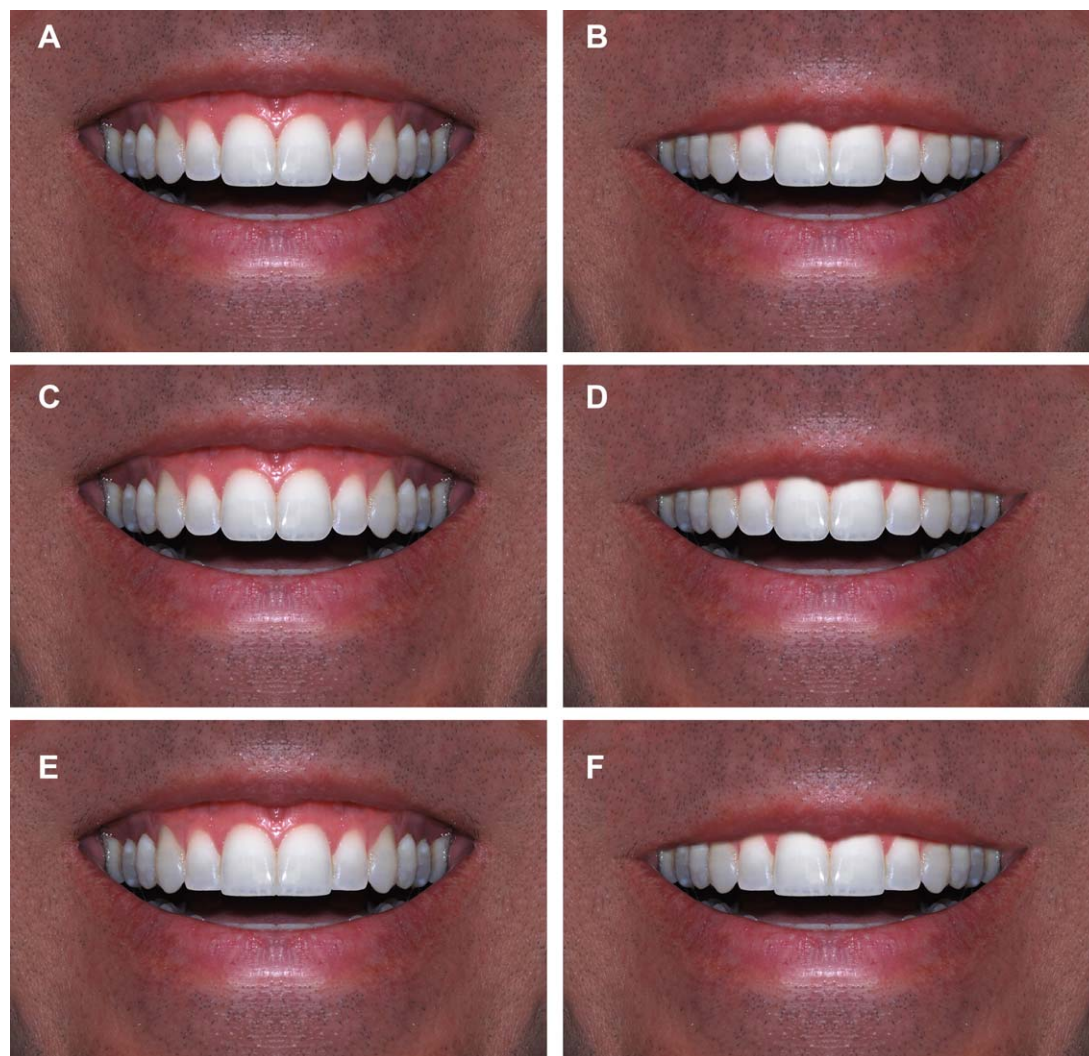
In many cases, professionals have the opportunity to make final adjustments in the shapes of teeth in order to achieve better esthetic results. Adjustments to the incisal embrasures should then be included, being preceded by various techniques, with burs of various sizes and different shapes.<sup>7,18</sup>

