Details of pleasing smiles

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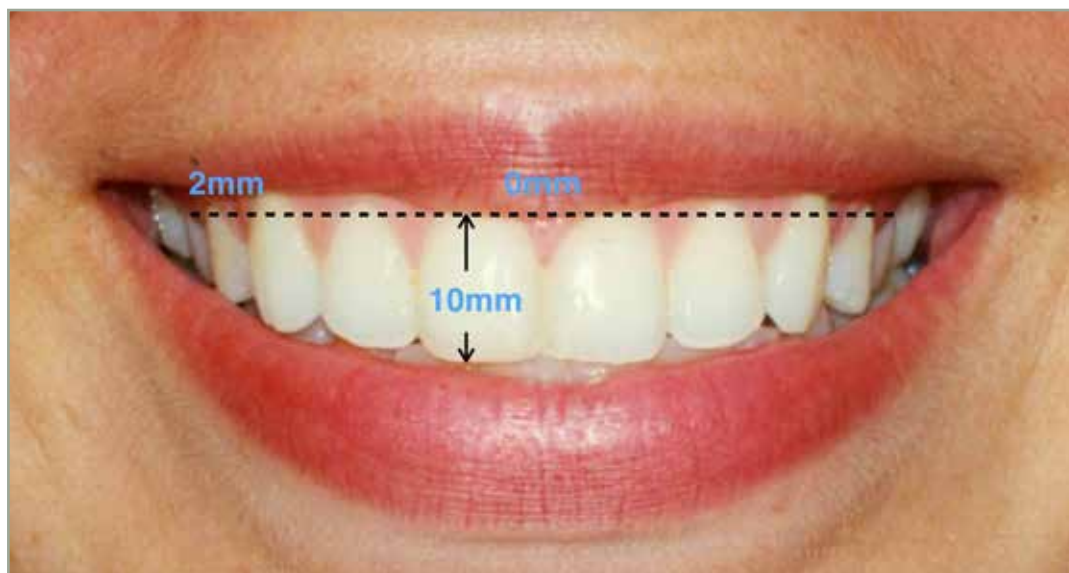
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Abstract

Purpose: To determine the most and least attractive smiles from a Brazilian sample and to correlate the anatomical characteristics identified in these smiles. *Materials and methods:* Orthodontists, dentists, and laypeople assessed the photographs of 86 students (66 women and 20 men), aged between 19 and 30 years, using a visual analog scale (VAS). An evaluator blinded to the results measured the esthetic composition of the eight photographs with the highest and the eight with the lowest ratings for women, and the two with the highest and the two with the lowest ratings for men. The mean and standard deviations were calculated for the descriptive analysis. *Results:* A total of 42 anatomical smile details were identified and described, obtaining the means of the characteristics.

Conclusions: The following characteristics were observed from the selected most attractive smiles: parallel smile arc, oval-shaped incisors with square-rounded edges, increase of the incisal embrasure and reduction of connector space in distal progression, display of maxillary incisors and minimum display of mandibular teeth, gingival margin of central incisors 0.5 mm coronal to the canines and 0.8 mm apical to the lateral incisors, posterior gingival display of 1.5 mm, less than 20% of buccal corridor and display of 12 teeth, and canines with -2 degrees of inclination. The most attractive smiles also had an absence of asymmetries, diastemas, black spaces, incisal plane inclination, and anterior gingival display.
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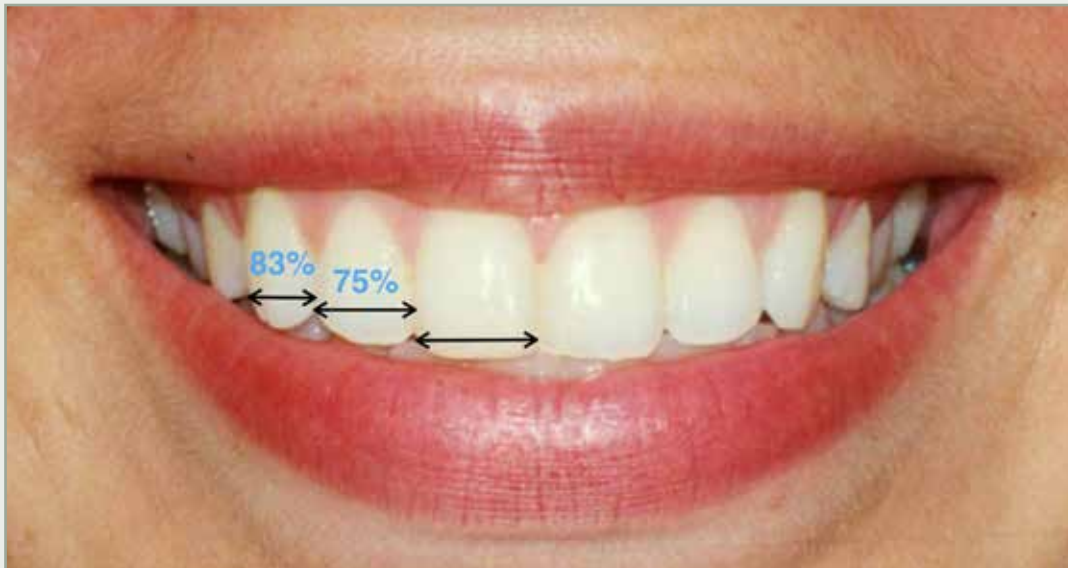
Introduction

