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RESEARCH ARTICLE

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Esthetics and smile-related characteristics assessed by laypersons

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Abstract

Purpose: This study aimed to identify the characteristics of full-smile images assessed by laypersons using visual analog scale measurement.

Materials and Methods: A total of 176 young Chinese subjects (88 males and 88 females; 20-35 years of age) with healthy dentogingival tissue were recruited to have their dynamic smiles captured using digital technology. A full-smile frame image of each subject was selected and evaluated by 22 laypersons (11 males and 11 females; 20-35 years of age) using visual analog scale measurement. Unattractive and attractive groups were designated according to the 25th percentile and 75th percentile of average visual analog scale score for the subjects, respectively. Eight smile variables were used to measure the characteristics of the full-smile images. Pearson's Chi-square test and unpaired *t* tests were used to analyze the data with significance level $\alpha = 0.05$.

Results: The visual analog scale measurement scores of unattractive and attractive subgroups, respectively, were 37.89 ± 2.12 and 50.67 ± 2.75 (male subjects), and 37.14 ± 2.80 and 51.92 ± 1.99 (female subjects). VAS scores were significantly different between subgroups for both male and female subjects ($P < .001$). No significant differences were observed between male and female subjects ($P > .05$).

Conclusions: Attractive full-smiles in young Chinese subjects demonstrated higher frequencies of average or low anterior smile line, average or low posterior smile line, upward upper lip curvature, and "broad and short" smile with high smile index.

Clinical Significance

The smile variables of anterior smile line, posterior smile line, upper lip curvature, and smile index are predominant factors of smile attractiveness, which should be given priority to consider and manage in the anterior esthetic treatment plan.

KEYWORDS
esthetic preference, laypersons, smile analysis

1 | INTRODUCTION

An esthetic smile is indispensable to facial attractiveness, which is an important contributory factor to psychosocial well-being.[1,2] Results of previous studies support the idea that people with attractive smiles are judged to be more intelligent, treated more positively, and exhibit more socially desirable behaviors and traits than unattractive people.[3,4] Investigations also have demonstrated a correlation between self-reported attractiveness and self-esteem.[2,5] Inspired by the benefits of an attractive smile, an increasing number of people seek to improve smile attractiveness by various cosmetic treatments including plastic surgery, orthodontic treatment, orthognathic treatment, and perio-restorative treatment. In general, an esthetic smile is the result of the interaction of different components including the soft tissues and the

teeth exposed during smiling, and all the components should form a harmonious symmetrical whole.[5] A comprehensive understanding of factors affecting the perception of smile attractiveness is an important prerequisite for cosmetic dentistry. Determining the preference or esthetic standards of such factors would provide guidance in the diagnosis and treatment of the esthetic smile.

Laypersons may be less sensitive than dental professionals in measuring the dentoalveolar complex; however, previous studies have shown that laypersons are capable of identifying most of the factors that detract from a smile.[6–11] Given that the majority of dental patients and the population in general are comprised of laypersons, they in fact are the ultimate judges of dental esthetic treatment outcomes. Hence, it is of great significance to have a comprehensive understanding of laypersons' preferences with regard to esthetic-related smile characteristics. This can also help clinicians to understand the ways in which patients will evaluate their smiles, to identify patients' perceptions of the need and expectations for treatment, and eventually to resolve their chief complaints.

Recent reports have reviewed various smile characteristics affecting the perception of smile attractiveness, including tooth shape, tooth size and proportion, incisor position, maxillary gingival display and architecture, maxillary gingival morphology, maxillary midline deviation, smile arc, buccal corridor, smile index, and smile symmetry evaluated by laypersons.[10,12–16] The majority of these studies are survey-based with laypersons evaluating a number of frontal smile photographs modified such that only one research parameter is changed at a time. Only a few studies have explored the influence of multiple factors simultaneously on laypersons' perception of frontal smile attractiveness.[9,17,18] In addition, individual and cultural characteristics must be considered in smile evaluation as demographic, racial, ethnic, and cultural differences may play an important part in the perception of smile esthetics.[19–21] Investigation of the combination of multiple factors acting simultaneously on the perception of smile attractiveness in young Chinese laypersons is lacking in the published literature.

