Scientific Research Report

Morphological features of smile attractiveness and related factors influence perception and gingival aesthetic parameters

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ARTICLE INFO

Article history:
Received 3 February 2021
Accepted 4 February 2021
Available online 9 March 2021

Key words:
Morphological feature
Smile attractiveness
Gingival aesthetic parameter
Vietnamese people

ABSTRACT

Introduction: In addition to understanding the basic standards of a smile and patient's opinion, dentists should take into account smile aesthetics, an essential factor for optimal outcomes. This study aimed to evaluate the factors that affect the perception of an aesthetic smile and determine its morphological characteristics and measure the gingival aesthetic parameters.

Methods: In all, 200 Vietnamese aged 18-35 years were recruited to have their spontaneous smiles captured. These smile images were assessed by 50 laypersons and 50 dentists using a visual analogue scale measurement. The images were analysed to evaluate perceptions of evaluators, determine smile attractiveness, and measure gingival aesthetics.

Results: The difference in the judgements of laypersons and dentists, males and females, and laypersons aged 18-25 and 26-35 years were nonsignificant. High or average anterior smile line, parallel smile arc, upward upper lip curvature, second premolars as the posterior-most teeth displayed, smile index of 5.23-5.63, and dynamic smile symmetry of 1 were scored highly on smile attractiveness. The following maxillary gingival aesthetic parameters were preferred: gingival zenith (GZ) of the canine 0.72-0.75 mm apical to the GZ of the central incisor; GZ of the lateral incisor 0.66 mm coronal to the gingival line; gingival line angle of ~87°; for the central incisor, lateral incisor, and canines, distance from the GZ to the long axis of 1, 0.4, and 0 mm, respectively; interdental papilla height of 4.25, 3.60, and 3.85 mm, respectively; ratio of the distance from the GZ and the interdental papilla tip to the incisal edge of ~1.74-1.77 mm.

Conclusions: Factors including profession, gender, and age of evaluators had almost no impact on their perception of aesthetics. Smile attractiveness characteristics and gingival aesthetic parameters have clinical applicability for patient care.

Introduction

Presently, a marked improvement in the material and spiritual life of the population has led to an increasing demand for beauty. Facial attractiveness plays a vital role in social interaction.[1] It has been reported that an attractive smile influences personality development, social relationships, and employment success.[2] A previous study presented evidence that people with attractive smiles are judged and treated more positively, behave more cheerfully, and work more effectively than unattractive people.[3] Because of the undeniable benefits of an attractive smile, dental professionals are required to provide high-quality dental restorations. Specialists must consider the needs of patients before treatment. Previous studies have shown that there was a significant difference in the perceptions of smile attractiveness between laypersons and specialists, males and females, and among laypersons of different ages.[4-14] This information can help dentists understand how different subjects evaluate their smile. Once the treatment plan meets a subject's desires, dental treatment can be proceed smoothly.

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https://doi.org/10.1016/j.identj.2021.02.001

An attractive smile is a combination of the hard-tissue component (ie, the teeth), the amount of gingival display, and framing of the lips displayed in a smile.[15,16] Researchers have suggested several definitions and concepts for smile aesthetics, such as anterior smile line, smile arc, upper lip curvature, most posterior visible teeth in a smile, smile index, and dynamic smile symmetry.[1,3] These characteristics of smile attractiveness were considered as the primary standard for specialists to rely on and design an appropriate treatment plan.[3] Specialists often focus on hard-tissue aesthetics: teeth position, size, shape, and colour but underestimate the critical role of gingival display in constructing an aesthetically pleasing smile.[16] Recently, several studies have been conducted on gingival contours to measure gingiva-related parameters,[17-25] and the results are highly applicable to clinical dental practice. In addition to healthy gingiva characteristics, clinical parameters of interdental gingiva height, gingival zenith (GZ) point position, gingival line direction, and gingival symmetry are also important.[17,25] To predict results and achieve optimal outcomes in gingival contour rehabilitation, it is crucial to consider gingival aesthetics during treatment planning.[17]

Remarkably, the principle of beauty varies depending on culture and ethnicity.[1] Several studies have been conducted on Caucasian subjects to assess smile characteristics and related factors, but such data are unavailable for Asian populations.[21] The number of smile aesthetics-related studies on the Vietnamese population is limited. Thus, it is necessary to establish scientific analytical methods to identify the correlated elements of smile perception of young Vietnamese people who demand dental services for achieving an attractive smile. This study aimed to determine some highly preferred characteristics of smile attractiveness, to indicate how related factors influence perception by comparing pairs of groups, including laypersons and dental professionals, males and females, and laypersons aged 18-25 and 26-35 years, and to measure gingival aesthetic parameters related to an attractive smile.