Dental treatment can have a great influence on the attractiveness of a smile,[1] and this is sometimes a criterion that orthodontists, dentists, and laypeople use to judge the quality of orthodontic treatment.[2] Even if malocclusion has a greater psychological impact on a specific case,[3] understanding the factors that help or hinder the attractiveness of a smile is an important step in creating attractive smiles and achieving clinical success.[4]

In patients undergoing orthodontic treatment, the harmonic esthetics of the smile can be related to the height of the incisal edges,[5-7] type of smile arch,[5,8,9] absence of diastemas,[4,10,11] shape of incisors and canines,[12,13] amount of gingival exposure,[5,9-11,14-16] absence of black spaces,[16,17] height of the gingival margin,[7,10,17-19] incisal plane inclination,[16,17] and ratio of tooth size.[20,21] These are only some of the characteristics known to affect the esthetic results of orthodontic treatment.

To more precisely determine the details to be enhanced when finishing an orthodontic treatment, it is important to understand the judgment of the orthodontist, dentist, and layperson concerning the attractiveness of the smile. The preference among the different groups of evaluators may differ in terms of rating[10,16,20,22-25] due to orthodontic experience,[17,26] but the average score of the different groups was taken into account in determining the most pleasing smile. For assessment purposes, an observational tool such as a visual analog scale (VAS) has been shown to be reliable. [27] A score of 100 is widely used in studies to assess esthetic preferences.[6,7,11,15,17,19,24,28]

To achieve optimal esthetic results, it is imperative that orthodontists follow esthetic guidelines[6] and studies on standards and norms related to the attractiveness of smiles, to achieve a so-called 'golden smile.'[4] However, there are no specific studies in the literature that evaluate a natural smile and delineate the optimal smile characteristics.

Some studies on the esthetic perception of the smile have focused on digital manipulation of image details,[6,10-12,16,19,22,23,29-39] while others have adopted natural images without any digital manipulation.[5,40-42] Durgekar et al[56] selected five smiles with the highest and lowest scores; however, only seven features were assessed.

Thus, the aim of the present study was to determine the most and least attractive smiles in both males and females from a representative sample of smiles. This was achieved through the assessment of smiles by orthodontists, dentists, and laypeople using a VAS, and consequent correlation to the anatomical characteristics identified in the smiles.

Materials and methods

To conduct this study of a qualitative and quantitative assessment of smiles, an album was created containing 258 color photographs of smiles obtained from 86 students enrolled in a dentistry course – 66 women and 20 men, aged 19 to 30 years.

The photographs belong to the Department of Orthodontics of Fluminense Federal University. The study was

approved by the Institutional Review Board of the School of Dentistry under protocol no. 337193.

To be included in the photographic sample, the students had to meet the following criteria: complete permanent dentition, from second molar to second molar; Angle Class I molar relationship; normal overbite; good facial profile, tending to straight; no previous orthodontic treatment; and minor dental misalignments.

Three standardized photographs were taken of each student: 1) with lips at rest; 2) slightly smiling; and 3) broadly smiling. A Minolta (Osaka) camera, equipped with a fixed 100-mm macrolens, was used to take the photographs. Kodak-100 photographic film was used, and the object–film distance was 1 m. To take the frontal photograph, the position of the head of each individual was maintained with the Frankfurt horizontal plane parallel to the ground.

The images were scanned with an HP Scanjet G4050 scanner. Once they were digitized, Photoshop software (Adobe CS4) was used to reduce confounding factors such as possible rotations, and to crop the images to focus on the (perioral) area of interest, excluding the nose, cheeks, and chin.[35,43,44]

With the help of a programmer (GB), a website was developed on which the album of photographs was uploaded, and an online questionnaire was formulated for use by the orthodontists, dentists, and laypeople to assess the attractiveness of the smiles.

The orthodontist and dentist evaluators, all working in the city of Vitória, ES, Brazil, were drawn from a Dentistry Council list. The laypeople had no specific knowledge of oral esthetics or any education in the sciences or arts related to the study of faces (such as plastic surgery, esthetics or architecture).[25] The laypeople were graduate students attending public and private universities who were invited to be volunteers.

The number of evaluators was calculated based on population estimates, with the same parameters used for the three groups (orthodontists, dentists, and laypeople), ie, 90% confidence level and 10% error of proportion in order to detect 10% differences among the groups. Thus, for a population of 140 orthodontists, the sample consisted of 23 orthodontists; for a population of 1,643 dentists, the sample was 25; and, as there was no accurate estimate of the population of laypeople, the sample was calculated without the correction factor for a finite population, and consisted of 27 individuals.

