ORIGINAL ARTICLE

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Variations between maxillary central and lateral incisal edges and smile attractiveness

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Introduction: In this study, we aimed to verify whether different levels of maxillary incisal edges influence the perception of smile attractiveness and whether gingival display affects this perception according to groups of orthodontists, dentists, orthodontic patients, and laypersons. **Methods:** Photographs of the smiles of 1 man and 1 woman showing the gingival contours of the incisors and the canines were digitally altered, creating steps from 0 to 2.0 mm in 0.5-mm increments, with and without gingival exposure. The 20 pictures were shown in random order to 240 evaluators divided into 4 groups who were asked to provide attractiveness scores on visual analog scales. **Results:** Both the steps ($P < 0.001$) and the gingival exposure ($P < 0.05$) had statistically significant influences on the evaluations in all groups. There was also a statistically significant difference ($P < 0.001$) between the evaluations of orthodontists and the other groups, with distinct patterns. **Conclusions:** The most accepted vertical relationship of incisor borders was the 1.0-mm step. There were significant differences in the evaluation of orthodontists when compared with the other 3 groups, and no significant difference was detected between these groups. The gingival display altered significantly the esthetic perception of the smiles evaluated. There were significant differences between the evaluations of the smiles of the man and the woman. (Am J Orthod Dentofacial Orthop 2016;150:425-35)

Because of its subjective nature, it is hard to measure the beauty of a smile.[1,2] However, orthodontists require tangible references regarding the factors that comprise harmonic smiles to identify their deviations[1] and elaborate evidence-based treatment plans[3] to create attractive smiles.[4]

Orthodontic planning should be based on the esthetic demands of the patient, in contrast to function-driven treatment plans[5,6] that create functionally perfect, although not necessarily esthetic, smiles.[7]

An adequate smile arch, with incisors aligned in a curve parallel to the lower lip contour, is an important factor in the construction of an attractive smile.[1,7-9] The vertical position of the incisors is of paramount importance in the formation of a more pleasant smile.[6,8,10] Straight or reversed smile lines have already been considered to be less attractive by many authors,[3,4,6,7,11] whereas more convex lines are considered more beautiful and youthful.[12]

With that in mind, a great uncertainty about the best vertical relationship between the lateral and central incisor borders for each patient emerges during the planning, bonding, and finishing procedures. The orthodontist's concepts of what is more attractive do not always coincide with the patient's or the referring clinician's expectations,[13,14] even though some studies suggest that there is no difference among evaluator groups.[5]

For that reason, it is important to address the relationship of the incisal borders for a more esthetic smile, among not only orthodontic patients and orthodontists but also dentists and laypersons. In this way, orthodontists may have a reference to support the communication with those groups, helping to achieve common treatment goals.

Considering these issues, in this study we aimed to determine (1) the most accepted vertical relationship of incisor borders, (2) whether there is a difference in the esthetic perceptions among different groups of

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evaluators, (3) whether gingival display alters this perception, and (4) whether there are differences between the evaluations of the smiles of men and women.

MATERIAL AND METHODS

This project was approved by the research ethics committee of Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil (number 643.906).

The photographs of smiles of 2 volunteers—a man and a woman—showing the gingival contours of the maxillary teeth had 1 side digitally altered with Adobe Photoshop (version CS5; Adobe Systems, San Jose, Calif) to adjust the proportion of the teeth according to the literature. Distractions, such as color, shape, and size alterations, of the teeth and surrounding structures were removed.[15,16] The volunteers signed a release form for use of their images for scientific research by the Department of Orthodontics of the university.

The new manipulation simulated changes to the vertical relationship of the incisor borders, varying from 0.0 to 2.0 mm in 0.5-mm steps exclusively by extrusion of the central incisors. No alterations were made to the crown length or the height-width ratio of the incisors.

To precisely graduate the vertical movement, the real incisors of the volunteers were measured with a digital caliper (Lotus, Serra, Espirito Santo, Brazil). A virtual ruler was then calibrated in proportion to the measurement in the software to standardize the 0.5-mm increments.

We made another manipulation, which consisted of downward movement of the upper lip so that all gingival contours of the canines and the incisors were hidden on the 2.0-mm extrusion of the central incisors. The side that was manipulated was then mirrored to ensure perfect symmetry.[12] All manipulations were made by the same operator (R.M.M.) and resulted in 20 images, 10 for each sex (Figs 1 and 2).

The sample size was calculated with G*Power software (version 3.1.9.213; Heinrich Heine Universitat Dusseldorf Institute Experimentelle Psychologie, Dusseldorf, Germany), considering an alpha error of 0.01, 80% power, and 0.25 effect size. The total sample size suggested was 239 subjects. Then, 60 evaluators were recruited in each of 4 groups (orthodontists, dentists, orthodontic patients, and laypersons), resulting in 240 evaluators. This number was consistent with studies that used similar methods.[6,17,18]

As inclusion criteria, the evaluators were required to be between 18 and 60 years old, with no sex distinction. Participants in the orthodontic patients group were required be involved in active orthodontic treatment for at least 6 months in private offices or at the clinic of the Department of Orthodontics at the university. Those in the layperson group were required to have a completed or an uncompleted college degree. They were randomly selected from among students in graduate courses at the university, unrelated to dentistry. The members of the dentist group were required to have graduated more than 2 years previously and to practice any specialty other than orthodontics. The group of orthodontists included specialists who worked with fixed orthodontics techniques.