Materials and methods

Smiling image collection

A total of 200 young people aged 18-35 years, who visited the Faculty of Odonto-Stomatology, University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam, for a dental checkup were selected. Selection criteria were full maxillary and mandibular dentition, including second molars; no obvious dentofacial disharmonies; no symptoms of facial paralysis or lip irregularities; no anterior crowding and malposition; no anterior carious lesions; no restorations or evidence of incisal wear ≥1 mm into the dentin; no gingival recession; no bleeding on probing; and marginal tissue showing knife-edged form, firm consistency, and pink color.[3]

The photos were taken in a studio by 1 trained photographer using a digital SLR camera (Canon EOS 6D Mark II; Canon Inc.) mounted on a tripod at a distance of 150 cm from the subject's upper lip. The subject was instructed to sit and hold the head naturally after levelling with the Frankfort horizontal plane. A millimetre scale was placed adjacent to the subject's right tragus as an external reference. A tablet (iPad Pro; Apple Inc.) was placed at the subject's eye level behind the camera to present three 1-minute-long comedy films to watch during photography. Three processes of spontaneous smile were continuously shot with a speed of 6.5 frames per second, maintained up to 150 images in JPEG. All photos were copied to a computer and code numbers were assigned using Windows XP Professional (Microsoft). Adobe Photoshop CS6 (Adobe Systems) was used to edit the full-smile images to eliminate the influence of other facial morphological characteristics and skin colour variations on evaluation. Finally, images were converted to black and white 70-dpi JPEG files of 6 × 3 inches and 0% saturation and uploaded to a specific website for assessment. This research was approved by the Human Subjects Ethics Board of the University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam (protocol number 256/DHYD-HDDD), and was conducted in full accordance with the Helsinki Declaration of 1975 as revised in 2013.

Smile image assessment

One hundred raters were recruited using the following selection criteria: 50 Vietnamese laypersons (18-35 years old; 28 males, 22 females) of native Vietnamese nationality, with no dental- or art-related educational background, and not engaged in dental health services or art-related jobs and 50 dental professionals (19 males, 31 females), divided into 10 general dentists, 15 prosthodontists, 15 orthodontists, and 10 periodontists aged 30-52 years who had at least 5 years of practical experience in dentistry.

A smile evaluation website was established. The 100 evaluators had private access to the website; they evaluated 200 full-smile photos using a 100-mm visual analogue scale (VAS) (0: most unattractive; 100: most attractive). At first, the evaluators previewed all images once and were then asked to assess the attractiveness of each smile independently by placing a tick mark within the VAS bar that best reflected their assessment. They were given 10 seconds to assess each image, and the score of each measurement could be revised any time during the assessment period. Two weeks later, 4 random evaluators (2 males and 2 females) were selected to repeat their assessments for intrarater reliability. The mean values were calculated from the VAS scores obtained for each image. Images were separated into 3 pairs of evaluator groups (laypersons and specialists, males and females, laypersons aged 18-25 and 26-35), and mean VAS values were ranked from lowest to highest within each group. The lowest 25% and the highest 25% of the male and female groups were deemed unattractive and attractive subgroups, respectively.

Smile variables

Six smile variables were digitally assessed.[3] Adobe Photoshop CS6 was used for the measurements based on the enlargement ratio of each image.

1. Anterior smile line (according to Liebert and Deruelle):[16] (1) Very high: >2-mm marginal gingiva visible, (2) High: 0- to

2-mm marginal gingiva visible, (3) Average: gingiva embrasure visible only, (4): Low: no gingiva visible.
2. Smile arc:[3] (1) Parallel, (2) Straight, (3) Reverse.
3. Upper lip curvature:[3] (1) upward, (2) straight, and (3) downward.
4. Most posterior teeth displayed: up to the canine, first premolar, second premolar, first molar, or second molar.
5. Smile index:[3] calculated as (1-2)/(3-4)*
6. Dynamic smile symmetry:[3] calculated as [(1−3)+(1−4)]/[(2− 3)+(2−4)]*

*A total of 4 reference points were defined as follows: point 1, right outer commissure; point 2, left outer commissure; point 3, the centre of the inferior border of the upper lip; and 4, the centre of the superior border of the lower lip.

Assessment of gingival aesthetic parameters

After assessing the perception of evaluators on smile attractiveness, the photos of the most attractive smiles, which were similar for laypersons and professionals, were chosen to measure clinical aesthetic parameters of gingival contours (Figure 1).