Each evaluator rated the photographs using a VAS. A bar with a slider was developed on the website, and the evaluators placed the score on the scale to represent their judgment. A score of '0' was the lowest level of attractiveness, and '100' was the highest level (most attractive).

The number of students enrolled in the School of Dentistry was 350. Thus, it was decided to conduct a sample calculation in two scenarios. The first sample consisted of a simple random sample, with a 95% confidence level, maximum expected error of 9%, and ratio of 50%, which resulted in the highest possible value for the sample, maximizing variability and the correction factor for a finite population. Therefore, the sample established was composed of

Table 1 An evaluation chart of the details of the smiles selected and appropriate variations according to previous studies

Number		Characteristics	Variations		
Tooth position	1	Step between CI edges[6]	( ) 0 mm ( ) 0.5 mm	( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) _____
	2	CI-to-LI incisal step[7]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) _____
	3	Step between LI edges[6]	( ) 0 mm ( ) 0.5 mm	( ) 1.5 mm ( ) 1 mm	( ) 2 mm ( ) _____
	4	Step between the cusps of the canines[19]	( ) 0 mm ( ) 0.5 mm	( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) _____
	5	Disposition of the maxillary incisors, incisal edges, and the lower lip[44,48,49]	( ) Parallel ( ) Straight	( ) Inverted ( ) _____	
Tooth shape	6	Shape of incisal edges[12,13]	( ) Square ( ) Round	( ) Square-rounded ( ) _____	
	7	Shape of incisors[54]	( ) Oval ( ) Square	( ) Triangular ( ) _____	
	8	Shape of canines[12,13]	( ) Flat ( ) Pointed	( ) Round ( ) NA	
Incisal embrasure	9	CI incisal embrasure[54,55,58]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) NA ( ) _____
	10	CI and LI incisal embrasure[54,55,58]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) NA ( ) _____
	11	LI and canine embrasure[54,55,58]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) NA ( ) _____

Number		Characteristics	Variations		
Interdental spaces	12	Diastema between CI[10,11,23,35]	( ) Absence ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) _____
	13	Diastema between CI and LI[50]	( ) Absence ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) _____
	14	Black spaces[16,46,47]	( ) Absence ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) _____
Gingival and dental display	15	Gingival display above CI[9,10,14,15,35,44]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) 2.5 mm ( ) 3 mm ( ) 3.5 mm	( ) 4 mm ( ) 4.5 mm ( ) 5 mm ( ) _____
	16	Posterior canine gingival display[52]	( ) 0 mm ( ) 1 mm ( ) 2 mm	( ) 3 mm ( ) 4 mm ( ) 5 mm	( ) 6 mm ( ) 7 mm ( ) _____
	17	Maxillary CI display[14,51,54,63]	( ) 5.5 mm ( ) 6 mm ( ) 6.5 mm	( ) 7 mm ( ) 7.5 mm ( ) 8 mm	( ) 8.5 mm ( ) 9 mm ( ) _____
	18	Mandibular CI display[51]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) 3.5 mm ( ) _____
Periodontal esthetics	19	CI-to-canine gingival margin[7]	( ) 1mm above ( ) 0mm	( ) 0,5mm below ( ) 1mm below	( ) _____ ( ) NA
	20	CI-to-LI gingival margin[11]	( ) 0 mm ( ) 0.5 mm below	( ) 1 mm below ( ) 2 mm below	( ) _____ ( ) NA
	21	Asymmetry between gingival margin of CI[17,19,35]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm	( ) 1.5 mm ( ) 2 mm ( ) 2.5 mm	( ) 3 mm ( ) _____ ( ) NA
	22	Papillae height[23,35]	( ) Symmetric ( ) Asymmetric	( ) Unexposed	

Table 1 cont

Number		Characteristics	Variations		
Tooth size and proportion	23	CI connector height[55,58]	( ) 0.5 mm ( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) 2.5 mm ( ) 3 mm	( ) 3.5 mm ( ) _____ ( ) NA
	24	CI connector height ratio[55,58]	( ) 15% ( ) 20% ( ) 25%	( ) 30% ( ) 35% ( ) 40%	( ) 45% ( ) _____ ( ) NA
	25	CI and LI connector height[55,58]	( ) 0.5 mm ( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) 2.5 mm ( ) 3 mm	( ) 3.5 mm ( ) _____ ( ) NA
	26	CI and LI connector height ratio[55,58]	( ) 15% ( ) 20% ( ) 25%	( ) 30% ( ) 35% ( ) 40%	( ) 45% ( ) _____ ( ) NA
	27	LI and canine connector height[55,58]	( ) 0.5 mm ( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) 2.5 mm ( ) 3 mm	( ) 3.5 mm ( ) _____ ( ) NA
	28	LI and canine connector height ratio[55,58]	( ) 15% ( ) 20% ( ) 25%	( ) 30% ( ) 35% ( ) 40%	( ) 45% ( ) _____ ( ) NA
	29	Comparison of width between LI[10,11,17,35]	( ) Symmetric ( ) Asymmetric	( ) NA ( ) _____	
	30	CI width/height ratio[5,20,55,63]	( ) 60% ( ) 65% ( ) 70% ( ) 75%	( ) 80% ( ) 85% ( ) 90%	( ) 95% ( ) 100% ( ) _____
	31	LI to CI width ratio[21]	( ) 45% ( ) 50% ( ) 55%	( ) 60% ( ) 65% ( ) 70%	( ) 75% ( ) 80% ( ) NA
	32	Canines to LI width ratio[21]	( ) 45% ( ) 50% ( ) 55%	( ) 60% ( ) 65% ( ) 70%	( ) 75% ( ) 80% ( ) NA