The purpose of this study was to identify the smile-related characteristics affecting the perception of attractiveness of frontal full-smile and the qualities of these parameters as preferred by young Chinese laypersons using VAS measurement. The null hypotheses of this study were that there were no significant differences in smile variables of full-smile characteristics between attractive and unattractive smiles, and between young male and female Chinese subjects.

2 | MATERIALS AND METHODS

2.1 | Ethical approval

This research was conducted in accordance with the World Medical Association Declaration of Helsinki and approved by the Institutional Review Boards of the University Medical Ethics Committee. Written informed consents were obtained from all participants following the guidelines of the committee for the research process.

2.2 | Sampling and selection criteria for dynamic smile recording

One hundred and seventy-six young Chinese subjects (88 men and 88 women; 20–35 years of age) were recruited to have their dynamic smiles recorded digitally. Inclusion criteria were: (1) Chinese Han-nationality youths between 20 and 35 years old; (2) full maxillary and mandibular dentition with erupted second molars; (3) skeletal and dental class I relationships; (4) no anterior malposition conditions such as severe crowding, spacing, tipping, or rotations; (5) no anterior teeth loss, caries lesions, restorations or prostheses; (6) no active gingival and periodontal disease, gingival recessions; and (7) no symptoms of facial paralysis or lip irregularities. Subjects who were systemically compromised, pregnant or lactating, and those who had taken gingival hyperplasia-induced drugs in the preceding three months were excluded. All subjects received oral hygiene instructions and prophylaxis at least 2 weeks before recording their dynamic smiles.

Details of the test setup and procedures for recording dynamic smiles have been reported in a previous study.[22] Video clips were downloaded to a computer and processed using video-editing software (Sony Vegas Pro 10.0; Sony Creative Software Inc., Middleton, WI, USA) to review the dynamic smiling process frame by frame. A scale frame and a full-smile frame of each subject were selected (Figure 1), then converted into JPEG file images and saved with assigned code numbers using Windows XP Professional (Microsoft, Redmond, WA, USA). In total, 176 scale images and 176 full-smile images were collected. Adobe Photoshop CS6 (Adobe Systems, San Jose, CA, USA) was used to edit the full-smile images. All full-smile images were cropped to leave a proportionate area around the lips to eliminate the influence of other facial morphological characteristics and skin color variations on the esthetic evaluation. Images were edited to remove facial irregularities and/or blemishes to avoid any distraction during the assessment process. Finally, images were converted to 5 × 3 inches, black and white, −100 saturation, 70-dpi JPEG files (Figure 2), and copied to PowerPoint (Windows XP Professional, Microsoft, Redmond, WA, USA) for assessment.

2.3 | Full-smile images assessment

The minimum sample size for each subgroup (attractive vs. unattractive smile subgroups) was estimated to be 18 according to a previous study.[17] Twenty-two young Chinese adults (11 males and 11 females; 20–35 years of age) were recruited from the University as raters to assess and rate the sampled smile images. Selection criteria for these raters included: native Han-nationality, no dental- or art-related educational background, and not engaged in dental health services or art-related jobs. Demographic information was obtained including sex, age, education, and occupation.

Ten-page questionnaire was prepared with the first page explaining the research aim and instructions for using visual analog scale (VAS) measurement.[18,23–26] The remaining pages of the questionnaire included 100-mm VAS at a fixed width of 100 mm (0: the most unattractive; 100: the most attractive), which was used by the raters to