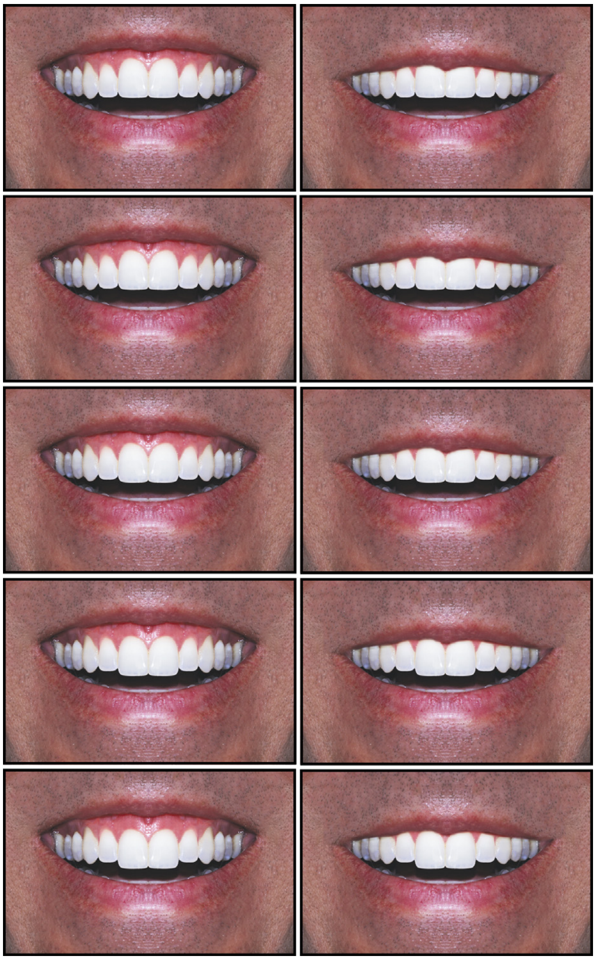

Fig 1. Smiles of the man after manipulation.

Dentists, dental students, and spouses of dentists were excluded from the layperson and orthodontic patient groups. All volunteers provided informed consent.

To grade smile attractiveness, a sheet with 20 visual analog scales (VAS) 100 mm wide was used, with zero (0 mm) as the most unattractive and 100 (100 mm) as the most attractive. The measurements were made with the same digital caliper by the same operator (R.M.M.).

Fig 2. Smiles of the woman after manipulation.

Using Keynote software (version 6.1; Apple, Cupertino, Calif), the 10 manipulated pictures of each model were assembled in a presentation. After a brief explanation of the study and how to use the VAS, a slide with all pictures of the male model's smile in increasing order of incisal steps was displayed for 20 seconds as a calibration method. After that, the same 10 pictures were shown, one by one, in random order. The transition was automatic after 15 seconds of display. The same procedure was then repeated for the smiles of the woman. The pictures were shown on either a tablet or a computer screen for luminosity control. Reevaluation of the pictures was not allowed.

The exact wording given to the evaluators was this: "Please give grades to the following pictures according to their attractiveness, considering 0 as extremely unattractive and 10 as extremely attractive. The grades can be marked at any point of the scale, as shown in the example. The transition of pictures is automatic. There will be 10 pictures of each person, which will be displayed, at first all together for 20 seconds, and then in random order, one by one, for 15 seconds each. The grading must be done when they are displayed one by one. It is not allowed to reevaluate the pictures." The evaluators were not told at any point which characteristics would be altered in the pictures.

To compensate for printing distortions on the VAS sheet, the first VAS of each page was measured, and each score was adjusted proportionally.

Statistical analysis

Statistical analysis was made with software (version 20; IBM, Armonk, NY). The normality of the sample was checked with Shapiro-Wilk and Kolmogorov-Smirnov tests. Descriptive statistics used frequencies, means, standard deviations, maximums, and minimums (Table I).

Repeated-measures analysis of variance (SPANOVA) with the Tukey post hoc test at a 5% significance level was conducted, considering 1 between-groups (evaluator group) and 3 within-subjects (smile model sex, incisal step, and gingival contour exposure) factors. To determine the effect size (partial eta squared) and the significance level of the SPANOVA, the Greenhouse-Geisser test was performed. The Huynd-Feldt correction was applied to adjust the degrees of freedom of the F tests, and therefore the *P* value wherever there was violation in the sphericity on Mauchly's test. This was also 1 more action to control the tendency of increase in the type I error during the comparisons.

These analyses verified not only the isolated influence of each factor but also the effect of its interactions. The partial eta squared results for each factor or interaction show the proportional quantification of its participation on the esthetic perception, excluding the other factors.

Three judges from each group were asked to reevaluate the 20 photographs at least 2 months after the first test. A correlation test was taken, and a coefficient of 0.833 (83.3%; 95% confidence interval, 0.782-0.872) was found, ensuring reliability.[3,6,18]

RESULTS

The sample was composed of 240 evaluators (Table I), 29.6% men and 70.4% women.

The means for each picture, grouped and divided by the evaluator group, are shown in Table II. The highest ranked pictures without gingival exposure were the 1.0-mm step for both sexes. For the pictures with gingival exposure, the 0.0-mm step for the smile of the man and the 0.5-mm step for the smile of the woman received the highest grades.