Few studies have hitherto focused on the impact of incisal embrasures on smile esthetics.<sup>15,19</sup> In addition, there has been no research on this subject which showed differences in the opinions of evaluator groups, by separating laypersons and orthodontic patients into distinct groups. Thus, the aim of the present study was to determine: (1) which incisal embrasure form has been considered more esthetically pleasing; (2) whether there have been any differences of opinion among laypersons, orthodontic patients, general practitioners, and orthodontists, and (3) whether gingival display has any bearing on the perception of smile esthetics as it relates to different incisal embrasures.

## MATERIAL AND METHODS

Two photos of smiles, one male and one female, exhibiting the gingival zeniths of the maxillary incisors and canines were digitally manipulated with Adobe Photoshop CS5 software (Adobe Systems Inc., San Jose, California, USA). As in other studies,<sup>20,21</sup> one side of the photograph was standardized by removing distracting factors such as changes in color, in the shape of the teeth and adjacent structures. This side was mirrored to ensure perfect smile symmetry. The photographs were taken with half-open mouths, thus promoting little or no exposure of the mandibular incisors, so that the maxillary teeth were set against a dark background, which improved contrast and facilitated visual assessment. The individuals who posed for these photographs signed an image use authorization and the project was submitted to and approved by the Ethics in Research Committee.

A new manipulation of these photos was carried out to create a simulation of changes in the embrasures of the four maxillary incisors. The modifications were



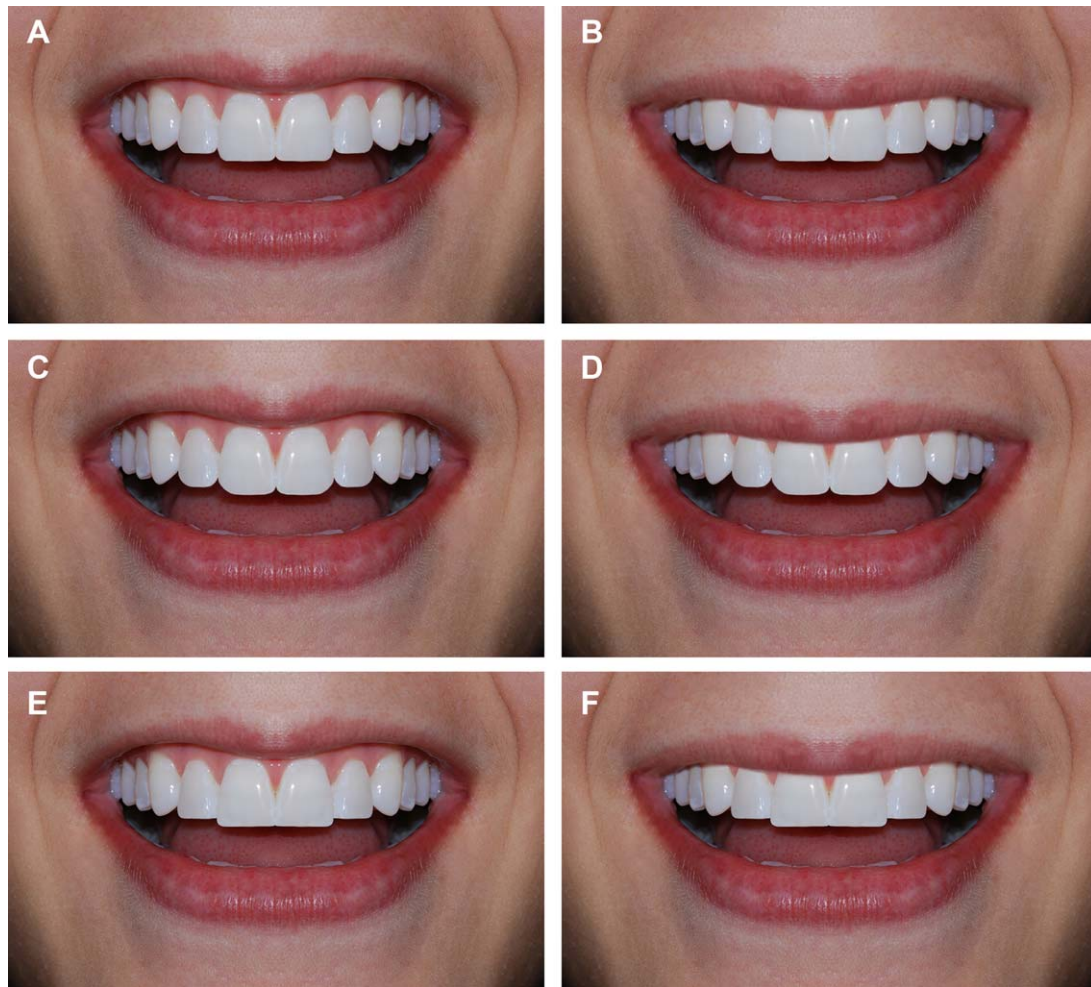
**FIGURE 1.** Male smiles after manipulations. A, Male smile with semi-rounded embrasures and gingival exposure. B, Male smile with semi-rounded embrasures and without gingival exposure. C, Male smile with rounded embrasures and gingival exposure. D, Male smile with rounded embrasures and without gingival exposure. E, Male smile with squared embrasures and gingival exposure. F, Male smile with squared embrasures and without gingival exposure.