1. The distance between the GZ of the central incisor and the corresponding canine (ZIC) The GZ is defined as the most apical point of the marginal gingival scallop. Positive values for the ZIC measurements were used when the GZ of the central incisor was apical to the GZ of the canine.
2. The GZ position is measured from the vertical bisected midline (ZMD) along the long axis of each anterior maxillary tooth.
3. Gingival line angle (GLA) is formed between the gingival and maxillary midline. The gingival line (GL) is defined as a line joining the tangent of the GZ, the left or right central incisor, and the corresponding canine. Three categories of GL were defined: straight GL (both the GZ points of the central incisor and canine are horizontal), upward or downward GL (the canine GZ is located apically or coronally to the central incisor). The most popular type of GL was also determined.
4. The distance between the GZ of the lateral incisor and GL (LID). Positive values for the LID measurements were used when the GZ of the lateral incisor was coronal to the GL.
5. The mesial and distal interdental papilla heights (IPH) in the anterior maxillary dentition, including the central incisors, lateral incisors, and canines, were measured from the level of the GZ of the corresponding tooth to the tip of the papilla.
6. The ratio between the distance from the GZ and tip of the interdental papilla to the incisal edge of all anterior maxillary dentition (ZPE).
7. Quantification of the asymmetry of gingival aesthetic parameters between left-right measurements.

Statistical analysis

Statistical analysis software (SPSS version 23.0 for Microsoft Windows) was used for statistical analysis. Means and standard deviations of the measurement data, including VAS rating, smile index, dynamic smile symmetry, and gingival aesthetic parameters, were calculated for subgroups and between subgroups using unpaired *t*-tests. Intraclass correlation coefficients (ICCs) were used to test the inter-rater consistency of the measurement data. Pearson χ^2 test was used to analyse the differences between subgroups in the frequencies of variables. All hypotheses were tested statistically at .05.

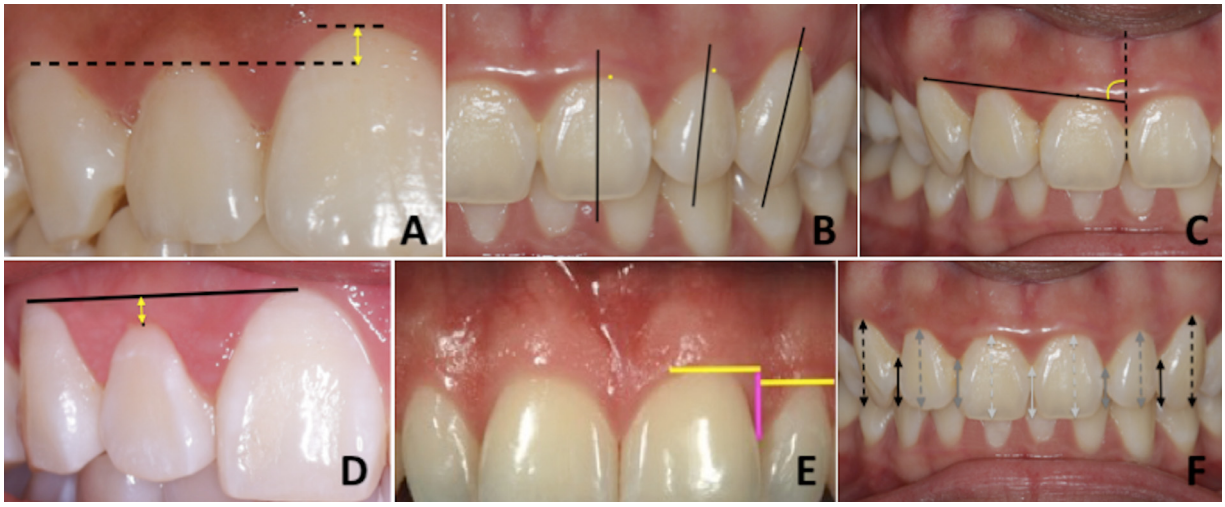

Fig. 1 – Assessment of gingival esthetic parameters. A, ZIC: The distance between the gingival zenith of the central incisor and the corresponding canine; B, ZMD: The distance between the gingival zenith and the vertical bisected midline; C, GLA: Gingival line angle; D, LID: The distance between the gingival zenith of the lateral incisor and the gingival line; E, IPH: Interdental papilla height; F, ZPE: The ratio between the distance from the gingival zenith and tip of the interdental papilla to the incisal edge of anterior maxillary dentition.