The estimated marginal means of the SPANOVA allowed for the evaluation of each factor, eliminating

Table I. Demographic distribution of the sample by groups

		Sex		Age (y)		
Group	*n*	*Male*	*Female*	*Mean*	*Minimum*	*Maximum*
Orthodontists	60	20	40	37.82 ± 08.67	25	58
Dentists	60	20	40	37.98 ± 06.21	29	55
Patients	60	17	43	30.85 ± 07.95	20	55
Laypersons	60	14	46	29.12 ± 12.83	18	59
Total	240	71	169	33.94 ± 10.02	18	59

Table II. Mean scores for each picture (per group and total)

Picture	*Orthodontists*	*Dentists*	*Patients*	*Laypersons*	*Total*
MN00	57.06 ± 18.28	64.58 ± 15.85	71.57 ± 16.68	69.19 ± 16.16	65.60 ± 17.56
MN05	55.30 ± 20.24	65.59 ± 14.72	73.81 ± 14.48	70.41 ± 15.01	66.27 ± 17.57
MN10	67.72 ± 17.82	68.34 ± 18.67	73.60 ± 15.13	68.90 ± 17.72	69.64 ± 17.43
MN15	64.65 ± 17.50	70.30 ± 13.98	71.56 ± 16.22	70.43 ± 14.22	69.24 ± 15.69
MN20	61.11 ± 18.81	70.50 ± 14.52	69.61 ± 17.20	66.23 ± 17.96	66.86 ± 17.48
ME00	65.26 ± 15.37	69.85 ± 16.32	73.70 ± 17.22	75.87 ± 14.95	71.17 ± 16.40
ME05	64.55 ± 15.83	67.47 ± 13.34	75.50 ± 14.75	70.79 ± 14.96	69.57 ± 15.20
ME10	68.05 ± 19.13	67.45 ± 16.06	76.19 ± 14.54	68.28 ± 17.20	69.99 ± 17.09
ME15	67.08 ± 19.93	68.60 ± 15.04	69.92 ± 16.45	72.09 ± 14.33	69.42 ± 16.58
ME20	56.61 ± 18.84	66.06 ± 14.73	67.45 ± 17.93	69.89 ± 14.39	65.00 ± 17.02
FN00	40.10 ± 16.76	53.61 ± 15.13	61.37 ± 22.43	58.16 ± 19.41	53.31 ± 20.23
FN05	53.18 ± 15.38	61.23 ± 16.42	68.62 ± 18.38	60.38 ± 18.89	60.85 ± 18.07
FN10	68.94 ± 17.39	78.03 ± 12.99	77.01 ± 14.32	71.11 ± 17.21	73.77 ± 15.97
FN15	56.10 ± 12.12	68.27 ± 13.80	66.12 ± 19.20	62.69 ± 16.94	63.30 ± 16.33
FN20	52.56 ± 16.61	66.73 ± 15.71	63.55 ± 22.84	61.53 ± 18.25	61.09 ± 19.18
FE00	50.95 ± 17.25	61.69 ± 16.59	72.70 ± 17.50	62.56 ± 19.96	61.98 ± 19.36
FE05	73.85 ± 13.48	75.47 ± 12.67	84.01 ± 14.77	75.58 ± 16.41	77.23 ± 14.86
FE10	74.07 ± 12.95	77.00 ± 12.82	79.42 ± 15.37	72.60 ± 14.97	75.78 ± 14.23
FE15	57.37 ± 14.55	66.36 ± 13.25	63.52 ± 20.23	61.62 ± 18.30	62.22 ± 17.03
FE20	42.57 ± 14.40	57.76 ± 16.50	56.03 ± 24.90	56.28 ± 18.12	53.16 ± 19.76

M, Male; *F*, female; *N*, no exposure; *E*, exposed; *00*, 0 mm; *05*, 0.5 mm; *10*, 1.0 mm; *15*, 1.5 mm; *20*, 2.0 mm.

the interference of the others. A great reduction in the standard deviation was observed. This occurred because in the descriptive statistics, the means referred to 1 picture, which was a combination of all factors analyzed by the 240 evaluators, producing a mean of 240 scores.

On the other hand, when an isolated factor was evaluated, this mean would be the result of all possible combinations of that factor. For instance, if we considered the incisal step alone, it would receive scores for each of the 240 evaluators in each of the 2 gingival exposure possibilities in each of the 2 sex variations. The total number of scores composing this mean would be $240 \times 2 \times 2 = 960$. Because the number of scores was significantly higher, the standard deviation would be much smaller, and since it originated from different scores, the step with the higher score may be different from the one of the highest ranked picture. This logic can be applied to all of the studied factors.

The graphic representations of the variations on the estimated marginal means, when crossing group vs step, gingival exposure vs step, sex vs step, gingival exposure vs groups, and gingival exposure vs sex, whether statistically significant or not, can be seen in Figures 3 to 7.

The variations of all studied factors (evaluator group, incisal step, gingival exposure, and sex) showed statistically significant differences when isolated. The interactions of 2 or more factors did not show statistically significant differences in all situations. The quantification of this effect is indicated by the partial eta squared results (effect size), and the more relevant observations were associated with the incisal step (Table III). The results of the SPANOVA are presented in Table IV.

DISCUSSION

Although it was affirmed that the esthetic impact of smile visualization is smaller when the whole face is displayed,[19,20] some studies have shown no significant difference in esthetic evaluation when the framing changed between the whole face or just the

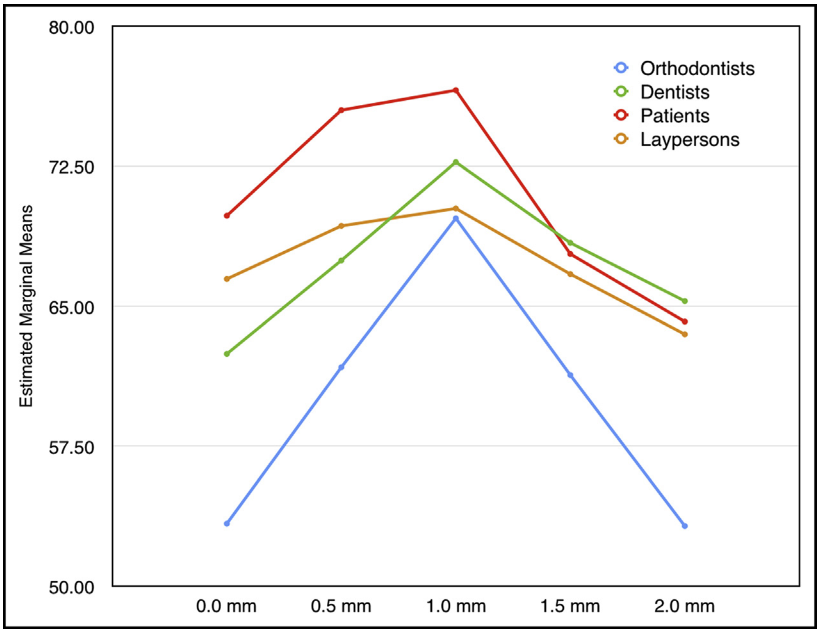

Fig 3. Estimated marginal means of the steps, according to the evaluator groups.