applied by changing only the incisal angle to semi-round, rounded, and squared forms without altering the length or width of the incisor crowns.

In a subsequent manipulation, a displacement was made toward the region below the upper lip, so that the gingival limits were covered in each of the images. No change was made in the contour of the gingival margin of the teeth. All manipulations were performed by the same operator, and generated six pictures of each model, bringing the absolute total to 12 images (Fig. 1 and Fig. 2).

Using Keynote 6.1 software (Apple Inc., Cupertino, California, USA), a presentation was set up with slides containing instructions and the 12 photos to be evaluated. After making sure the instructions had been fully understood, a slide with 6 images was displayed for 20 seconds; first, of the male smile, (a) grouped (the three forms of incisal embrasures with gingival display and three without gingival display); and (b) in order of manipulation of the incisal embrasures (semi-rounded, rounded and squared) as a way to calibrate the evaluator for what would be shown next. The same six images were then presented individually in





**FIGURE 2.** Female smiles after manipulations. A, Female smile with semi-rounded embrasures and gingival exposure. B, Female smile with semi-rounded embrasures and without gingival exposure. C, Female smile with rounded embrasures and gingival exposure. D, Female smile with rounded embrasures and without gingival exposure. E, Female smile with squared embrasures and gingival exposure. F, Female smile with squared embrasures and without gingival exposure.

slides, in random order defined previously by lot, with automatic transition and 15 seconds' viewing time per photo. The same procedure was repeated with the subsequent slides of photos of the females' smiles. No opportunity was given to reevaluate. The presentation was shown to the evaluators on a MacBook Pro notebook, screen size 15" (Apple Inc. Cupertino, California, USA).

In order to grade smile attractiveness a sheet with 12 Visual Analogue Scales was used. The scales measured 100 mm, were divided into 10 mm intervals, and numbered according to the photos being displayed. The evaluators were asked to make a perpendicular marking on the scale representing the desired grade,

considering 0 as the least attractive, and the 100 as the most attractive.

Digital caliper (Lotus Comercial Ltda., Serra, ES, Brazil) was used, taking into account two decimal places for measuring the markings on the scales. With the purpose of eliminating potential distortions in printing the questionnaire scales, the total in mm of the first scale of all evaluators was calculated. Thereafter, the rule of three was applied with the aid of Excel (Microsoft Excel Mac 2011 14.2.0, Washington, USA) software for each measurement taken at subsequent scales, considering that each scale was 100 mm long.