Table 1 – Comparison of lay evaluators' and dental professional evaluators' perceptions of smile variables.

Smile feature	Classification	Unattractive smile			Attractive smile		
		Layperson *n* (%)	Dentist *n* (%)	P*	Layperson *n* (%)	Dentist *n* (%)	P*
Anterior smile line	Very high	19 (47.5)	21 (52.5)	.567	5 (83.3)	1 (16.7)	.2
	High	2 (33.3)	4 (66.7)		25 (53.2)	22 (46.8)	
	Average	9 (45)	11 (55)		20 (43.5)	26 (56.5)	
	Low	20 (58.8)	14 (41.2)		0 (0)	1 (100)	
Smile arc	Parallel	22 (50)	22 (50)	.784	42 (51.2)	40 (48.8)	.603
	Straight	24 (52.2)	22 (47.8)		8 (44.4)	10 (55.6)	
	Reverse	4 (40)	6 (60)		0 (0)	0 (0)	
Upper lip curvature	Upward	12 (54.5)	10 (45.5)	.347	18 (45)	22 (55)	.476
	Straight	23 (56.1)	18 (43.9)		27 (56.2)	21 (43.8)	
	Downward	15 (40.5)	22 (59.5)		5 (41.7)	7 (58.3)	
Most posterior teeth displayed	Canine	4 (50)	4 (50)	.85	0 (0)	1 (100)	.471
	First premolar	15 (44.1)	19 (55.9)		11 (40.7)	16 (59.3)	
	Second premolar	14 (51.9)	13 (48.1)		33 (55)	27 (45)	
	First molar	17 (54.8)	14 (45.2)		6 (50)	6 (50)	
		Mean ± SD	Mean ± SD	P**	Mean ± SD	Mean ± SD	P**
Smile index		4.71 ± 0.55	4.79 ± 0.62	.49	5.55 ± 0.71	5.66 ± 0.71	.648
Dynamic smile symmetry		0.95 ± 0.09	0.96 ± 0.10	.679	1.00 ± 0.05	1.01 ± 0.05	.708

n = sample size; SD = standard deviation.

* Pearson χ^2 test.
** *t*-test.

Results

The intraclass correlation coefficients between the first and second ratings of the 4 randomly selected raters were 0.758, 0.628, 0.658, and 0.783, respectively. Therefore, the results of the VAS measurements were deemed reliable.

Factors that impact the perception of an aesthetic smile

Differences in the smile variables (anterior smile line, smile arc, upper lip curvature, most visible posterior teeth, smile index, and dynamic smile symmetry) evaluated by laypersons and dental professionals (Table 1) or by males and females (Table 2) or by laypersons aged 18-25 and 26-35 (Table 3) in the attractive subgroups were not statistically significant.

Morphological characteristics of attractive smile

The number of images with high or average anterior smile line, parallel smile arc, upward or straight upper lip curvature, and smile displaying up to second premolars was higher in

Table 2 – Comparison of male and female evaluators' perceptions of smile variables.

Smile feature	Classification	Unattractive smile			Attractive smile		
		Male *n* (%)	Female *n* (%)	P*	Male *n* (%)	Female *n* (%)	P*
Anterior smile line	Very high	22 (51.2)	21 (48.8)	.868	5 (50)	5 (50)	.867
	High	3 (60)	2 (40)		20 (45.5)	24 (54.5)	
	Average	8 (42.1)	11 (57.9)		24 (54.5)	20 (45.5)	
	Low	17 (51.5)	16 (48.5)		1 (50)	1 (50)	
Smile arc	Parallel	23 (47.9)	25 (52.1)	.915	40 (51.3)	38 (48.7)	.629
	Straight	22 (52.4)	20 (47.6)		10 (45.5)	12 (54.5)	
	Reverse	5 (50)	5 (50)		0 (0)	0 (0)	
Upper lip curvature	Upward	12 (52.2)	11 (47.8)	.827	21 (53.8)	18 (46.2)	.726
	Straight	18 (46.2)	21 (53.8)		22 (45.8)	26 (54.2)	
	Downward	20 (52.6)	18 (47.4)		7 (53.8)	6 (46.2)	
Most posterior teeth displayed	Canine	4 (50)	4 (50)	.979	12 (50)	12 (50)	.839
	First premolar	17 (51.5)	16 (48.5)		30 (48.4)	32 (51.6)	
	Second premolar	14 (51.9)	13 (48.1)		8 (57.1)	6 (42.9)	
	First molar	15 (46.9)	17 (53.1)		0 (0)	0 (0)	
		Mean ± SD	Mean ± SD	P**	Mean ± SD	Mean ± SD	P**
Smile index		4.71 ± 0.60	4.73 ± 0.67	.869	5.53 ± 0.84	5.63 ± 0.67	.527
Dynamic smile symmetry		0.97 ± 0.12	0.96 ± 0.10	.87	1.02 ± 0.06	1.01 ± 0.05	.659

n = sample size; SD = standard deviation.