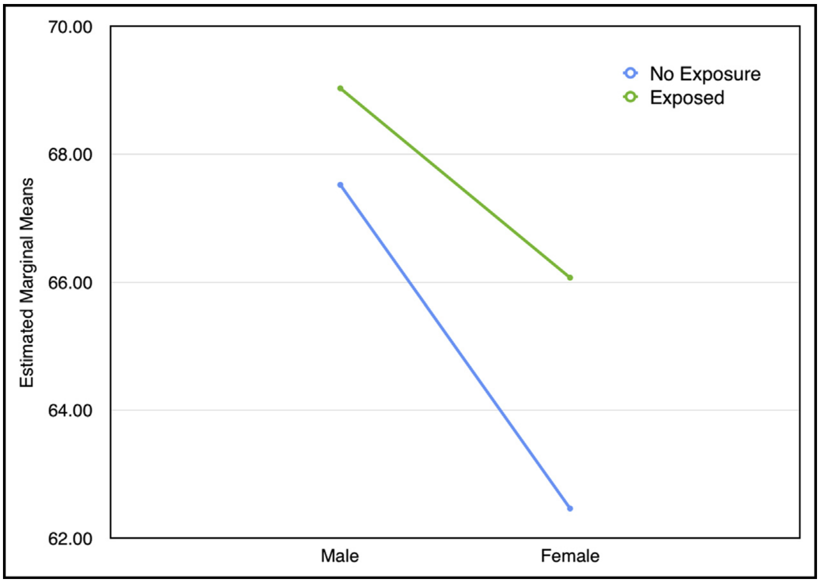

Fig 4. Estimated marginal means of the steps, according to the variations in gingival exposure.

smile.[4,21-23] For this reason, we conducted this study with photographs of smiles to increase the focus on local alterations and reduce the distraction of other facial characteristics.[3]

The photographs were taken with the mouth partially opened, in a way that the maxillary incisors were against a dark background, increasing the contrast, and resembling speech and spontaneous smiling.

The VAS is a reliable[24] and commonly used scoring method in health research to generate parametric data from subjective notions, such as pain, attractiveness, and anxiety, even though there is a tendency for some evaluators not to use the whole scale.[3,20] They tend to score around the central values, especially in comparative studies. This occurs because the evaluator is afraid of giving a high score to a situation in case he

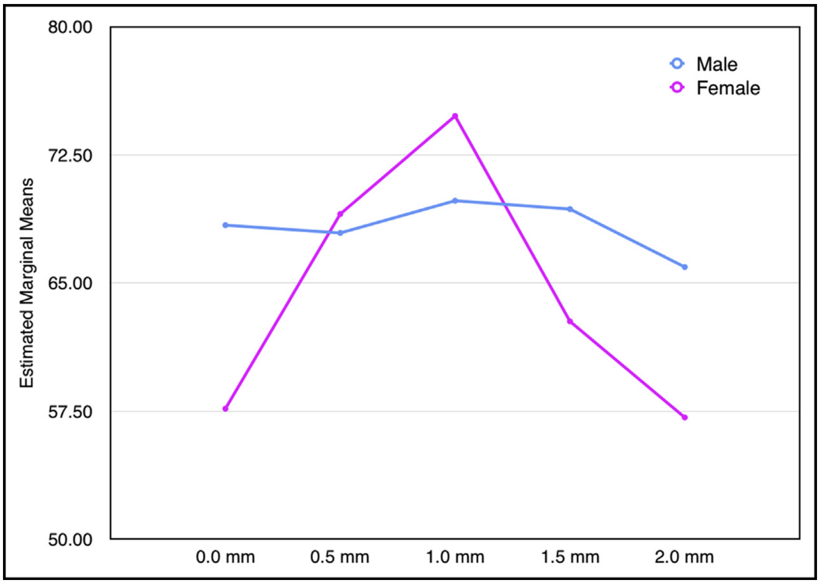

Fig 5. Estimated marginal means of the steps, according to sex variations.

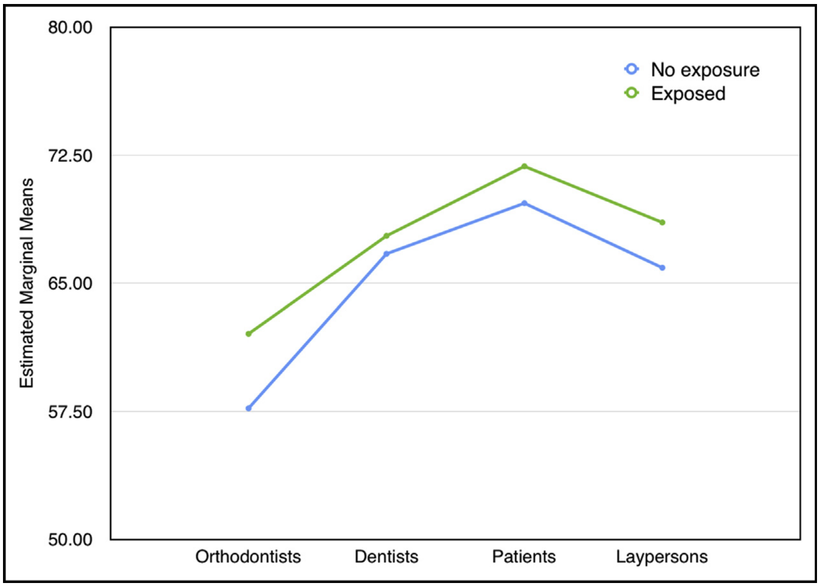

Fig 6. Estimated marginal means per evaluator group, according to the gingival exposure variations.

likes the next one better. In order to control this effect in this study, we showed a composition of all pictures of each model for 20 seconds before the evaluations, so that the evaluator would be calibrated to the more and less attractive pictures.