Number		Characteristics	Variations		
Width and extent of smile	33	Smile height (interlabial gap)[44,56]	( ) 7 mm ( ) 7.5 mm ( ) 8 mm	( ) 8.5 mm ( ) 9 mm ( ) 9.5 mm	( ) 10 mm ( ) 10.5 mm ( ) _____
	34	Smile index (intercommissural width divided by interlabial gap)[56,57,69]	( ) 4 mm ( ) 5 mm ( ) 6 mm	( ) 7 mm ( ) 8 mm ( ) 9 mm	( ) 10 mm ( ) 11 mm ( ) _____
	35	Buccal corridor[88,32,38,56]	( ) 0 mm ( ) 0.5 mm ( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) 2.5 mm ( ) 3 mm ( ) 3.5 mm	( ) 4 mm ( ) 4.5 mm ( ) 5 mm ( ) _____
	36	Buccal corridor ratio[8,32,38,56]	( ) 0% ( ) 5% ( ) 10%	( ) 15% ( ) 20% ( ) 25%	( ) 30% ( ) _____ ( ) NA
	37	Teeth displayed[24]	( ) 10 teeth ( ) 12 teeth	( ) 14 teeth ( ) _____	
Tooth inclinations	38	Incisal plane inclination[38,39]	( ) 0 degrees ( ) 0.5 degrees	( ) 1 degrees ( ) 1.5 degrees	( ) 2 degrees ( ) _____
	39	Buccolingual inclination of canines[28]	( ) -5 degrees ( ) -3 degrees	( ) 0 degrees ( ) 5 degrees	( ) NA ( ) _____
Dental midline	40	Upper midline and face[11,17,19]	( ) Coincident ( ) 0.5 mm	( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) _____
	41	Lower midline and face[39]	( ) Coincident ( ) 0.5 mm	( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) _____
	42	Upper and lower midline[48,53]	( ) Coincident ( ) 0.5 mm	( ) 1 mm ( ) 1.5 mm	( ) 2 mm ( ) _____

CI: central incisor; LI: lateral incisor; NA: not able to evaluate

86 students. As this is a heterogeneous population, it was decided to divide it into sub-populations.[45] The technique used for the calculation was stratified sampling with proportional allocation, establishing a sample of 66 female and 20 male students.

When evaluating the smiles of each of the 86 students, the ratings attributed to their esthetics were given by orthodontists, dentists, and laypeople. Thus, for the second stage of the sample calculation, but now using the mean scores, the following parameters were used to determine the best and worst smiles of the sample: 95% confidence level, maximum expected error of 10%, and population standard deviation of 26.[37] Therefore, the sample size was 20, and again, using the stratified sampling with proportional allocation, 16 females and four males were obtained.

The esthetic compositions of the smiles from 16 broadly smiling photographs of women – the eight most voted for and the eight least voted for – and four men (following the same criteria), selected by the three groups of evaluators were assessed by a blind evaluator (VLBM) on two occasions to assess intra-evaluator error.

The most frequently judged smile components from publications related to this subject were assessed,[5-17,19-21,23,28,32,35,38,39,44,46-59,61,62] as shown in Table 1. The connector is the place above the contact points where teeth appear to touch, and its proportions in relation to the central incisor were calculated. The buccal corridor proportion was calculated in relation to the intercommissural distance. A smile index was calculated by dividing the intercommissural width by the interlabial gap. A total of 42 smile variables were determined, of which 36 were numerical and eight categorical.

The 20 photographs (16 women and four men) voted to be the most and least attractive, as selected by the three groups of evaluators, were corrected to a 1:1 ratio related to real size. The correction factor was 0.995, and so the 1:1 ratio was considered.

The blind evaluator (VLBM) – a 30-year-old dentist – calibrated the features using a millimeter screen (Velopex), a protractor and, in cases of doubt, a digital caliper (Starrett), to quantitatively assess the photographs. The measurements were recorded in the column for variations (Table 1). When the measurements of the characteristics on the right and left sides of the smile differed, a mean value was used. Finally, the evaluator noted the features as 'not able to evaluate' (NA) if they were not fully visible or were impossible to measure. The data that differed in the table were noted when this situation occurred. The evaluator performed the same measurements in two stages, with an interval of 1 week between them.