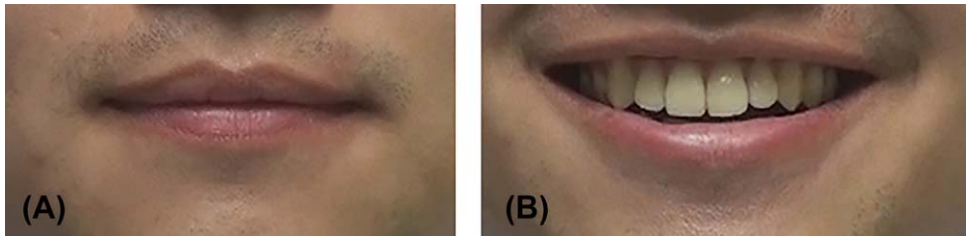

FIGURE 1 Two major images captured from dynamic smile video records. (A) Scale frame: The enlargement ratio of each image was calculated by comparing true 10 mm from the scale and the corresponding value in the image; and (B) full-smile frame: The image was captured to collect data of smile characteristics and standardized for VAS assessment

assess the attractiveness of the images. All 176 full-smile images in PowerPoint format were displayed using a laptop computer (DELL Inspiron 1545; Dell, Round Rock, TX, USA). Raters first previewed all images once and were asked to assess smile attractiveness of each image independently by placing a tick mark within the VAS bar that best reflected their assessment. Each image was allowed 10 seconds for assessment and the score of each measurement could be revised any time during this assessment period. The location of the tick mark of each assessment was measured in millimeters from the left end of the 100-mm VAS bar using a digital caliper (MNT-150; Meinaite, Shanghai, China) with accuracy of 0.01 mm. Mean values were calculated from the 22 VAS scores obtained for each image. Images were separated into male subject and female subject groups, and mean VAS values were ranked from lowest to highest within each group. The lowest 25% and the highest 25% of male and female group were identified and assigned as subgroup A (unattractive subgroup; $n = 22$) and subgroup B (attractive subgroup; $n = 22$), respectively. In addition, 4 raters (2 males and 2 females) were randomly selected to repeat their assessments 2 weeks later to assess intrarater reliability.

2.4 | Data collection on smile characteristics

Eight smile variables (anterior smile height, posterior smile height, upper lip curvature, smile pattern of Rubin classification, smile arc, most visible posterior tooth, smile index, and dynamic smile symmetry) were assessed digitally on the full-smile images. Image Tool for Windows version 3.00 (UTHSCSA, San Antonio, TX, USA) was used for the measurements. The enlargement ratio of each image was calculated by comparing the true length from the scale and measured length in the corresponding scale framed image. In addition, 5 male and 5 female full-smile images were randomly selected and measured again after 2 weeks in order to test intra-rater reliability.

FIGURE 2 Final image format for VAS assessment use

1. ***Anterior smile line*:** According to Tjan et al.,[27] the anterior smile line is divided into three categories depending on the percentage of visible teeth and gingiva: high smile line revealing 100% of the maxillary anterior teeth and a contiguous band of gingiva, average smile line revealing 75% to 100% of the maxillary anterior teeth and interproximal papilla, and low smile line revealing less than 75% of the maxillary teeth (Figure 3).
2. ***Posterior smile line*:** Categorized as follows: high smile line displaying a contiguous band of gingiva above the maxillary first premolar, average smile line displaying 75% to 100% of the maxillary first premolars, and low smile line displaying less than 75% of the maxillary first premolars (Figure 4).[28]
3. ***Upper lip Curvature*:** This specifies the horizontal morphology of the inferior border of the upper lip and is based on the positional relationship of the corner of the mouth and the center of the inferior border of the upper lip. Three categories were classified as follows: upward lip curvature means that the corner of the mouth is at 1 mm higher than a horizontal line drawn through the center of the inferior border of the upper lip; straight lip curvature means that the corner of the mouth is at or within 1 mm above or below a horizontal line drawn through the center of the lower border of the upper lip; downward lip curvature means that the corner of the mouth is at more than 1mm lower than a horizontal line drawn through the center of the lower border of the upper lip (Figure 5).[22]
4. ***Smile pattern of Rubin classification*:** Rubin classification[29] was adapted to categorize smile patterns of the subjects. In the commissure smile, the corners of the mouth turn upward due to the pull of the zygomaticus majorly. In the cuspid smile, the upper lip is elevated without the corners of the mouth turning upward; the entire lip rises like a window shade. In the complex or gummy smile, the upper lip is elevated uniformly as the cuspid smile and the lower lip moves inferiorly (Figure 6).
5. ***Smile arc***: This was determined by the relationship of the line drawn along the incisal edges of the maxillary central incisors to the cusp tips of the maxillary canines and the superior border of the lower lip. Three categories were defined as follows: parallel

