**RESEARCH**

# Evaluation of aesthetics of posed smiles based on smile-related characteristics

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## Abstract

**Purpose** The purpose of this study was to investigate the aesthetics evaluation of four smile-related characteristics among different genders and professional subgroups, including dental professionals (DPs), non-dental healthcare professionals (NDPs), and laypersons (LPs).

**Methods** Smile photographs were selected and digitally manipulated to determine changes in various smile aesthetic parameters (lip thickness ratio, smile line/smile index, upper lip curvature, and smile arc/dental curvature). These altered images were rated by Chinese participants (dental professionals, non-dental healthcare professionals, and laypersons). A total of 1469 subjects were recruited to complete the questionnaire. Smile aesthetics ratings were calculated, and comparisons between groups were made.

**Results** All respondents chose 1:1.5 lip thickness ratio, average smile line, upward upper lip curvature, and upward dental curvature (consonant smile arc) parallel to the lower lip curvature smile arc as the most attractive. Dental professionals (DPs) more focus on smile aesthetics compared to the others($p < 0.01$). Significant differences were detected in the perception of smile-related characteristics across gender and professional subgroups($p < 0.05$). In addition, there were significant differences in the attractiveness ratings for smiles among professional subgroups($p < 0.05$). The most important factor influencing smile aesthetics in the present study was smile arc.

**Conclusion** The smile-related characteristics of the smile, such as the lip thickness ratio, smile line, upper lip curvature, and smile arc are predominant factors influencing smile attractiveness and should be given priority when considering and managing aesthetic treatment plans. Females and DPs are more critical of smile aesthetics, and DPs are also focused more on smile aesthetics than laypersons. So it is necessary to account for the influence of gender and profession on personal evaluation and treatment plans.

**Keywords** Smile aesthetics · Smile analysis · Lip · Smile line · Smile Arc

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## Introduction

The attractiveness of human faces has been studied by researchers in diverse fields, and many rules of thumb have been given as to what kind of faces are the most attractive [1]. Aesthetic assessment is an extremely complex element influenced by gender, age, culture, ethnicity, and other factors [2–4]. Each individual has a unique aesthetic standard, which means that there are differences and subjectivity in aesthetics. However, there is still an objective standard of aesthetics in appearance, which leads to a general agreement among the public regarding evaluating appearance. There is a consensus that facial proportions that are harmonized significantly affect facial aesthetics [5, 6].

Beauty perception principles can also be applied to smile aesthetics. The smile is widely considered to be one of the most significant of facial expressions. Aesthetically pleasing or harmonious smiles have been demonstrated to enhance initial impressions during interpersonal interactions and to markedly increase an individual's self-esteem and societal acceptance [4, 6]. As seen patients' rising requests for improving their facial aesthetics, the goal of modern dentistry has shifted from improving function to balancing function and aesthetics [7, 8]. However, it has been found in clinical practice that even after orthodontic and orthognathic treatment, an attractive smile is not always obtained. Hulsey [5] found that although orthodontic treatment corrected the anomalies of some of the patients' dentition, their smiles were not aesthetically pleasing because the curvature of the dentition did not match the curvature of their lower lip. Smile aesthetics have become one of the objective indicators for dentists to assess treatment efficacy [9, 10]. Ackerman JL's study [11] states that a posed smile is repeatable, independent of emotion, can be measured and analysed, and can be acquired through training. In contrast, Darwin's [12] and Ekman's [13] views suggest that smiling facial expressions can be either posed or spontaneous. Perceptions of dentofacial aesthetics often differ greatly between dentists and patients. Orthodontists judge the relationship between the lips and teeth by employing lateral radiographs [14] and lateral photographs [15]. Bookstein F [16] argues that facial smile images are important for evaluating treatment outcomes, even in the absence of morphometric tools to quantify smile characteristics.

Previous studies on smile aesthetics mainly focused on the effect of dental-gingiva related factors, such as the shape, size, proportion, and position of anterior teeth, midline deviation, and anterior teeth and gingival display [2, 7, 17–19]. Only a few reports focused on the lips and the overall relationships among the lips, teeth, and gingiva [20, 21]. Smiles are mainly characterized by the relationship between the lips, gingiva, and teeth [22, 23]. The relationships among the lips, teeth, and gingiva can be used to establish treatment goals and evaluate the effectiveness of treatment.

A questionnaire was developed to explore the Chinese perspective on smile aesthetics. The survey was designed to assess four key variables of smile aesthetics—upper and lower lip thickness, smile line, upper lip curvature, and smile arc—by using a standardized posed smile image of one female with adjusting smile variables in image production. Aiming to provide insightful guidance for dentists.