To verify the intrarater agreement of the measurements for the continuous variables, an intraclass correlation coefficient (ICC) was suggested. Measurements of the central trend (mean and standard deviation) were used to summarize and describe the data obtained from the VAS scales. Comparisons were stratified by scale, gender, and group (orthodontists, dentists, and laypeople). The means of the measurements of the 42 features related to the eight highest-rated and eight lowest-rated smiles for

Table 2 Descriptive analysis of the images according to gender and group of evaluators

Evaluation		Dentists		Laypersons		Orthodontists		Mean
Gender	Image	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Female highest score	1	62.6	18.3	56.4	23	62.6	17.5	60.3
	15	65.5	21.3	62.6	23.8	62.5	17.5	63.5
	19	61.1	24.2	49.1	27.8	60	18.8	56.4
	25	80.4	16.2	77.9	23.3	69.6	20.7	76.2
	27	65.8	18.7	55.4	25.5	62.6	21	61.1
	29	70.4	19.5	57	23.9	68.5	18.2	65.0
	39	71.7	14.6	52.4	25	55	19.4	59.6
	53	56.2	25	56.6	27.4	59.7	28.1	57.4
Female lowest score	2	27.1	19.3	25	12.8	33	16.3	28.5
	8	15	14.1	15.8	11.7	22	15	17.4
	16	25.2	18.6	25.8	18.6	27.8	14.5	26.2
	18	19.7	18.9	14.1	12	19.3	11.3	17.5
	23	14.8	16.5	9.8	6.9	19.9	14.1	14.6
	44	20.1	15.5	14.3	12.6	25.8	15.7	19.7
	46	34.4	19.5	20.1	16.1	35.3	17.2	29.5
	48	34	23.6	25.1	15.9	29.7	18.7	29.5
Male highest score	69	78.6	12.8	60.4	19.5	69.4	26.5	69.46
	75	66.9	19.2	60.1	18.9	62.5	20	63.1
Male lowest score	82	19.1	18	19.7	13.2	20.4	15.4	19.7
	84	16.2	16.9	15.6	10.6	20.4	16.9	17.4

Table 3 Means and standard deviations of the continuous variables per group of photographs

	Continuous variables	Highest female		Lowest female		Highest male		Lowest male	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Step between CI edges (mm)	0.07	0.19	0.29	0.49	0.13	0.18	0.00	-
2	CI-to-LI incisal step (mm)	1.21	0.64	1.17	0.61	2.25	0.35	-0.25	-
3	Step between LI edges (mm)	0.44	0.50	0.50	0.55	0.75	1.06	0.13	0.18
4	Step between the cusps of the canines (mm)	0.54	0.85	0.83	0.98	1.00	-	1.00	-
9	CI incisal embrasure (mm)	0.47	0.39	0.64	0.38	0.50	0.00	0.00	-
10	CI and LI incisal embrasure (mm)	0.53	0.41	0.89	0.61	1.00	0.00	0.00	-
11	Canines and LI incisal embrasure (mm)	0.88	0.27	0.97	0.57	1.50	0.71	1.00	-
12	Diastema between CI (mm)	0.00	0.00	0.25	0.71	0.00	0.00	0.50	0.71
13	Diastema between CI and LI (mm)	0.00	0.00	0.25	0.46	0.00	0.00	0.00	0.00
14	Black spaces (mm)	0.03	0.09	0.06	0.18	0.00	0.00	0.00	-
15	Gingival display above CI (mm)	0.13	0.35	1.38	1.77	0.00	0.00	0.00	0.00
16	Posterior gingival display (mm)	1.44	1.18	1.25	1.58	1.75	0.35	0.50	0.71
17	Maxillary CI display (mm)	9.00	1.07	7.50	1.58	11.13	0.18	5.63	4.07
18	Mandibular CI display (mm)	1.88	1.46	1.38	1.51	1.00	1.41	3.00	4.24
19	CI-to-canine gingival margin (mm)	0.50	1.00	-0.50	0.58	-	-	-	-
20	CI-to-LI gingival margin (mm)	0.83	0.29	0.88	0.63	-	-	-	-
21	Asymmetry between gingival margin of CI (mm)	0.17	0.29	0.00	0.00	-	-	-	-
23	CI connector height (mm)	3.50	1.31	2.83	0.75	4.00	1.41	4.00	-