FIGURE 3 Anterior smile line reference. (A) High anterior smile line. (B) Average anterior smile line. (C) Low anterior smile line

FIGURE 4 Posterior smile line reference. (A) High posterior smile line. (B) Average posterior smile line. (C) Low posterior smile line

smile arc means that the two lines are parallel to each other, straight smile arc means that the maxillary incisal edges and canine cusp tips are connected by a straight line with no curvature, and reverse smile arc means that the maxillary incisal edges and canine cusp tips form a reverse line relative to the superior border of the lower lip; the latter two were collectively called "not parallel"(Figure 7).[30]

6. ***The most posterior teeth displayed*:** A tooth was counted as visible when more than 50% of its surface was revealed. Smiles were categorized as displaying teeth up to the first premolar, the second premolar, the first molar, or the second molar (Figure 8).
7. ***Smile index*:** Smile index is the ratio of the horizontal distance between the outer commissure (ie, smile width) and the vertical distance between the inferior border of the upper lip and the superior border of the lower lip (ie, smile height) during smiling. It is calculated as smile width/smile height (Figure 9).
8. ***Dynamic smile symmetry*:** Dynamic smile symmetry refers to the movement uniformity of the bilateral outer commissure in the horizontal and vertical direction. It is calculated as (1–3) + (1–4)/(2–3) + (2–4) (Figure 9).

2.5 | Statistical analysis

All calculations were performed with statistical analysis software (SPSS version 23.0 for Microsoft Windows, Redmond, WA, USA). Means and standard deviations of the measurement data including VAS rating,

FIGURE 5 Upper lip curvature categories. (A) Upward upper lip curvature. (B) Straight upper lip curvature. (C) Downward upper lip curvature

FIGURE 6 Smile pattern of Rubin classification. (A) Commissure smile. (B) Cuspid smile. (C) Complex smile

FIGURE 7 Smile arc reference. (A) Parallel smile arc. (B) Straight smile arc. (C) Reverse smile arc

FIGURE 8 The most posterior teeth displayed. (A) The first premolar. (B) The second premolar. (C) The first molar

smile index and dynamic smile symmetry were calculated for both subgroups and compared between subgroups using unpaired *t* tests. Intraclass correlation coefficients (ICCs) were used to test intrarater consistency of the measurement data. The enumeration data including anterior smile line, posterior smile line, smile pattern of Rubin classification, upper lip curvature, smile arc, and the most posterior teeth visible were expressed as percentages for each subgroup, and the Pearson's Chi-square test was used to analyze the differences between subgroups in the frequencies of the above variables. The kappa statistics test was used to examine the reliability of the enumeration data. All hypotheses were tested statistically at $\alpha = 0.05$.

3 | RESULTS

3.1 | VAS measurements

ICCs between the first and second ratings of the 4 randomly-selected raters were 0.603, 0.620, 0.707, and 0.726, respectively. Moreover, the ICC was 0.800 when comparing the average of 4 VAS scores from the first and second measurement, which indicates a high level of repeatability for these measurements. The results of VAS measurements therefore were deemed reliable.

The mean values of VAS scores (±standard deviation) for 176 full-smile images (88 males and 88 females) are given in Table 1. The mean values of VAS scores for unattractive and attractive subgroups were 37.89 ± 2.12 and 50.67 ± 2.75 (male subjects), and 37.14 ± 2.80 and 51.92 ± 1.99 (female subjects), respectively. Differences between subgroups were statistically significant ($P < .001$) for both males and females (Table 2).