* Pearson χ^2 test.
** *t*-test.

Table 3 – Comparison of lay evaluators' (aged 18-25 and 26-35 years) perceptions of smile variables.

Smile feature	Classification	Unattractive smile			Attractive smile		
		18-25 *n* (%)	26-35 *n* (%)	P*	18-25 *n* (%)	26-35 *n* (%)	P*
Anterior smile line	Very high	19 (51.4)	18 (48.6)	0.667	6 (54.5)	5 (45.5)	.894
	High	4 (66.7)	2 (33.3)		21 (47.7)	23 (52.3)	
	Average	8 (40)	12 (60)		22 (52.4)	20 (47.6)	
	Low	19 (59.4)	18 (48.6)		1 (33.3)	2 (66.7)	
Smile arc	Parallel	19 (43.2)	25 (56.8)	0.479	39 (48.1)	42 (51.9)	.444
	Straight	27 (55.1)	22 (44.9)		11 (57.9)	8 (42.1)	
	Reverse	4 (57.1)	3 (42.9)		0 (0)	0 (0)	
Upper lip curvature	Upward	12 (52.2)	11 (47.8)	0.445	17 (48.6)	18 (51.4)	.908
	Straight	17 (42.5)	24 (57.5)		28 (51.9)	26 (48.1)	
	Downward	21 (56.8)	16 (43.2)		5 (45.5)	6 (54.5)	
Most posterior teeth displayed	Canine	5 (55.6)	4 (44.4)	0.937	1 (50)	1 (50)	.98
	First premolar	16 (48.5)	17 (51.1)		12 (52.2)	11 (47.8)	
	Second premolar	15 (53.6)	13 (46.4)		30 (48.4)	32 (51.6)	
	First molar	14 (46.7)	16 (53.3)		7 (53.8)	6 (46.2)	
		Mean ± SD	Mean ± SD	P**	Mean ± SD	Mean ± SD	P**
Smile index		4.76 ± 0.60	0.74 ± 0.63	.911	5.53 ± 0.70	5.47 ± 0.75	.708
Dynamic smile symmetry		0.95 ± 0.13	0.95 ± 0.10	0.986	1.01 ± 0.52	1.00 ± 0.05	.541

n = sample size; SD = standard deviation.

* Pearson χ^2 test.
** *t*-test.

attractive than in unattractive subgroups. In contrast, the number of images with low or very high smile line, straight or reverse smile arc, downward upper lip curvature, smile displaying up to canines, first premolar or first molar teeth was lower in attractive than in unattractive subgroups. The difference was statistically significant. Patterns of these 4 features were similar among groups of evaluators, and the illustrative chart for layperson evaluators is shown in Figure 2. The smile index and dynamic smile symmetry were significantly higher in the attractive than in the unattractive subgroups (Tables 1-3).

Gingival aesthetic parameters

Thirty-five full-smile photos, evaluated as attractive by laypersons and professionals, were selected to measure gingival aesthetic parameters. Fourteen males and 21 females aged 19-34 were included in these photos. The aesthetic parameters of the gingiva are shown in Table 4. The differences in gingival aesthetic parameters between the right and left sides were not statistically significant. The ratios of those right and left were approximately 1.