	Continuous variables	Highest female		Lowest female		Highest male		Lowest male	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
24	CI connector height (%)	39.60	15.26	38.42	5.61	-	-	-	-
25	CI and LI connector height (mm)	3.31	0.96	2.70	0.57	3.50	0.71	-	-
26	CI and LI connector height (%)	38.20	9.34	25.00	3.92	-	-	-	-
27	Canine and LI connector height (mm)	2.56	0.73	2.57	1.10	3.50	0.71	3.00	-
28	Canine and LI connector height (%)	29.80	6.57	24.30	11.42	-	-	-	-
30	CI width/height ratio (%)	79.20	11.34	79.38	10.84	-	-	-	-
31	LI to CI width ratio (%)	67.69	7.04	66.61	6.48	75.00	0.00	-	-
32	Canine to LI width ratio (%)	85.38	14.03	86.07	15.40	78.75	18.03	-	-
33	Smile height (mm)	10.25	2.19	9.75	2.12	12.50	0.71	9.00	8.49
34	Smile index	6.15	1.33	5.78	1.15	5.50	0.71	12.00	11.31
35	Buccal corridor (mm)	10.63	2.26	12.38	6.35	12.50	3.54	13.50	2.12
36	Buccal corridor (%)	17.36	3.50	21.62	9.38	18.11	3.85	22.50	3.54
37	Teeth displayed	12.00	0.00	10.25	1.16	12.00	0.00	11.00	1.41
38	Incisal plane inclination (degrees)	0.00	0.00	0.06	0.18	0.00	0.00	0.00	-
39	Canine buccolingual inclination (degrees)	-2.14	2.67	-0.93	1.88	0.00	0.00	-1.00	-
40	Upper midline and face (mm)	0.00	0.00	0.31	0.70	0.50	0.71	0.00	0.00
41	Lower midline and face (mm)	0.80	0.84	1.50	1.00	0.00	-	2.00	-
42	Upper and lower midline (mm)	0.80	0.84	1.50	1.00	0.00	-	2.00	-

CI: central incisor; LI: lateral incisor; (-): not able to evaluate; (*): ICC single measurement;
SD: standard deviation

Fig 1 Adequate level of the incisal edges and gingival margins. Incisal edges parallel to the lower lip.

the women (and two highest/lowest for the men), obtained by the VAS were calculated.

Results

The means and standard deviations of the scores for each gender, assigned by the orthodontists, dentists, and laypeople using the VAS, are shown in Table 2. Among 66 images of women, eight images with the highest scores and eight with the lowest were selected. From these images, four were selected, two with the highest and two with the lowest scores. Figure 1 shows the best smile, as selected by the three groups of evaluators.

The 42 variables were divided into continuous and categorical groups. The means and standard deviations for the 36 continuous variables (of the most and least attractive male and female smiles) for each group are shown in Table 3, and the six categorical variables in Table 4. All variables showed significant ICC, ie, there was agreement between the two measurements, which confirms the reliability of the method. The variables 'diastemas between central

and lateral incisors' and 'incisal plane inclination' showed the maximum coefficients (1.00), so there was complete agreement on the two measurements for the same photograph. The variables 'gingival margin of central incisors' and 'width proportion of lateral incisors and central incisors' showed the lowest coefficient (0.63), but this was still satisfactory. All other variables were satisfactory ($0.40 \leq$ ICC < 0.75) and optimum (ICC ≥ 0.75), according to Szklo and Nieto,[60] resulting in similar measurements for the two timepoints.

For the most and least attractive male smiles, the covering of the maxillary incisors made it impossible to calculate the gingival margin difference between the central incisors and the canines, the gingival margin difference between the lateral and central incisors, the gingival margin difference between the central incisors, the height of the contact point of the central incisors (%), the height of the contact point of the central incisors and the lateral incisors (%), the height of the contact point of the lateral incisors with the canines (%), or the width/height proportion of the central incisors. Neither the width proportion between the lateral incisors and central incisors among the least attractive male smiles, nor the incisal edges between the central and lateral incisors among the most attractive male smiles were assessed because there were only two cases in the sample.

Discussion

The dental and gingival components were classified and are discussed

Table 4 Characterization of categorical variables per groups assessed

| Number	Categorical variables		Highest female		Lowest female		Highest male		Lowest male	
			n	%	n	%	n	%	n	%
5	Incisal edges and inferior lip	Inverted	0	0.0	0	0.0	0	0.0	1	50.0
		Parallel	6	75.0	1	12.5	2	100.0	0	0.0
		Straight	1	12.5	6	75.0	0	0.0	0	0.0
		NA	1	12.5	1	12.5	0	0.0	1	50.0
6	Shape of incisal edges	Round	0	0.0	1	12.5	0	0.0	0	0.0
		Square-round	8	100.0	7	87.5	2	100.0	1	50.0
		Square	0	0.0	0	0.0	0	0.0	0	0.0
		NA	0	0.0	0	0.0	0	0.0	1	50.0
7	Shape of incisors	Oval	7	87.5	6	75	2	100.0	0	0.0
		Square	1	12.5	2	25.0	0	0.0	0	0.0
		Triangular	0	0.0	0	0.0	0	0.0	1	50.0
		NA	0	0.0	0	0.0	0	0.0	1	50.0
8	Shape of canines	Round	4	50.0	3	37.5	0	0.0	0	0.0
		Flat	0	0.0	1	12.5	0	0.0	1	50.0
		Pointed	3	37.5	4	50.0	1	50.0	0	0.0
		NA	1	12.5	0	0.0	1	50.0	1	50.0
22	Papillae height	Asymmetric	0	0.0	1	12.5	0	0.0	0	0.0
		Unexposed	0	0.0	1	12.5	0	0.0	1	50.0
		Symmetric	8	100.0	6	75.0	2	100.0	1	50.0
		NA	0	0.0	0	0.0	0	0.0	0	0.0
29	Comparison of width between lateral incisors	Symmetric	8	100.0	5	62.5	2	100.0	0	0.0
		Asymmetric NA	0 0	0.0 0.0	0 3	0.0 37.5	0 0	0.0 0.0	0 2	0.0 100.0