3.2 | Smile characteristics comparisons

Results of the intrarater reliability test demonstrated good agreement between the first and second measurements of the smile characteristics. The Kappa ratings of anterior smile line, posterior smile line, smile arc, upper lip curvature, and smile pattern of Rubin classification ranged from 0.837 to 0.886. The ICC of smile index was 0.988 and was 0.417 for dynamic smile symmetry measurements.

The results of smile variable analysis of full-smile images comparing unattractive and attractive subgroups of male subjects only are shown in Table 3. Attractive smiles of male subjects demonstrated significantly higher frequencies of average or low anterior smile line (90.9%), average or low posterior smile line (72.7%), upward upper lip curvature (50.0%), and commissure smile pattern (72.7%) than did unattractive smiles of male subjects ($P < .05$). A statistically significant difference between unattractive and attractive smiles of male subjects also was observed for the smile index measurement (4.64 ± 1.17 versus 6.31 ± 1.19, $P < .05$). No statistically significant differences were found for smile arc, most posterior teeth visible, or dynamic smile symmetry between unattractive and attractive male subjects ($P > .05$). For female full-smile images, attractive subjects demonstrated significantly higher frequencies of average or low anterior smile line (86.4%), average or

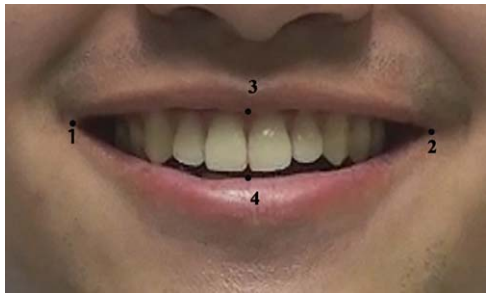

FIGURE 9 Reference points for smile index and dynamic smile symmetry. Point 1, right outer commissure; point 2: left outer commissure; smile width, the horizontal distance between point 1 and point 2; point 3, the center of the inferior border of the upper lip; 4: the center of the superior border of the lower lip; smile height, the vertical distance between point 3 and point 4

TABLE 1 Mean and standard deviation (SD) of VAS scores (mm/100 mm) of 176 full-smile images

	Mean value	SD	Minimum value	Maximum value	25th percentile	75th percentile
Male Group	44.00	5.09	31.81	58.48	39.79	47.30
Female Group	44.20	5.92	28.55	56.59	39.94	49.25

low posterior smile line (77.3%), and upward upper lip curvature (54.5%) than did unattractive subjects ($P < .05$). The mean value of the smile index was significantly smaller for the unattractive subgroup than for the attractive subgroup (4.73 ± 1.09 vs. 6.02 ± 1.20, $P < .05$). No statistically significant differences were determined for smile pattern, smile arc, the most posterior teeth visible, or dynamic smile symmetry between unattractive and attractive female subjects ($P > .05$; Table 4).

No statistically significant differences were observed between male and female subject groups for variables of anterior or posterior smile line, upper lip curvature, smile pattern or smile index in either attractive or unattractive smile subgroups ($P > .05$; Tables 5 and 6).

TABLE 2 Mean and standard deviation (SD) of VAS (mm/100 mm) scores of two subgroups

	Subgroup A (Unattractive Group)		Subgroup B (Attractive Group)		
	Mean	SD	Mean	SD	*P* value
Male Group	37.89	2.12	50.67	2.75	<.001*
Female Group	37.14	2.80	51.92	1.99	<.001*

*Statistical significance between subgroups at $P < .01$.

4 | DISCUSSION

This study focused on esthetic preferences of soft-tissue related smile characteristics evaluated by young Chinese laypersons because they are the primary consumers of cosmetic dental services, and satisfaction with dental treatment depends on patients' innate expectations. The null hypothesis of no significant differences between attractive and unattractive smiles in smile variables of full-smile characteristics was rejected. Scores measured by the VAS method were significantly different between samples of unattractive and attractive smile images, demonstrating that laypersons can reliably identify unattractive and attractive smiles when viewing a lower face perspective. The lower face view used in this study may have facilitated the detection of small clinical differences compared with a full-face perspective.