According to the inclusion criteria all evaluators were between 18 and 60 years of age, without gender distinction. The group of lay evaluators had not undergone orthodontic treatment in the past five years, were either university graduates or undergraduates, and had no involvement or direct contact with dentistry. The group of patients undergoing orthodontic treatment had to be at least 6 months into treatment or finished treatment 1 year at the most at the Department of Orthodontics, or in private practices. The group of dentists comprised those graduated for at least 2 years and active in any specialty except orthodontics. Moreover, the group of orthodontists consisted of professionals with graduate degrees in orthodontics, who worked with fixed orthodontics. All volunteers were asked to fill out a free and informed consent form, confirming their participation in the study.

Exclusion criteria in the group of lay evaluators and in the group of patients undergoing orthodontic treatment required that none of the volunteers be dentists, dentistry undergraduates, or married to dentists.

According to sample calculation performed with G\*Power 3.1.9.213 software (Heinrich Heine Universität Dusseldorf Institute Experimentelle Psychologie, Dusseldorf, Germany), with an observed power of 80% and “effect size” of 0.25. The sample should comprise 56 individuals in each assessment group (laypersons, orthodontic patients, general dentists and orthodontists), but  $N = 60$  was adopted as a safety margin, resulting in a total of 240 evaluators. The value found was consistent with other studies that used similar methodology.<sup>22,23</sup>

Three evaluators from each group reassessed the 12 photographs with a minimum interval of two months since the first assessment. A reliability test was conducted through intraclass correlation coefficient (ICC). A high coefficient correlation was found (83.3% - IC95 0.782-0.872), thereby attesting to the reliability of the results.<sup>22-24</sup>

Statistical analysis was performed using SPSS 20 software (IBM Corp., Los Angeles, California, USA).

Descriptive parametric statistics revealed the minimum, maximum, mean, and standard deviation values. The Multiple factor ANOVA (SPANOVA) was conducted with an intergroup factor (level of orthodontic knowledge), and three intrasubject factors (gender of the models, form of the incisal embrasures, and gingival display). Furthermore, the Tukey's post-test was applied with a 5% significance level. To determine the significance levels and “effect size” (“partial eta squared”) of SPANOVA, the Greenhouse-Geisser test was used, and Huynh-Feldt correction applied.

## RESULTS

The sample consisted of 240 evaluators, 71 males and 169 females, aged at least 18 years, and at most 59 years.

Means and standard deviations of the evaluations obtained for each photo were divided by evaluator group, and grouped in Table 1. The male smile that obtained the best scores was the one with semi-rounded embrasures and no gingival display. As regards the female smile, the best evaluation was assigned to a smile with semi-rounded embrasures and gingival display. In comparing the two – male and female - the women's smiles received the most positive assessment (highest score) in the overall mean (77.26) than the men (70.83). Both the men's and the women's smiles that were assigned the worst ratings, on average, were those with squared incisal embrasure, and no gingival display. Regarding the squared embrasure, the women's smiles were assigned worse scores than the men's smiles.

Multiple factor ANOVA results are shown in Table 2, indicating the influence of each factor in evaluating smile esthetics. Descriptive statistics uses as reference the grades assigned to a photograph by a total of 240 evaluators, thus generating 240 scores. When a single factor is considered, one can evaluate all possible combinations to be made with this factor. For example, each form of incisal embrasure will be assessed by each of the evaluators, yielding 240 scores

**TABLE 1.** Means and standard deviations of the evaluations. M: male smile; F: female smile; A: gingival exposure; B: without gingival exposure; 1: semi-rounded embrasures; 2: rounded embrasures; 3: squared embrasures