NA: not able to evaluate
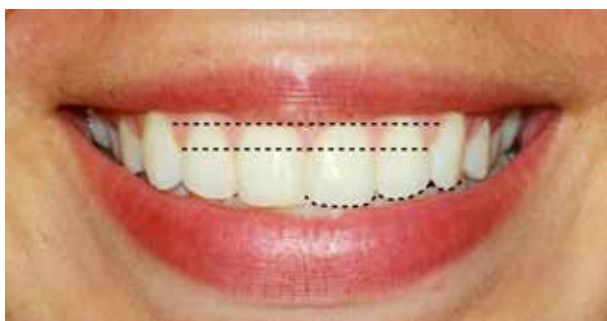
Fig 2 Symmetric interdental papillae height. Square-rounded incisal edges and round canine cusps.

Fig 3 Well-delimited incisal embrasure. Absence of black spaces and diastemas.

according to their location in the spatial plane:

- Smile line: related to tooth position, tooth shape, and incisal embrasure.
- Gingival components: related to gingival and dental display, periodontal esthetics, and interdental spaces.
- Horizontal arrangement: tooth size and proportion, width and extent of smile, tooth inclinations, and dental midline.

Smile line

Tooth position

The best-rated male and female smiles showed no steps between the maxillary central incisors, corresponding to the ideal standard (Fig 1).[6] There should be no difference between the incisal edges of the lateral incisors, 1 mm being the limit accepted by laypeople;[6] nevertheless, the best-rated male smile presented 0.75 mm.

Between the central and lateral incisors, the mean step in the best-rated female smile was 1.2 mm (± 0.64), close to 1.2 mm,[39] 1.4 mm,[38,61] and 1.5 mm.[7] For males, a measurement of 2.25 mm (± 0.35 mm) indicated that other details

defined these as the best smiles, but this was still within the acceptable limit of 2.9 mm.[61] The difference between the cusp heights of the canines was between 0.5 and 1 mm in all the groups assessed, which corroborates the notion that cusp wear has no esthetic impact.[19]

Incisal edges parallel to the lower lip were the preferred shape in the most attractive smiles, which is in agreement with most studies (Fig 1).[38,39,49,62] An inverted shape is considered less attractive,[49] and this was observed in the least attractive male smile. Flat smiles also decrease attractiveness,[8] and these were observed in 75% of the least attractive female smiles.

Tooth shape

Square-rounded incisal edges were observed predominantly in all of the groups assessed, and they were the ones preferred in other studies.[12,13] Oval-shaped incisors were the most frequently observed in the groups, except among the least attractive male smiles. Similarly, in other studies, oval-shaped incisors were more pleasing in women, while square incisors were more pleasing in men.[40,54] Round canine cusps were observed in

Fig 4 Gingival and dental display.

Fig 5 Incisors and canine connector height.

the most attractive female smiles; pointed canines were rated least attractive in women and more attractive in men; and flat canines were rated least attractive in men; however, this feature has little influence on esthetic perceptions.[12,13]

Incisal embrasure
Incisal embrasure increased in the distal progression of the central incisors in all groups, which is in agreement with most studies (Fig 3).[54 55,58] One of the worst-rated male smiles had no space between the maxillary central incisors and the central to lateral incisors, causing a negative esthetic impact.[58]

Gingival components

Gingival and dental display
No gingival display above the central incisors was observed in the most attractive smiles (up to 0.13 mm in women), which is in agreement with other studies.[9,39,62] The best-rated smile presented a posterior gingival display of 1.44 mm in women, and 1.75 mm in men (Fig 4).[52]

Maxillary incisors with greater vertical exposure were found in the best-rated smiles – 9 mm in female smiles and 11 mm in male smiles. These values are similar to those of other studies,[54,63] and correspond to the natural size of these teeth.[54] The least attractive male smiles displayed mandibular incisors of up to 3 mm, greater than individuals at rest above the age of 50 years.[51]

Periodontal esthetics
The gingival margins of the central incisors should be at the same level,[19,38,39] 0.5 mm coronal to the canines, which is in agreement with other studies,[7,62] and 0.83 mm apical to the lateral incisors. When the central incisor margin is coronal to the lateral incisor, the esthetic influence is negative.[11]

The height of the interdental papillae should be symmetrical, which is in agreement with other studies (Fig 2).[23,35]

Interdental spaces
Smiles without a diastema are always preferable to those with a diastema, even if the diastema is only 0.5 mm in size.[10,11] Diastemas between the central incisors of 0.25 mm in women and 0.5 mm in men were rated as the least attractive smiles. The least attractive female smiles presented a diastema

Fig 6   Height/width ratio of central incisor.