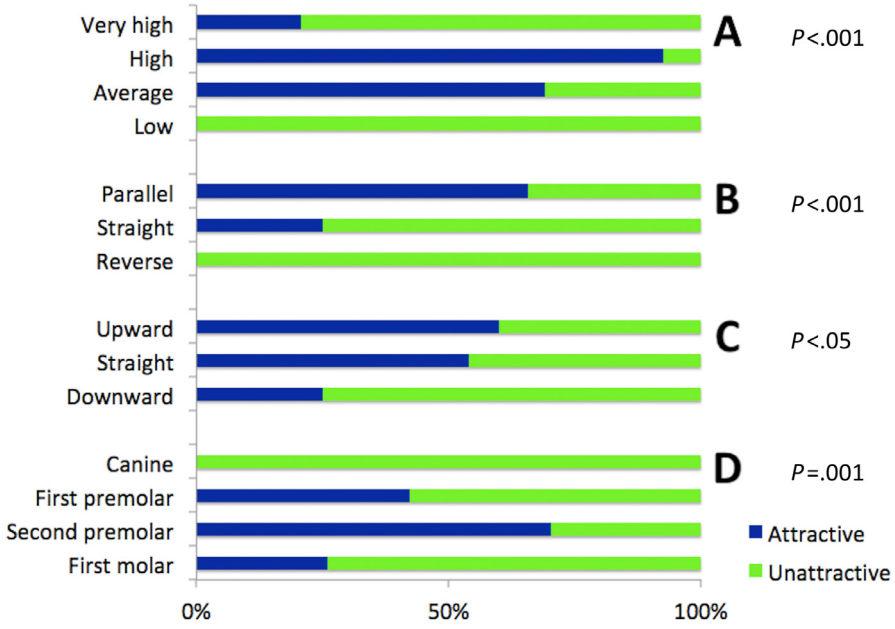

Fig. 2 – Comparison of smile features between attractive and unattractive groups evaluated by laypersons. A, anterior smile line; B, small arc; C, upper lip curvature; D, most posterior teeth displayed.

Table 4 – Comparison of gingival aesthetic parameters between right and left sides.

Gingival aesthetic parameters	Right side (Mean ± SD)	Left side (Mean ± SD)	P*
ZIC (mm)	0.75 ± 0.64	0.72±0.64	.876
ZMD of central incisors (mm)	0.97 ± 0.23	1.00±0.23	.569
ZMD of lateral incisors (mm)	0.42 ± 0.16	0.44 ± 0.16	.613
GLA (°)	86.75 ± 7.80	87.15 ± 9.31	.843
LID (mm)	0.66 ± 0.30	0.66 ± 0.29	.933
IPH of central incisors (mesial) (mm)	4.33 ± 0.53	4.35 ± 0.52	.886
IPH of central incisors (distal) (mm)	4.16 ± 0.61	4.13 ± 0.60	.821
IPH of lateral incisors (mesial) (mm)	3.70 ± 0.73	3.74 ± 0.77	.832
IPH of lateral incisors (distal) (mm)	3.45 ± 0.77	3.46 ± 0.81	.983
IPH of canines (mesial) (mm)	4.12 ± 0.70	4.14 ± 0.68	.893
IPH of canines (distal) (mm)	3.57 ± 0.88	3.54 ± 0.87	.889
ZPE of central incisors (mm)	1.76 ± 0.14	1.77 ± 0.14	.683
ZPE of lateral incisors (mm)	1.77 ± 0.25	1.74 ± 0.21	.548
ZPE of canines (mm)	1.74 ± 0.18	1.74 ± 0.18	.946

* *t*-test.GLA = gingival line angle; IPH = interdental papilla height; LID = the distance between the gingival zenith of the lateral incisor and the gingival line; SD = standard deviation; ZIC = the distance between the gingival zenith of the central incisor and the corresponding canine; ZMD: the distance between the gingival zenith and the vertical bisected midline; ZPE: the ratio between the distance from the gingival zenith and tip of the interdental papilla to the incisal edge of anterior maxillary dentition.

Discussion

In this study, 200 smile photos of 200 subjects who matched inclusion criteria were assessed by 100 evaluators. The differences between pairs of evaluator groups including laypersons and dental professionals, males and females, and laypersons aged 18-25 and 26-35 years in their perceptions on attractive smiles features were not significant. Therefore, factors such as profession, sex, and age of evaluators did not affect perception. Also, highly preferred characteristics of smile were determined, that is, the high or average anterior smile line, parallel smile arc, upward upper lip curvature, visible teeth up to second premolars, smile index approximately 5.53-5.63, and dynamic smile symmetry close to 1 (Figures 3–6). Besides, 35 smile photos, which were similarly evaluated by laypersons and professionals, were chosen to measure comprehensively gingival clinical aesthetic parameters. Here clinical parameters relating to GZ, gingival line, interdental papilla and gingival symmetry, the pattern of cosmetic gingiva frame could be visualised.

Consistent with our results, in a recent study with research methods relatively similar to ours, there was no difference in the evaluations of single smile images between laypersons and specialists.[1] Thanks to advances in multimedia, knowledge of dental aesthetics is widespread in the population, especially among urban and young populations. Thus, the concepts and knowledge of aesthetics were comparable between professionals and nonprofessionals. In other words, laypersons with high aesthetic demands knew the

Fig. 4 – Attractive smile: Anterior smile line: High; Smile arc: Parallel; Upper lip curvature: Upward; Most posterior teeth displayed: First molar; Smile index: 5.42; Dynamic smile symmetry: 0.99.