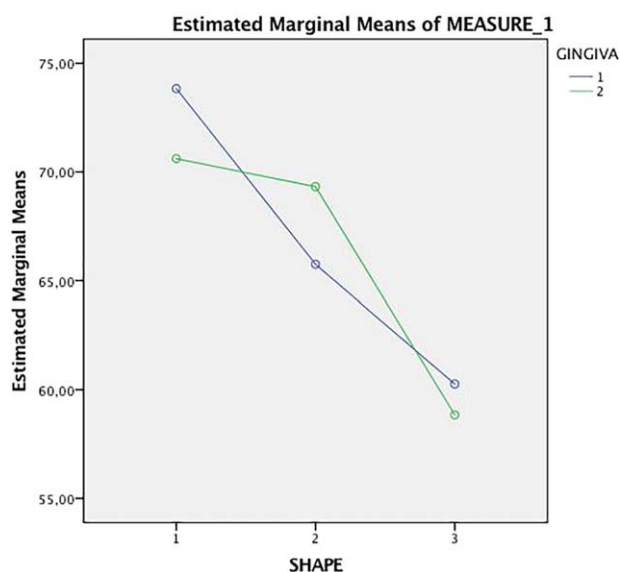
Photos	Orthodontists	General dentists	Patients	Laypersons	Total
<b>MA1</b>	70,45 ± 14,69	71,42 ± 17,87	75,29 ± 15,47	64,45 ± 17,34	70,40 ± 16,75
<b>MA2</b>	60,84 ± 20,80	62,29 ± 17,42	68,17 ± 18,58	63,48 ± 16,63	63,70 ± 18,52
<b>MA3</b>	58,95 ± 17,64	62,56 ± 15,87	70,27 ± 18,46	61,14 ± 16,39	63,23 ± 17,54
<b>MB1</b>	70,95 ± 15,52	69,38 ± 17,49	74,87 ± 15,43	68,13 ± 15,33	70,83 ± 16,07
<b>MB2</b>	60,97 ± 21,70	66,41 ± 17,12	71,04 ± 17,15	67,33 ± 15,76	66,44 ± 18,32
<b>MB3</b>	57,56 ± 18,26	61,87 ± 15,57	68,85 ± 18,37	63,10 ± 15,20	62,85 ± 17,28
<b>FA1</b>	77,54 ± 10,74	76,05 ± 14,62	80,43 ± 12,86	75,04 ± 15,03	77,26 ± 13,49
<b>FA2</b>	61,88 ± 19,89	68,02 ± 17,20	71,27 ± 20,31	70,04 ± 15,97	67,80 ± 18,67
<b>FA3</b>	52,12 ± 17,42	57,71 ± 16,15	63,62 ± 20,80	55,67 ± 19,06	57,29 ± 18,79
<b>FB1</b>	67,10 ± 14,95	72,53 ± 16,74	72,09 ± 17,52	69,84 ± 16,85	70,39 ± 16,58
<b>FB2</b>	65,83 ± 18,29	72,24 ± 14,93	74,98 ± 17,58	75,79 ± 13,61	72,21 ± 16,58
<b>FB3</b>	47,45 ± 18,52	55,80 ± 18,73	61,50 ± 22,32	54,61 ± 19,14	54,84 ± 20,24

**TABLE 2.** Multiple Factor ANOVA results

Source	Sig.	Partial Eta Squared	Observed Power <sup>a</sup>
SEX	0,558	0,001	0,090
SEX * GROUP	0,189	0,020	0,420
GINGIVA	0,582	0,001	0,085
GINGIVA * GROUP	0,265	0,017	0,353
SHAPE	0,000	0,555	1,000
SHAPE * GROUP	0,001	0,066	0,939
SEX * GINGIVA	0,001	0,047	0,925
SEX * GINGIVA * GROUP	0,590	0,008	0,183
SEX * SHAPE	0,000	0,297	1,000
SEXO* SHAPE * GROUP	0,360	0,013	0,289
GINGIVA * SHAPE	0,025	0,021	0,615
GINGIVA * SHAPE * GROUP	0,932	0,002	0,077
SEX * GINGIVA * SHAPE	0,000	0,053	0,951
SEX * GINGIVA * SHAPE * GROUP	0,248	0,017	0,366