Fig 7   Width ratio between central incisor/lateral incisor and lateral incisor/canine.

of 0.25 mm between the central incisor and lateral incisor, causing a negative esthetic impact.[50]

Black spaces also negatively affect smiles,[46,47] but were not observed in either group (max 0.06 mm).

Horizontal arrangement

Tooth size and proportion

The connector height of the central incisors was 39.6% of the length of the central incisors, 38.2% between the central incisor and the lateral incisor, and 29.8% between the lateral incisor and the canine (Fig 5). These values are close to the 50-40-30% rule;[54,55] 3.5-3.3-2.5 mm was observed.

The width/height proportion of the central incisor in the female smile was 79%, being in agreement with most studies,[20,54,55,63] and symmetrical lateral incisors were present in the best-rated smiles (Fig 6).[10,11,17,35] The width proportions between the lateral and central incisors in the best-rated smiles were 67% and 75%, and 78% and 85% between the canines and lateral incisors – values slightly above the golden proportion when converted (Fig 7).[54,59]

Width and extent of smile

The distance between the upper and lower lip in the best-rated smiles was 10.25 and 12.5 mm, respectively, which can be estimated as an average smile height (Fig 8).[44,56] The smile index for the best-rated smiles was 5.5 to 6.15, similar to that found by Durgekar et al.[56]

The buccal corridor was between 10.6 and 12.5 mm, and 17.36% and 18.11% in the best-rated male and female smiles, respectively. These values are similar to those found by some authors[38,64,65] but different from those found by others,[48,49,56] probably because the characteristic has little esthetic influence.[1,32,66]

The best-rated smiles displayed 12 teeth, but according to Martin et al,[24] 10 teeth are preferred.

Tooth inclinations

No incisal plane inclination was found in the best-rated smiles, which is in agreement with other studies.[17,38,39,67] The buccolingual inclinations of the canines was 0 and -2 degrees in the best-rated smiles, similar to those of other studies.[28,68]

Fig 8 Smile height and smile index.

Fig 9 Absence of incisal plane inclination and angulation of canines. Midline without deviation.

Dental midline

Deviations of up to 0.5 mm from the upper midline were found in the best-rated male smiles, a value that is not detectable.[17,19,48] Deviations of 2 mm from the lower midline were observed in the worst-rated male smiles, not detectable in relation to the face,[39] but detectable in relation to the upper midline (Fig 9).[48]

Conclusions

The best and worst smile characteristics, according to the preferences of orthodontists, dentists, and laypeople, are as follows:

Most attractive smiles

- Edges of central incisors at the same level, 1.2 mm below the lateral incisors in women.
- No differences between the edges of the lateral incisors.
- No differences between the cusps of the canines.
- Incisal edges parallel to the lower lip.
- Oval-shaped incisors with square-rounded edges.
- Round canines in women and pointed canines in men.
- Increase of the incisal embrasure in distal progression.
- Absence of diastemas and black spaces.
- No anterior gingival display, and approximately 1.5 mm of posterior display.
- Vertical exposure of maxillary incisor of 9 mm in women, and 11 mm in men.
- Gingival margin of central incisors at the same level, 0.5 mm coronal to the canines and 0.8 mm apical to the lateral incisors.
- Reduced connector height in distal progression.
- Symmetrical papillae height.
- LI symmetrical in width.
- Height/width proportion of central incisors of 79%.
- Width proportion between lateral incisor and central incisor of 68% in women, and 75% in men.
- Width proportion between canines and lateral incisor of 85% in women, and 79% in men.
- Smile height between 10.5 and 12.5 mm.

- Buccal corridor below 20%, and 12 teeth displayed.
- Absence of incisal plane inclination.
- Canines with -2 degrees of inclination.
- Absence of dental midline deviation.

Least attractive smiles

- Straight arch smile in women and inverted smile in men.
- Triangular male incisors.
- Pointed canines in women and flat canines in men.
- Presence of diastemas.
- Display of maxillary incisors up to 7.5 mm in women, and 5.6 mm in men, and greater display of mandibular teeth.

- Smile width and extent: height lower than 10 mm and smile index of 12 mm in men.
- Buccal corridor above 20%, and fewer than 12 teeth displayed.
- Deviation of 2 mm from the lower dental midline in relation to the face and upper dental midline.

Clinical relevance

The goals to be sought at the end of dental treatment are made clearer by the results obtained in this study.

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