## Materials and methods

### Ethical approval

This research was approved by the Institutional Review Boards of the Fourth Military Medical University Medical Ethics Committee (IRB-REV-2022110). We declare that all methods in the study were performed in accordance with the guidelines and regulations of the Institutional Review Board. The images in the questionnaire of this study were open-source and localized images of the face and did not involve facial privacy.

### Experimental equipment

The survey utilized a Huawei MateBook D16 SE (China) laptop, operating system Windows 10, 64-bit Home Chinese Edition, graphics card type Intel® UHD Graphics, memory capacity 16 GB, hard disk capacity 512 GB, CPU Intel Core i5-12450 H, Adobe Photoshop CC 2017 version, and Questionnaire Star web version (Changsha Ranxing Information Technology Co., Ltd., ICP licence: Xiang B2-20220508, Xiang ICP 17005436-1).

### Questionnaire design

A collection of standardized posed smiles (Fig. 1).

### Image editing

In the Adobe Photoshop CC 2017 version, images were edited based on specific criteria.

1. The ratios of the upper lip to the lower lip were 1:1, 1:1.5, and 1:2 (Fig. 2).
2. The smile line was adjusted:
   Low smile line: The lower edge of the upper lip was located at the upper 1/3 of the crown of the upper anterior teeth.

Fig. 1 Standard Posed Smile

Average smile line: The lower edge of the upper lip was located at the gingival margin of the anterior teeth and revealed only the interproximal gingiva.

High smile line: The lower edge of the upper lip was located 3 mm above the gingival margin of the upper anterior teeth (Fig. 3).

3. The upper lip curvature was redesigned to be downward, flat, and upward (Fig. 4).
4. The dental curvature (smile arc) was designed with the upper lip curvature remaining unchanged while the dental curvature was adjusted to be downward, flat (not parallel to the curvature of the lower lip), and upward (parallel to the curvature of the lower lip). (Fig. 5).

## Design of questionnaires

This study employed a questionnaire that included a brief overview of the study as well as information about the gender, age, and profession of the raters, followed by questions about smile aesthetics: "Have you ever paid attention to smile aesthetics, the most important factors affecting smile aesthetics, rater's satisfaction with different adjusted smile images, and the most important factor affecting smile aesthetics based on the above questions?". The questionnaire had acceptable reliability and good structural validity. A five-point Likert scale was employed (1 = very high, 2 = high, 3 = medium, 4 = low, and 5 = very low) for scoring [24]. The definitions of the smile variables are shown in Table 1.

The limited understanding of specialized terms related to smile aesthetics among the general population could



Fig. 2 Upper lip to lower lip thickness ratio: (A) 1:1, (B) 1:1.5, (C) 1:2



Fig. 3 Smile Line (Smile Index): (A) Low, (B) Average, (C) High

**Fig. 4** Upper Lip Curvature: (**A**) Downward, (**B**) Flat, (**C**) Upward



**Fig. 5** Dental Curvature (Smile Arc): (**A**) Downward, (**B**) Flat, (**C**) Upward

**Table 1** Definitions of terms related to the smile variables

| Smile variable | Definition | Range of values |
|---|---|---|
| Lip thickness ratio | The ratio of "vertical distance from the upper edge of the upper lip to the lower edge of the upper lip" to "vertical distance from the upper edge of the lower lip to the lower edge of the lower lip" | 1:1, 1:1.5, 1:2 |
| Smile line/ Smile index | The position of the lower edge of the upper lip/the intercommisural width divided by the interlabial gap during a smile | Low, average, high/great, average, small |
| Upper lip curvature | The curvature of the lower edge of the upper lip | Downward, flat, upward |
| Smile arc | The relationship of the curvature of the incisal edges of the maxillary incisors and canines to the curvature of the lower lip | Upward(Parallel), flat, downward (unparallel) |

lead to ambiguity in questionnaire questions and options. Therefore, we developed the questionnaire to have a more understandable presentation. Smile index was reflected by the position of the smile line, and the smile arc was replaced by the curvature of the anterior teeth. There were 12 photographs to be judged, and raters rated as follows: (1 = very attractive, 2 = attractive, 3 = accepted, 4 = unattractive, and 5 = very unattractive).

## Questionnaire collection and exclusion

The questionnaire was created using the Questionnaire Star platform, which is a professional online questionnaire survey platform in China. The link to the Questionnaire Star was disseminated to various groups, whose primary members were the authors' colleagues, relatives, and friends. The questionnaire was limited to two weeks, after which the collection of questionnaire information was closed. The exclusion criteria of questionnaires were: (1) Questionnaires in which all the answers to the questions had the same value; (2) Questionnaires in which all the answers to the questions were either ≤2 or ≥4. A total of 1738 responses were collected through a questionnaire in two weeks. After removing 269 invalid questionnaires based on the criteria, 1469 questionnaires remained.