Regarding the smile characteristics assessment, the null hypothesis of no significant differences between male and female Chinese subjects in smile variables of full-smile characteristics was not rejected for either

TABLE 3 Comparisons of smile characteristics between unattractive and attractive male subjects

		Subgroups		Statistical analysis	
Smile variables	Classification	Unattractive *n* (%)	Attractive *n* (%)	χ^2-value	*P* value
Anterior smile line	High	13 (59.1)	2 (9.1)	12.239	.000**
	Average or low	9 (40.9)	20 (90.9)		
Posterior smile line	High	16 (72.7)	6 (27.3)	9.091	.003**
	Average or low	6 (27.3)	16 (72.7)		
Upper lip curvature	Upward	3 (13.6)	11 (50.0)	6.705	.010*
	Straight or downward	19 (86.4)	11 (50.0)		
Smile pattern	Commissure	8 (36.4)	16 (72.7)	5.867	.015*
	Cuspid or complex	14 (63.6)	6 (27.3)		
Smile arc	Parallel	7 (31.8)	13 (59.1)	3.300	.069
	Not parallel	15 (68.2)	9 (40.9)		
The most posterior teeth visible	Premolar	12 (54.5)	14 (63.6)	.376	.540
	Molar	10 (45.5)	8 (36.4)		
		Mean ± SD	Mean ± SD	*T*-value	*P* value
Smile index		4.64 ± 1.17	6.31 ± 1.19	−4.697	.000**
Dynamic smile symmetry		1.00 ± 0.53	0.99 ± 0.64	.656	.515

n, sample size.
*Statistical significance at $P < .05$; **Statistical significance at $P < .01$.
SD, standard deviation.

TABLE 4 Comparisons of smile variables between unattractive and attractive female subjects

		Subgroups		Statistical analysis	
Smile variables	Classification	Unattractive *n* (%)	Attractive *n* (%)	χ^2-value	*P* value
Anterior smile line	High	17 (77.3)	3 (13.6)	17.967	.000**
	Average or low	5 (22.7)	19 (86.4)		
Posterior smile line	High	14 (63.6)	5 (22.7)	7.503	.006**
	Average or low	8 (36.4)	17 (77.3)		
Upper lip curvature	Upward	5 (22.7)	12 (54.5)	4.697	.030*
	Straight or downward	17 (77.3)	10 (45.5)		
Smile pattern	Commissure	12 (54.5)	17 (77.3)	2.529	.112
	Cuspid or complex	10 (45.5)	5 (22.7)		
Smile arc	Parallel	15 (68.2)	18 (81.8)	1.091	.296
	Not parallel	7 (31.8)	4 (18.2)		
The most posterior teeth visible	Premolar	14 (63.6)	19 (86.4)	3.030	.082
	Molar	8 (36.4)	3 (13.6)		
		Mean ± SD	Mean ± SD	*T*-value	*P* value
Smile index		4.73 ± 1.09	6.016 ± 1.204	−3.720	.001**
Dynamic smile symmetry		1.00 ± 0.05	0.99 ± 0.23	1.450	.155

n, sample size.
*Statistical significance at $P < .05$; **Statistical significance at $P < .01$.
SD, standard deviation.

attractive or unattractive smiles. Results revealed that young Chinese laypersons have similar smile esthetic preferences for multiple variables for both male and female smiles and they preferred attractive smiles characterized by average or low anterior smile line, average or low posterior smile line, upward upper lip curvature, and "broad and short" smile with high smile index. Our results are not in agreement with some previous studies that suggest the existence of a sex bias in the esthetic perceptions of some smile characteristics.[31,32]

Anterior and posterior smile lines were shown in this study to affect the perception of smile attractiveness, with average or low smile line preferred over high smile line. Similarly, previous investigations reported a negative relationship between anterior gingival display and

TABLE 5 Comparison of esthetic perception-related smile variables between unattractive male and female subjects