Since we used male and female models for the smiles, conclusions about the sex variations may reflect characteristics of the picture acquisition (inclination, framing, colors) or anatomic features of that person, not necessarily dependent on the model's sex. Because of this, the results should be viewed only as tendencies to be confirmed in future studies with more smiles from each sex.

Our findings were obtained in a defined population, so that their extrapolations to other situation should be done carefully, because of ethnic and sociocultural variations.

The orthodontist group was the only one with statistically significant differences compared with the others (Table IV), in contrast to the findings of Feu et al.[25]

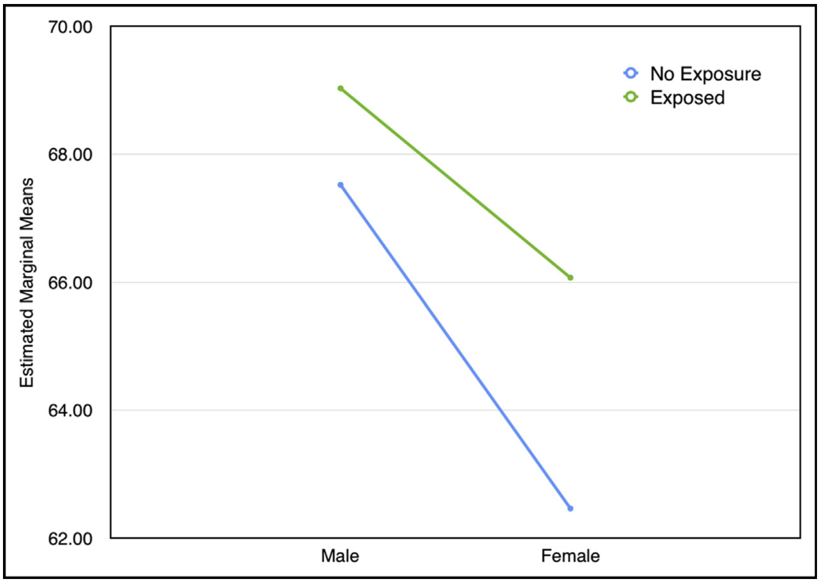

Fig 7. Estimated marginal means for sex, according to the gingival exposure variations.

Orthodontic patients provided the highest scores among the groups. During treatment, patients receive much information about the goals to be achieved, making them more analytical with regard to smiles, as suggested in some studies.[20] This is a possible explanation for the higher grades because the smiles analyzed did not exhibit orthodontic problems. Despite the lack of a statistically significant difference, the fact that their curve of evaluation had a distinct design from those of the laypersons, dentists, and orthodontists might indicate that it could be interesting to consider orthodontic patients as a different group from laypersons in future studies.

It was also shown that the means for dentists and laypersons were similar, perhaps because both groups tended to focus on the more general characteristics of the smile, such as the proportions, shape, and color of the teeth, since they were not influenced by the orthodontic aspect.

The orthodontists showed lower mean scores. This was understandable because the factors analyzed in this study are fundamental for evaluation of orthodontic treatment results, so they tended to be more strict in their evaluations. The same results have been found in other studies.[6,12-14] One can see that their preferences are more homogeneous and that they tolerate fewer deviations from what they consider to be correct. There is a great separation between the means for each step when compared with the other groups.

Table V shows the pairwise comparison of steps. There were statistically significant differences between all of them, except for the comparison of 0.0 and 2.0 mm. Both extremes were equally rejected, showing the lower means. The higher means were for 1.0 and 0.5 mm.

Despite this tendency, although extreme values appeared to elicit the same response in every group, the nominal value for each group was distinct. Orthodontists gave much lower grades for extremes, whereas for dentists, the difference was remarkably lower.

All groups showed significant discrepancies between the smiles with and without gingival exposure, except for the dentists, who gave similar scores for both cases. Perhaps this strengthens the idea that they are more concerned about the intrinsic characteristics of the smile, such as dental esthetics, placing less emphasis on the relationship with other structures, such as lips and gums.

Crossing step information with gingival exposure, one can notice that for the extreme values (0.0 and 2.0 mm), gingival exposure causes evident variations, probably because of the variations of the gingival contours with extrusion of the central incisors. This alteration is unesthetic because it breaks the harmony of smile lines.[1,8,10] When the gingival contour was hidden by the lip, this disharmony disappeared, making the step between incisal borders more significant for judgment.

It has been verified that maxillary gingival exposure and the position of the maxillary front teeth have definitive effects on the esthetic perception of a smile.[17] We found that the variations of gingival exposure produced statistically significant differences in that perception (Table IV). In general, the smiles with gingival exposure received better scores, especially in the pictures of the

Table III. Factors causing variations in esthetic perceptions in the SPANOVA

Source	P	*Partial eta squared**
Sex	0.000†	0.115
Sex + group	0.066	0.030
Gingival exposure	0.000†	0.062
Gingival exposure + group	0.336 NS	0.014
Step	0.000†	0.289
Step + group	0.000†	0.107
Sex + gingival exposure	0.009†	0.029
Sex + gingival exposure + group	0.683 NS	0.006
Sex + step	0.000†	0.284
Sex + step + group	0.000†	0.039
Gingival exposure + step	0.000†	0.271
Gingival exposure + step + group	0.000†	0.039
Sex + gingival exposure + step	0.000†	0.139
Sex + gingival exposure + step + group	0.186 NS	0.017

NS, statistically not significant.
*Correspondent to effect size; †statistically significant (P <0.05).