Fig. 3 – Attractive smile: Anterior smile line: High; Smile arc: Parallel; Upper lip curvature: Straight; Most posterior teeth displayed: Second premolar; Smile index: 5.36; Dynamic smile symmetry: 0.99.

Fig. 5 – Unattractive smile: Anterior smile line: Average; Smile arc: Parallel; Upper lip curvature: Downward; Most posterior teeth displayed: Canine; Smile index: 4.79; Dynamic smile symmetry: 0.95.

Fig. 6 – Unattractive smile: Anterior smile line: Very high; Smile arc: Straight; Upper lip curvature: Straight; Most posterior teeth displayed: First premolar; Smile index: 4.28; Dynamic smile symmetry: 0.98.

flaws in their smile and consulted specialists to achieve the desired aesthetics. Some previous studies used intentionally altered photographs of various smile features of model images,[4,26] but this method created unnatural and artificial smile photos that negatively impacted the study outcomes.[1] A previous study with a relatively large population suggested that laypersons had a wider range of acceptance of perception than professionals.[4] However, the sex and socioeconomic status of the models were not accounted for, which may have affected the results. It was accepted that the general concept of aesthetic standards was relatively homologous,[5] even though there was a discrepancy in agreement among different groups. It was suggested that the difference in perceptions of attractiveness exists at the individual rather than group level. Therefore, to achieve optimal outcomes, specialists should obtain personal views from the patient in addition to considering common standards.

With regards to the effect of the sex of raters, the findings of this study showed that there was no significant difference in aesthetic judgments between male and female evaluators. These results are consistent with those of several recent studies on Chinese,[3] Jordanian,[4] and Indonesian populations.[6-8] In contrast, a study by Bolas-Colvee et al[9] using 250 evaluators aged around 19 years reported that the perceptions were affected by sex; however, the percentage of males and females was not equal, at 34.4% and 65.6%, respectively. Age was also one of the factors influencing the perception of an attractive smile because people of different ages had specific attitudes, lifestyles, and viewpoints.[10] Previous studies found differences in the judgements on smile features between males and females.[10-12] However, the present study showed no sex-related differences, consistent with the findings of Gracco et al[13] and Tüzgiray et al.[14] This could be explained by the way the age groups were defined: we recruited young adults aged 18-25 years, which is a population with a high demand for an attractive appearance. The division into groups of 18-25 and 26-35 years also did not result in any significant differences. We did not include individuals aged 40 years or older, as done in previous studies, because this age group was not suitable for the purpose of the study and the target population.

In this study, a high or average anterior smile line, defined as only the interdental papilla of the gingiva or maximum 2-mm marginal gingiva displayed when smiling, according to Liebert and Deruelle,[16] was evaluated as being more attractive than others. Using Tjan's classification, Wang et al[3] found that an average or low smile line was favoured. Almost all previous studies agreed that marginal gingiva visible below 2 mm was the most suitable reference for smile attractiveness.[27-30] The smile arc is an important feature in smile aesthetics because it is related to the visible incisal edge of the anterior maxillary dentition, which has attracted much attention. It was reported that a parallel smile arc made people look younger, happier, and more attractive than a nonparallel one.[30] The findings of previous studies have been consistent with this statement,[30-32] while a study of Chinese people reported no significant difference between parallel or nonparallel smiles.[3] Papers discussing the upper lip curvature are limited; in general, this feature was muscle-driven and is not modified with dental treatment.[3] However, research on this feature provides specialists with basic knowledge and allows them to predict the outcomes. In the current study, upward upper lip curvature was reported to be more attractive than others, similar to the findings in previous studies.[15,33] A study conducted in India showed a preference for straight or little downward upper lip curvature,[34] which could be attributed to racial differences. Martin et al[35] concluded that laypersons tended to prefer 10 anterior teeth displayed when smiling, whereas orthodontists preferred 12 maxillary teeth visible. Most of the previous studies did not present the number of visible teeth in a spontaneous smile; thus, the comparison of results was challenging.[35] However, our result showed that 78.5% of attractive smile images had visible teeth up to the second premolar, which is relatively consistent with previously reported results.[35] The smile index, first established by Ackermann and Ackermann,[3] was reported to be over 5.0 in an attractive smile. Murakami et al[36] found that the smile index for Japanese models was around 5.37-7.0. Wang et al[3] reported the smile index for Chinese males and females at 6.31 and 6.02, respectively. In this study, the indices were 5.53 and 5.63, respectively. Dynamic smile symmetry, using the formula of Wang et al,[3] was reported to be approximately 1 for attractive smiles. In our study with a large population, the results showed that dynamic smile symmetry in attractive smiles was closer to 1 than in unattractive smiles, and the difference was statistically significant. In other words, symmetrical smiles were judged to be more attractive than asymmetrical smiles.