		Group		Statistical analysis	
Smile variables	Classification	Female *n* (%)	Male *n* (%)	χ^2-value	*P* value
Anterior smile line	High	17 (77.3)	13 (59.1)	1.676	.195
	Average or low	5 (22.7)	9 (40.9)		
Posterior smile line	High	14 (63.6)	16 (72.7)	0.419	.517
	Average or low	8 (36.4)	6 (27.3)		
Upper lip curvature	Upward	5 (22.7)	3 (13.6)	0.611	.434
	Straight or downward	17 (77.3)	19 (86.4)		
Smile pattern	Commissure	12 (54.5)	8 (36.4)	0.834	.361
	Cuspid or complex	10 (45.5)	14 (63.6)		
		Mean ± SD	Mean ± SD	*T*-value	*P*-value
Smile index		4.73 ± 1.09	4.64 ± 1.17	–.253	.802

n, sample size.
SD, standard deviation.

TABLE 6 Comparison of esthetic perception-related smile variables between attractive male and female subjects

Smile variable	Classification	Group Female *n* (%)	Statistical analysis Male *n* (%)	Smile variable χ^2-value	Classification *P* value
Anterior smile line	High	3 (13.6)	2 (9.1)	0.226	0.635
	Average or low	19 (86.4)	20 (90.9)		
Posterior smile line	High	5 (22.7)	6 (27.3)	0.121	0.728
	Average or low	17 (77.3)	16 (72.7)		
Upper lip curvature	Upward	12 (54.5)	11 (50.0)	0.091	0.763
	Straight or downward	10 (45.5)	11 (50.0)		
Smile pattern	Commissure	17 (77.3)	16 (72.7)	0.121	0.728
	Cuspid or complex	5 (22.7)	6 (27.3)		
		Mean ± SD	Mean ± SD	*T*-value	*P* value
Smile index		6.02 ± 1.20	6.31 ± 1.19	0.824	0.415

n, sample size.
SD, standard deviation.

smile esthetics.[16,26,32–35] Another previous study, however, reported a contradictory finding of no correlation between anterior gingival display and smile esthetics.[18] A few studies have focused on the influence of posterior gingival display on smile attractiveness, with results similar to the present study.[28,36,37] Rodriguez-Martinez et al.[36] demonstrated that excessive posterior gingival display compromised smile attractiveness. Crawford et al.[37] reported a correlation between position of the posterior gingival margin and smile esthetics. Therefore, to improve smile esthetics as a whole, clinicians should pay close attention to coordinate the lip-teeth-gingiva relationships of the maxillary anterior region as well as of the posterior region by various treatment modalities including clinical crown lengthening combined with/without prosthodontic treatment, lip repositioning or Botox injection, orthodontic treatment, and orthognathic surgery aimed at different etiologies such as altered passive eruption, short or hyperactive upper lip, and excess maxillary growth.[38]

Previous studies have analyzed the frequencies of different smile patterns of Rubin classification in general populations,[29,39,40] but no previous study has explored the preference of smile patterns as it relates to smile attractiveness. In this study, laypersons' esthetic preference of smile pattern was analyzed and results revealed that commissure smile is deemed attractive for males ($P = .015$), but not significantly so for females. Although the frequency of commissure smile was higher in the female attractive subgroup (77.3%) than in the corresponding unattractive subgroup (54.5%), this difference was not statistically significant ($P = .112$). The smile pattern of Rubin classification depends on the attachment position and contraction of the perioral muscles, anatomical position of maxilla and mandible, and dental arches, and is thereby not controllable by dental treatment. Hence, clinicians should encourage reasonable treatment expectations for patients whose smile esthetics are compromised by a nonideal smile pattern.