**TABLE 3.** Multiple Factor ANOVA considering only shape of incisal embrasure (pairwise comparisons). 1: semi-rounded embrasures; 2: rounded embrasures; 3: squared embrasures

(I) Shape of incisal embrasure		Mean difference (I-J)	Std. Error	95% Confidence Interval for Difference	Sig. <sup>b</sup> (p value)
1	2	4,69*	0,838	[3,01, 6,37]	0,000
	3	12,67*	0,739	[11,19, 14,15]	0,000
2	1	-4,69*	0,838	[-6,37, -3,01]	0,000
	3	7,98*	0,784	[6,42, 9,54]	0,000
3	1	-12,672*	0,739	[-14,15, -11,19]	0,000
	2	-7,984*	0,784	[-9,54, -6,42]	0,000



**FIGURE 3.** Graphic of estimated means of shape of incisal embrasures associated with gingival display in esthetic perceptions of evaluators. 1: semi-rounded embrasures; 2: rounded embrasures; 3: squared embrasures; Blue: with gingival exposure; Green: without gingival exposure.

for each type of gingival display and each gender of the smile model. The total of this combination would then be  $240 \times 2 \times 2 = 960$  possible scores.

The factor that appeared most often as being statistically significant ( $p$  value  $<0.05$ ) in this statistical analysis was the form of the incisal embrasures. Thus, it was the factor that influenced the most the evaluation of smile esthetics, as evidenced in Table 3. In comparing the three forms of incisal embrasures

between each other in all possible combinations, statistically significant differences were found in the scores.

The smiles that had gingival display received better ratings with all forms of incisal embrasures, except for the embrasures with a rounded form, whose smiles were preferred without any gingival display (Fig. 3).

Statistically significant differences were found only between groups of patients undergoing orthodontic treatment and orthodontists in their evaluations of smile esthetics, as shown in Table 4.

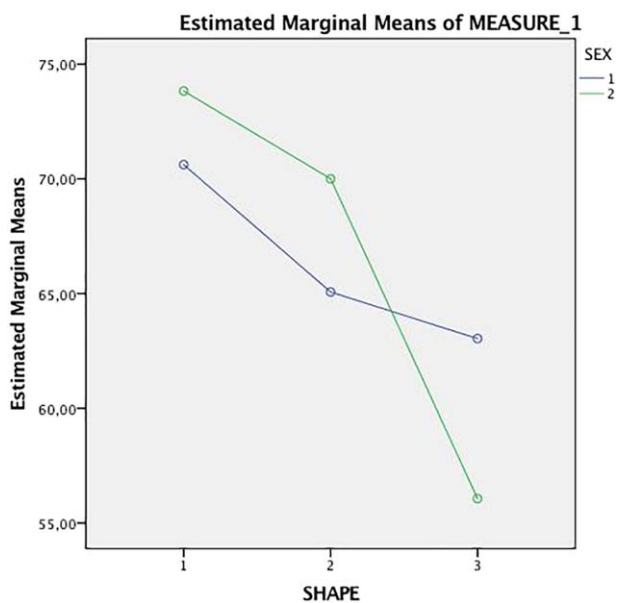
Evaluations of the male smiles generally varied less within the assigned values when compared to female smiles, considering the esthetic impact of different forms of incisal embrasures. The squared incisal embrasure was the least preferred in general, but even so achieved better ratings in male compared to female smiles (Fig. 4).