Table IV. Comparison between evaluator groups' overall means (post hoc Tukey test)

Group	*Mean difference*	*SD*	P*
Orthodontists			
Dentists	−7.390*	1.959	0.001
Patients	−10.911*	1.959	0.000
Laypersons	−7.375*	1.959	0.001
Dentists			
Patients	−3.522	1.959	0.277
Laypersons	0.015	1.959	1.000
Patients			
Laypersons	3.536	1.959	0.273

*Significant at P <0.050 (Bonferroni correction for multiple comparisons).

female model. Other studies demonstrated that smiles with some gingival exposure tended to be considered more attractive and young.[11,26] In this study, we aimed to turn an original smile with gingival exposure into a smile that could hide the gingival contour but not to quantify the amount of gum exposure or simulate the characteristics of more or less tooth display in a relaxed lip position or vertical excess of the maxilla.

The fact that the means for the 0.0-mm and 0.5-mm steps had large variations when the gingival contour was exposed strengthens the hypothesis that alterations in the gingival contour are as important as the incisal step in patients with gingival exposure.[3] This should be considered during planning and bonding, especially in patients with a gummy smile. The mean for the 0.5-mm step in this case was slightly higher than the mean

Table V. Differences in incisal step comparisons

Step	*Mean difference*	*SD*	P*
0.0			
0.5	−5.470*	0.481	0.000
1.0	−9.282*	0.662	0.000
1.5	−3.029*	0.626	0.000
2.0	1.484	0.663	0.262
0.5			
1.0	−3.811*	0.520	0.000
1.5	2.441*	0.622	0.001
2.0	6.954*	0.778	0.000
1.0			
1.5	6.252*	0.554	0.000
2.0	10.765*	0.758	0.000
1.5			
2.0	4.513*	0.474	0.000

*Significant at P <0.050 (Bonferroni correction for multiple comparisons).

for the 1.0-mm step; although this difference may not be statistically significant, it may indicate a tendency of clinical relevance.

When the effect of sex variation is added, distinct behavior can be seen: the highest means for the smiles of the man and the woman without gingival exposure corresponded to the 1.0-mm step, but for the smiles with gingival exposure, the highest means corresponded to the 0.0-mm step for the man and the 0.5-mm step for the woman (Table VI). Some studies have stated that steps varying from 1.0 to 1.5 mm are recommended for women, and steps from 0.5 to 1.0 mm are recommended for men.[6,11] Our findings reinforce the hypothesis that flat smiles are more accepted for men, and more convex smile arches better characterize attractive smiles for women.[3,26]

When this concept was verified in the groups, the orthodontists showed more homogeneity, preferring the 1.0-mm step in every variation of sex and gingival exposure tested. This is likely because orthodontists are better trained to observe this particular characteristic. When analyzing a smile, they may be more centered on the relationship between the central and lateral incisors than on its influence on the many factors of the smile.

For dentists, the preferred smiles of the women with and without gingival exposure had a 1.0-mm step, whereas for the men, the higher means corresponded to the 0.0-mm step with gingival exposure and the 1.5-mm step without gingival exposure. These findings imply the significance of the role of the gingival contour on this evaluation for dentists.

Orthodontic patients selected the 1.0-mm step in every situation, except for the smile of the woman