The data of this current study showed that upward upper lip curvature is more attractive than straight or downward upper lip curvature, which is consistent with studies by Dong et al.[41] Upper lip curvature is muscle-driven and cannot be altered by dental treatment, therefore, straight and especially downward upper lip curvatures are limiting factors to creating an ideal smile through cosmetic dental treatment.[42]

Ackermann et al.[14,15] first introduced the concept of smile index and reported that the smaller the smile index, the younger the smile appears, and that an esthetic smile has a ratio larger than 5.0. Murakami et al.[42] found that the average smile index of young Japanese females after orthodontic treatment and of magazine models were 5.37 and 7.00, respectively, suggesting that models, possibly due to their extensive training, have more attractive smiles than do average people. A similar result was observed in the present study in which smile index was significantly higher in the attractive subgroup for both male and female subjects (mean values 6.31 ± 1.19 and 6.02 ± 1.20, respectively, ranged from 4.82 to 7.50).

Smile arc has extensively been shown to be correlated with smile esthetics, parallel smile arc being more attractive,[12] which contradicts the results of this study in which no significant differences were observed for smile arc (parallel vs. not parallel) between attractive and unattractive smiles. Research on different races and cultures may account for this difference.

Apart from the above smile characteristics, this study also explored the influence of dynamic smile symmetry on attractiveness. However, no significant differences were uncovered between attractive and unattractive groups as the average dynamic smile symmetry of each group was close to 1, which indicates a symmetrical smile. Low ICC for dynamic smile symmetry may explain this result.

Finally, this study compared smile characteristics between male and female subjects for both attractive and unattractive subgroups to explore whether preferences of smile characteristics are different based on sex. Results revealed that laypersons' preferences did not differ by sex of subject for all smile characteristics examined.

The current study has the following characteristics: (1) Method of acquisition of smile images: full-smile (ie, maximum smile) images were captured by videography instead of still photography in this study as

these were more easily reproducible,[29,43] thus reducing measurement error and allowing for relative ease in analysis and measurement. (2) Smile images or photographs evaluated: The majority of similar previous studies involved digital manipulation of smile images or photographs with one specific dental feature altered while keeping other facial features constant to more fully control all variables other than the specific dental feature of interest. However, the degree of realism archived by this digital manipulation method varies depending on the skill of the operator, and some unrealistic images may be created. To avoid the variance of digital manipulation, we used real full-smile images captured from natural dynamic smiles with no manipulation of any smile characteristics. (3) Number of smile characteristics analyzed: Various smile variables have been evaluated separately in previous investigations, but the influence of the interactions among these variables has not been extensively examined. This study evaluated eight smile-related characteristics simultaneously, which is essential for discovery of the predominant factors that affect the esthetic perception of smile attractiveness given the natural coexistence of a variety of factors.

Limitations of this study included the following: (1) Only young Chinese adults were recruited to evaluate smile attractiveness; future study should include evaluators from different age groups to explore the impact of age on esthetic preference of smile characteristics. (2) Selection criteria both for subjects whose smile images were evaluated as well as for raters might have suffered from some degree of bias in terms of population and/or ethnicity selection (3) Several qualitative smile-related characteristics were examined and further quantitative research on smile variables reflecting the relationship of lip, teeth, and gingiva should be conducted to advance a comprehensive understanding of factors influencing smile attractiveness and to determine the standards and norms of various smile variables. This will provide important guidance for cosmetic dental treatment with diagnostic criteria applicable to treatment planning.

5 | CONCLUSIONS

Based on the limitations imposed in the current study, the following conclusions may be drawn:

1. Laypersons can reliably identify unattractive and attractive smiles when viewing a lower face perspective.
2. The smile variables of anterior smile line, posterior smile line, upper lip curvature, and smile index were found to be correlated with laypersons' perception of smile attractiveness in both male and female subject groups, which should be given priority to consider and manage in the anterior esthetic treatment plan.
3. Smile-related characteristics such as downward upper lip curvature, cuspid or complex smile, and small smile index are limiting factors for achieving an attractive smile.

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DISCLOSURE

The authors do not have any financial interest in the companies/products used in with study.

ETHICAL APPROVAL

This research was conducted in accordance with the World Medical Association Declaration of Helsinki and approved by the Institutional Review Boards of the University Medical Ethics Committee. Written informed consents were obtained from all participants following the guidelines of the committee for the research process.

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