## DISCUSSION

Smile esthetics is seen as paramount for the self esteem of the patient, resulting in better quality of life and social well being. In studies involving an analysis of facial photographs it has been observed that the evaluators tend to focus their attention on the mouth and eyes.<sup>14</sup> Negative features of the smile can affect an individual’s personality, their emotional stability,

**TABLE 4.** Statistical analysis of differences between groups of evaluators

(I) GROUP		Mean Difference (I-J)	Std. Error	Sig. <sup>b</sup>
Orthodontists	Dentists	-3,717	2,166	0,525
	Patients	-8,390*	2,166	0,001
	Laypersons	-3,078	2,166	0,939
Dentists	Orthodontists	3,717	2,166	0,525
	Patients	-4,673	2,166	0,192
	Laypersons	0,638	2,166	1,000
Patients	Orthodontists	8,390*	2,166	0,001
	Dentists	4,673	2,166	0,192
	Laypersons	5,312	2,166	0,089
Laypersons	Orthodontists	3,078	2,166	0,939
	Dentists	-0,638	2,166	1,000
	Patients	-5,312	2,166	0,089



**FIGURE 4.** Graphic of estimated means of shape of incisal embrasures associated with sex of model. 1: semi-rounded embrasures; 2: rounded embrasures; 3: squared embrasures; Blue: male smile; Green: female smile.

dominance, sexuality and social interactions. The size, shape and color of the anterior maxillary teeth are among the factors that most influence the perception of facial esthetics.<sup>19</sup> The key role of the anterior teeth

in smile esthetics should be emphasized, encouraging professionals to be mindful of the finishing procedures in a treatment, such as small adjustments, and the reshaping of the incisal embrasures<sup>14</sup>.

The literature contains a significant number of studies aimed at investigating the esthetic impact of incisal embrasures on smile esthetics.<sup>15,16,19</sup> One particular study revealed that prosthetically restored teeth showed smaller areas of incisal embrasures, which lent these teeth a touch of artificiality compared to the embrasures of natural teeth.<sup>19</sup> An esthetic preference for more rounded incisal embrasures seems to exist, which progressively increase their area distally on the dental arch, thereby imparting a sense of joviality to the smile.<sup>15,19</sup> This present study is important to the extent that it investigates esthetic preference regarding incisal embrasures, so that in the final phase of restorative procedures or orthodontic treatment proper adjustments can be made to dental anatomy.

Esthetics, as related to incisal embrasures, and in association with changes in the amount of gingival display, had not been hitherto examined as it is in the present study. Gingival display was analyzed in other studies, be it as a single factor, or in association with



others.<sup>4,25–27</sup> The results show that the greater, and the more excessive is the gingival display, the lower the scores assigned to the esthetics of the smile.<sup>4,25,26,28</sup>

The authors chose to use smiles involving only the lower third of the face in order to eliminate potential distractions in esthetic perception. It has been proven that the use of photographs revealing only the smile makes it easier to perform an esthetic evaluation compared to photos depicting the entire face.<sup>29</sup> Previous studies also demonstrated the importance of eliminating distracting factors in evaluating the smile.<sup>4,9,15,30</sup>

In this study, the amount of display on smiling can be regarded as moderate, as the authors sought to display the gingival zeniths only. After digital manipulation, the male smile displayed a slightly greater amount of gum due to the smaller proportions of the anterior teeth in the male smile compared to the female smile. This may have influenced the assessment whereby, in general, the preference was for the semi-rounded embrasure without gingival display in the male smile, and with gingival display in females (Table 1).

The evaluator groups that rated the male smiles preferred on average the semi-rounded embrasures without gingival display (Table 1). However, the difference in assessment of the same smile, but with gingival display, was very low (70.83 and 70.40), which allows one to assert that for the male smile the semi-rounded embrasure was preferred, regardless of the amount of gingival display.