Table VI. Estimated marginal means from SPANOVA

Factor	Orthodontists		Dentists		Patients		Laypersons		Total	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
General	58.99	1.46	67.73	1.46	70.58	1.53	68.32	1.63	66.27	0.69
Sex										
Male	61.79	1.62	68.37	1.62	72.45	1.70	71.55	1.81	68.28	0.77
Female	56.20	1.69	67.08	1.69	68.71	1.77	65.09	1.88	64.27	0.80
Gingival exposure										
No exposure	56.81	1.69	67.23	1.69	69.28	1.77	67.66	1.89	64.99	0.80
Exposed	61.17	1.54	68.23	1.54	71.87	1.61	68.97	1.71	67.55	0.73
Step (mm)										
0.0	53.34	1.70	62.43	1.70	69.83	1.70	66.44	1.70	63.01	0.85
0.5	61.72	1.45	67.44	1.45	75.49	1.45	69.29	1.45	68.48	0.72
1.0	69.70	1.51	72.70	1.51	76.56	1.51	70.22	1.51	72.30	0.75
1.5	61.30	1.52	68.38	1.52	67.79	1.52	66.71	1.52	66.04	0.76
2.0	53.21	1.77	65.26	1.77	64.16	1.77	63.48	1.77	61.53	0.89
Sex + gingival exposure										
MN	60.27	1.90	68.37	1.90	71.85	1.99	71.85	1.99	67.52	0.90
ME	63.30	1.82	68.38	1.82	73.04	1.91	73.04	1.91	69.03	0.86
FN	53.36	1.91	66.08	1.91	66.71	2.00	66.71	2.00	62.46	0.90
FE	59.04	1.72	68.07	1.72	70.71	1.80	70.71	1.80	66.07	0.81
Sex + step										
M0.0	61.16	1.71	67.22	1.71	72.64	1.71	72.53	1.71	68.39	0.85
M0.5	59.93	1.74	66.53	1.74	74.66	1.74	70.60	1.74	67.93	0.87
M1.0	67.89	1.91	67.89	1.91	74.90	1.91	68.59	1.91	69.82	0.95
M1.5	65.87	1.68	69.45	1.68	70.74	1.68	71.26	1.68	69.33	0.84
M2.0	58.86	1.80	68.28	1.80	68.53	1.80	68.06	1.80	65.93	0.90
F0.0	45.52	2.19	57.65	2.19	67.03	2.19	60.36	2.19	57.64	1.10
F0.5	63.51	1.68	68.35	1.68	76.32	1.68	67.98	1.68	69.04	0.84
F1.0	71.50	1.63	77.52	1.63	78.22	1.63	71.86	1.63	74.77	0.82
F1.5	56.73	1.95	67.31	1.95	64.83	1.95	62.16	1.95	62.76	0.97
F2.0	47.57	2.20	62.25	2.20	59.79	2.20	58.90	2.20	57.13	1.10
Gingival exposure + step										
N0.0	48.58	2.01	59.10	2.01	66.47	2.01	63.67	2.01	59.45	1.00
N0.5	54.24	1.81	63.41	1.81	71.22	1.81	65.39	1.81	63.57	0.91
N1.0	68.33	1.83	73.19	1.83	75.30	1.83	70.01	1.83	71.71	0.92
N1.5	60.37	1.70	69.28	1.70	68.85	1.70	66.56	1.70	66.27	0.85
N2.0	56.84	2.00	68.61	2.00	66.58	2.00	63.88	2.00	63.98	1.00
E0.0	58.10	1.78	65.77	1.78	73.20	1.78	69.22	1.78	66.57	0.89
E0.5	69.20	1.54	71.47	1.54	79.76	1.54	73.18	1.54	73.40	0.77
E1.0	71.06	1.65	72.22	1.65	77.81	1.65	70.44	1.65	72.88	0.83
E1.5	62.23	1.76	67.48	1.76	66.72	1.76	66.85	1.76	65.82	0.88
E2.0	49.59	1.96	61.91	1.96	61.74	1.96	63.09	1.96	59.08	0.98
Sex + gingival exposure + step										
MN0.0	56.01	2.28	64.82	2.28	71.19	2.39	72.16	2.54	65.60	1.08
MN0.5	54.57	2.23	65.54	2.23	73.21	2.33	71.61	2.49	66.28	1.05
MN1.0	67.01	2.36	69.74	2.36	73.66	2.47	71.90	2.63	69.64	1.12
MN1.5	64.40	2.14	70.89	2.14	71.44	2.23	72.08	2.38	69.24	1.00
MN2.0	59.38	2.33	70.86	2.33	69.77	2.44	68.98	2.60	66.86	1.11
ME0.0	63.39	2.18	70.02	2.18	74.10	2.28	75.44	2.43	71.17	1.03
ME0.5	63.62	2.03	67.70	2.03	75.20	2.12	71.06	2.26	69.58	0.95
ME1.0	66.90	2.30	68.21	2.30	75.62	2.41	69.75	2.56	69.99	1.09
ME1.5	66.04	2.26	69.50	2.26	71.64	2.36	72.28	2.52	69.42	1.07
ME2.0	56.54	2.25	66.47	2.25	68.66	2.35	70.22	2.51	65.00	1.06
FN0.0	39.55	2.56	54.44	2.56	61.12	2.68	59.37	2.86	53.31	1.20
FN0.5	52.14	2.37	62.35	2.37	68.60	2.48	62.03	2.64	60.85	1.12
FN1.0	67.50	2.12	77.96	2.12	75.71	2.22	72.48	2.36	73.77	1.01
FN1.5	55.17	2.16	68.51	2.16	65.10	2.26	63.36	2.41	63.29	1.02
FN2.0	52.43	2.56	67.16	2.56	63.01	2.68	62.65	2.85	61.09	1.20

Table VI. Continued

Factor	Orthodontists		Dentists		Patients		Laypersons		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FH0.0	49.76	2.45	62.13	2.45	72.54	2.56	64.10	2.73	61.98	1.15
FH0.5	73.48	1.98	75.69	1.98	83.16	2.07	74.99	2.21	77.23	0.93
FE1.0	73.74	1.93	76.99	1.93	77.92	2.02	71.92	2.15	75.78	0.91
FE1.5	56.22	2.30	67.21	2.30	62.89	2.40	63.17	2.56	62.22	1.09
FE2.0	42.02	2.60	58.35	2.60	57.01	2.72	56.80	2.90	53.16	1.22

M, Male; *F*, female; *N*, no exposure; *E*, exposed; *00*, 0 mm; *05*, 0.5 mm; *10*, 1.0 mm; *15*, 1.5 mm; *20*, 2.0 mm.

with gingival exposure, where they significantly preferred the 0.5-mm step. This may indicate that orthodontic patients are closer to orthodontists in their preference than to laypersons or dentists, even though there was no statistical significance in this comparison.

Laypersons preferred a smile for a man with aligned incisal borders (0.0-mm step) with or without gingival exposure. The better-rated smile of the woman was the one with a 1.0-mm step without gingival exposure, but with the 0.5-mm step when the gingival contour was exposed. This shows the need for more defined steps in the smiles for women. When the gingival contour was hidden, making the steps less noticeable, they favored a larger step to make it more obvious.

In general, the smiles of the men got higher scores than those of the women, but this may have been due to the specific characteristics of the pictures, not necessarily because of the sex of the model in the picture. The smile means of the man varied considerably less than the means of the woman. This suggests a greater influence of the incisal step variation on the smiles of women.

It has been described that straighter arches were scored higher when there was less gingival display, and more curved smile arches had better results along with more gingival display; this is different from the results of our study.[3,27,28] Smaller steps received better scores with gingival exposure, and bigger steps were better evaluated without exposure. This could be justified by the harmony of the gingival contour that is broken by the extrusion of the central incisors, proving the important role played by the gingival contour in the composition of an attractive smile.