Previous studies reported gingival contour parameters due to their vital roles in treatment planning and prediction of outcome.[17] However, the studies were conducted separately for a single parameter, and the measurements were not reported for highly evaluated aesthetic smiles. Moreover, to the best of our knowledge, no study has assessed the Vietnamese population. Thus, we used a new study design to reduce the effect of these limitations. In present study, the GZ was apically located in 71.4% of the attractive smiles and the vertical distance of the GZs of the right and left central incisors from the corresponding apical canines was 0.75 ± 0.64 mm and 0.72 ± 0.64 mm, respectively. A previous study conducted in a Chinese population found that the GZ of the canines was 0.33 mm more apically located than the GZ of the central incisors.[3] Chu et al[18] concluded that the GZ of the

central incisors was about 1 mm distal to the long axis of the teeth. In contrast, the long axis of the lateral incisors and canines corresponded to the GZ. The distance between the GZ and the long axis of the central incisors, lateral incisors, and canines was 1 mm, 0.4 mm, and 0 mm, respectively, in this study. This distribution was consistent with that reported in previous studies.[19,20] Theoretically, the position of the GZ of lateral incisors has been reported to be coronal to the gingival line in most previous studies.[17,20-22] Those studies also found the distance of the GZ of the lateral incisors was approximately 0.51 mm perpendicular to the gingival line, which was consistent with our results (the distance of 0.66 ± 0.30 mm). Regarding the gingival line angle, our result was approximately 87°, similar to that in previous studies.[17,20-22] In general, the gingival line angle was an acute angle; the angle on the left side was slightly larger than that on the right side, but the difference was not significant. The results indicated that the slope between the central incisor and canine zenith was approximately 4-5°, which could be considered small. However, this means the gingival contours were not lined up on a straight horizontal line,[17] which increased the naturalness and aesthetics of the smile. Specialists who understand minor variations in aesthetic features would be able to achieve good results. In the current study, the average interdental papilla height of the central incisors, lateral incisors, and canines was 4.25, 3.59, and 3.85, respectively, without any significant difference between the right and left sides. The findings from this study also showed that the interdental papilla height on the mesial side of the canines was significantly higher than that on the distal side. In contrast, Patil et al[23] reported that the height on the distal side was higher. The difference between the 2 studies may be due to the study methods. Patil et al[23] measured casts after a maxillary impression with alginate. The process had several stages and may have led to biased results.[24] The ratios of the distance from the GZ and tip of the interdental papilla to the incisal edge of the central incisors, lateral incisors, and canines were 1.80, 1.71, and 2.03, respectively, in a previous study.[25] The ratios on the right side in the current study were 1.76, 1.77, and 1.74, respectively, and on the left side, 1.77, 1.74, and 1.74, respectively. These ratios were not significantly different. In other words, the longer the tooth the longer the interdental papilla, and the ratio implied a principle similar to recurring aesthetic dental proportion in designing the dimensions of both teeth and gingiva.[25]

The differences between the left and right sides were not statistically significant. Asymmetry is a natural phenomenon and intentionally symmetrizing a smile could make it unattractive.[37] However, psychological studies have reported that aesthetic perception is sensitive to symmetry.[25] Symmetry and perfectionism are what people desire. After all, an attractive smile needs to have relative symmetry beside other aesthetical factors, and the term 'symmetry' should be replaced with balance and harmony.

The present study had certain limitations. The number of the most attractive photos that were chosen to measure clinical aesthetic parameters of gingival contours was quite small. It should be increased by increasing the initial sample size that could have generated more accurate results. In addition, people older than 35 years of age were not recruited in this study, although they are also increasingly interested in smile beauty. Thus, a larger age range of the subjects should be included in future studies.

Conclusions

Homogeneity in the evaluation of perception of aesthetics regardless of profession, sex, or age supported the high applicability of the smile attractiveness standard concept found in the current study. Detailed smile features and gingival aesthetic parameters add to the knowledge base in the field of dental aesthetics. These data could be used as aesthetic guidelines in clinical practice.

Funding

This study was supported by Vietnam National University, Ho Chi Minh City, Vietnam, under grant number 38/QĐ-ĐHQG (C2020-44-02).

Conflict of interest

None disclosed.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.identj.2021.02.001.

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