In the female smile squared embrasures were considered less esthetic when compared to the same embrasures in the male smile (Fig. 2). These results may be influenced by either the photographs *per se*, or personal preference. The fact that only a single man's and a single woman's smile were evaluated in this study also influences the outcome as there was not an adequate sample to reflect this difference between the model's gender smile. In addition, the shape of the teeth of the female smile model was originally more squared and with higher proportions than the shape of the teeth in the male smile, which caused - after digital

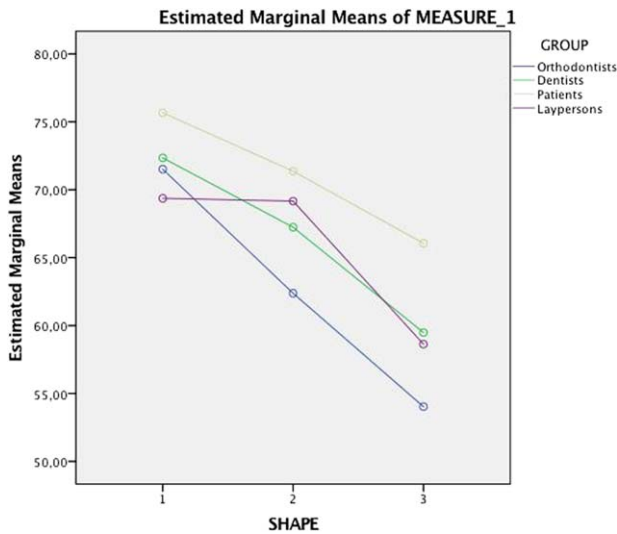
manipulation - the squared embrasures to appear more conspicuously in the female smile.

In another study that evaluated differences in esthetic perception of male and female smiles statistically significant differences were found between the scores of both smiles, while the female smile was more stringently evaluated, having been assigned lower scores.<sup>27</sup>

In general, to be considered more esthetically pleasing incisal embrasures should feature semi-rounded edges, in an inverted-V, narrow between central incisors, asymmetrical between central and lateral, and broad between lateral and canine.<sup>14–17</sup> These patterns, which are considered more esthetically pleasing corroborate the results of this study, in which semi-rounded embrasures received the highest scores in both smiles. The form of the incisal embrasure has proven to be the main factor underlying the evaluations (Table 2).

The esthetic perception of smiles varied in a statistically significant manner between orthodontists and patients undergoing orthodontic treatment (Table 4), with orthodontists proving more critical in their evaluations than patients, as reported by other studies.<sup>15,25</sup> The most significant difference was noted in the squared embrasure on smiling, which was rejected by the orthodontists and attained much lower means. In light of this finding one can highlight the importance of the patient's participation in and opinion of the esthetic features of their treatment plan.

Additionally, the evaluation group, which comprised laypersons, showed a different evaluation pattern compared with the group of patients (Fig. 5). Within the laypersons' group the female smile with rounded embrasures was assigned the highest scores, while among the patients the best scores went to the female smile with semi-rounded embrasures (Table 1). This difference, while not statistically significant, indicates different esthetic perceptions. This pattern was also observed in a recent study that used a methodology and sample similar to this study.<sup>31</sup> This analysis can lead to the consideration that possibly these groups possess different levels of knowledge in the field of dentistry, even though neither has ever received any



**FIGURE 5.** Graphic of estimated means of shape of incisal embrasures associated with evaluator group. 1: semi-rounded embrasures; 2: rounded embrasures; 3: squared embrasures; Blue: orthodontists; Green: dentists; Yellow: patients; Purple: laypersons.

dental education. This finding might be explained by the fact that the patient enjoyed greater contact with dental issues throughout the orthodontic treatment. Given that few studies are available that evaluate the differences of opinion between these groups, it is recommended that in future studies their relevance be emphasized.

## CONCLUSIONS

The incisal embrasure form considered most esthetically pleasing by the evaluators in general was the semi-rounded embrasure associated with gingival display in the female smile, and virtually no impact was exerted by gingival display on the male smile.

Evaluations by the groups of orthodontists and patients undergoing orthodontic treatment showed statistically significant differences. There was no statistically significant difference between the other groups, but the laypersons showed a different pattern of esthetic perception than the patients.

Regarding gingival display on smiling, such display was preferred only when associated with the semi-rounded

and squared embrasures. However, when associated with a rounded embrasure, most evaluators preferred smiles with no gingival display.

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