Because there were no variations in the positions of the lateral incisors and the canines, which would represent a true change in the smile arch, the display of a step between the gingival contour of the incisors in a smile with gingival exposure had a negative impact on esthetic evaluations.

The interaction of different factors had different effects on the esthetic perception of the smile. Table IV shows the factors that interact to create a statistically significant modification. Isolated factors, such as gingival exposure, incisal step, and sex, will have a larger effect than the interactions of these same factors because its action will be "diluted" with the other factors. It is clear in Table IV that the incisal step is the most significant factor because it has the largest effect size, but the interaction with other factors can also lead to modifications in the esthetic perception of the smile. This means, for example, that the variation of the gingival exposure changes the way a smile with a determined step is perceived, but the variation of the step also changes the way a certain type of gingival exposure is viewed.[3] The factors and interactions related to the incisal step are responsible for almost 3 quarters of the impact on the esthetic evaluations.

CONCLUSIONS

1. The most accepted vertical relationship of incisor borders was the 1.0-mm step.
2. There was a statistically significant difference in the esthetic perception from orthodontists when compared with dentists, laypersons, and orthodontic patients. No significant difference was detected between these last 3 groups.
3. The gingival display altered significantly the esthetic perception of the smiles evaluated.
4. There were statistically significant differences between the evaluations of the smiles of men and women.

REFERENCES

1. Câmara CA. Estética em ortodontia: seis linhas horizontais do sorriso. Dental Press J Orthod 2010;15:118-31.
2. McLeod C, Fields HW, Hechter F, Wiltshire W, Rody W Jr, Christensen J. Esthetics and smile characteristics evaluated by laypersons. Angle Orthod 2011;81:198-205.
3. Kaya B, Uyar R. Influence on smile attractiveness of the smile arc in conjunction with gingival display. Am J Orthod Dentofacial Orthop 2013;144:541-7.
4. Rodrigues CD, Magnani R, Machado MS, Oliveira OB. The perception of smile attractiveness. Angle Orthod 2009;79:634-9.

5. Krishnan V, Daniel ST, Lazar D, Asok A. Characterization of posed smile by using visual analog scale, smile arc, buccal corridor measures, and modified smile index. Am J Orthod Dentofacial Orthop 2008;133:515-23.
6. Machado AW, McComb RW, Moon W, Gandini LG Jr. Influence of the vertical position of maxillary central incisors on the perception of smile esthetics among orthodontists and laypersons. J Esthet Restor Dent 2013;25:392-401.
7. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop 2001;120: 98-111.
8. Câmara CA. Esthetics in orthodontics: interest points, reference points and discrepancy points. Dental Press J Orthod 2012;17:4-7.
9. Foulger TE, Tredwin CJ, Gill DS, Moles DR. The influence of varying maxillary incisal edge embrasure space and interproximal contact area dimensions on perceived smile aesthetics. Br Dent J 2010; 209:E4.
10. King KL, Evans CA, Viana G, BeGole E, Obrez A. Preferences for vertical position of the maxillary lateral incisors. World J Orthod 2008;9:147-54.
11. Machado AW. 10 commandments of smile esthetics. Dental Press J Orthod 2014;19:136-57.
12. Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod 2006;76:557-63.
13. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999;11:311-24.
14. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop 2006;130:141-51.
15. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod 1995;1:105-26.
16. Tjan AH, Miller GD, The JG. Some esthetic factors in a smile. J Prosthet Dent 1984;51:24-8.
17. Akyalcin S, Frels LK, English JD, Laman S. Analysis of smile esthetics in American Board of Orthodontics patients. Angle Orthod 2014;84:486-91.
18. Machado AW, Moon W, Gandini LG Jr. Influence of maxillary incisor edge asymmetries on the perception of smile esthetics among orthodontists and laypersons. Am J Orthod Dentofacial Orthop 2013;143:658-64.
19. Flores-Mir C, Silva E, Barriga MI, Lagravère MO, Major PW. Lay person's perception of smile aesthetics in dental and facial views. J Orthod 2004;31:204-9.
20. Witt M, Flores-Mir C. Laypeople's preferences regarding frontal dentofacial esthetics: tooth-related factors. J Am Dent Assoc 2011;142:635-45.
21. Correa BD, Bittencourt MA, Machado AW. Influence of maxillary canine gingival margin asymmetries on the perception of smile esthetics among orthodontists and laypersons. Am J Orthod Dentofacial Orthop 2014;145:55-63.
22. Springer NC, Chang C, Fields HW, Beck FM, Firestone AR, Rosenstiel S, et al. Smile esthetics from the layperson's perspective. Am J Orthod Dentofacial Orthop 2011;139:e91-101.
23. Nascimento DC, Santos ER, Machado AW, Bittencourt MA. Influence of buccal corridor dimension on smile esthetics. Dental Press J Orthod 2012;17:145-50.
24. Howells DJ, Shaw WC. The validity and reliability of ratings of dental and facial attractiveness for epidemiologic use. Am J Orthod 1985;88:402-8.
25. Feu D, Andrade FB, Nascimento AP, Miguel JA, Gomes AA, Capelli J Jr. Perception of changes in the gingival plane affecting smile aesthetics. Dental Press J Orthod 2011;16:68-74.
26. Zachrisson B. Esthetic factors involved in anterior tooth display and the smile: vertical dimension. J Clin Orthod 1998;32:432-45.
27. Ioi H, Nakata S, Counts AL. Influence of gingival display on smile aesthetics in Japanese adults. Eur J Orthod 2010;32:633-7.
28. Geron S, Atalia W. Influence of sex on the perception of oral and smile esthetics with different gingival display and incisal plane inclination. Angle Orthod 2005;75:778-84.