## Statistical analysis

Pearson chi-square test was used to evaluate the difference of smile perception to each smile-related characteristic.

**Table 2** The demographic data among the groups

|  | DP | | NDP | | LP | | Overall | |
|---|---|---|---|---|---|---|---|---|
|  | $n$ | % | $n$ | % | $n$ | % | $N$ | % |
| Gender |  |  |  |  |  |  |  |  |
| Male | 160 | 49.4 | 125 | 29.7 | 354 | 48.9 | 639 | 43.5 |
| Female | 164 | 50.6 | 296 | 70.3 | 370 | 51.1 | 830 | 56.5 |
| Total | 324 | 100.0 | 421 | 100.0 | 724 | 100.0 | 1469 | 100.0 |
| Age group |  |  |  |  |  |  |  |  |
| 18–29 | 176 | 54.3 | 142 | 33.7 | 413 | 57.0 | 731 | 49.7 |
| 30–39 | 108 | 33.3 | 196 | 46.6 | 207 | 28.6 | 511 | 34.8 |
| ≥40 | 40 | 12.3 | 83 | 19.7 | 104 | 14.4 | 227 | 15.5 |
| Total | 324 | 100.0 | 421 | 100.0 | 724 | 100.0 | 1469 | 100.0 |

**Table 3** Attention to smile aesthetics among professional subgroups

|  | DP $n$(%) | NDP $n$(%) | LP $n$(%) | Overall $N$(%) | $\chi^2$ | $p$ |
|---|---|---|---|---|---|---|
| Yes | 244$_a$(75.3) | 112$_b$(26.6) | 198$_b$(27.3) | 554(37.7) | 250.187$^a$ | 0.000** |
| no | 80$_a$(24.7) | 309$_b$(73.4) | 526$_b$(72.7) | 915(62.3) |  |  |
| Total | 324(100.0) | 421(100.0) | 724(100.0) | 1469(100.0) |  |  |

** $p < 0.01$

**Table 4** Components influencing the smile aesthetics

| Components | DP $n$(%) | NDP $n$(%) | LP $n$(%) | Overall $N$(%) | $\chi^2$ | $p$ |
|---|---|---|---|---|---|---|
| Teeth | 33$_a$(10.2) | 83$_b$(19.7) | 153$_b$(21.1) | 269(18.3) | 25.551$^a$ | 0.000** |
| Lips | 3$_a$(0.9) | 10$_a$(2.4) | 24$_a$(3.3) | 37(2.5) |  |  |
| Both | 288$_a$(88.9) | 328$_b$(77.9) | 547$_b$(75.6) | 1163(79.2) |  |  |
| Total | 324(100) | 421(100) | 724(100) | 1469(100) |  |  |

** $p < 0.01$

Means and standard deviations(SDs) of the attractiveness rating were calculated, and analysis of variance (ANOVA) was used to analyze the influence of professional subgroups on attractiveness rating. Statistical Package of Social Sciences (SPSS) version 23.0 was used for data analysis. Significance was set at $P < 0.05$.

# Results

This study had a total of 1469 raters, consisting of 639 males (43.5%) and 830 females (56.5%). By age, 730(49.7%) raters were in the 18–29 age range, 511(34.8%) raters were in the 30–39 years age range, and 228(15.5%) raters were ≥40 years, with a mean age of 30.86 years. In terms of occupation, 324(22.1%) dental professionals (DPs), 421(28.6%) non-dental healthcare professionals (NDPs) and 724(49.3%) laypersons (LPs) participated in the study (Table 2).

When investigating the attention to smile aesthetics amongst the groups, 554 (37.7%) respondents reported considering smile aesthetics, while 915(62.3%) reported not. Statistically significant differences were observed in attention to smile aesthetics across the different professions ($\chi^2 = 250.187$, $p = 0.000$**). It shows that DPs do pay more attention to smile aesthetics compared to NDPs and LPs (Table 3). The most important component affecting the

aesthetics of the smile was both dentition and lips (79.2%). Compared with NDPs and LPs, DPs were found to be the keenest to consider both components (88.9%, $p < 0.01$), suggesting that dentists are more concerned with the harmony of the teeth and lips (Table 4).

All respondents perceived 1:1.5 lip thickness ratio, average smile line, upward upper lip curvature, and upward dental curvature parallel to the curvature of the lower lip as the most attractive (73.66%, 81.76%, 91.70%, and 86.93% respectively). The results of smile variable analysis comparing male and female subgroups are shown in Table 5. No statistically significant differences were observed between male and female subgroups for lip thickness ratio ($\chi^2 = 2.284$, $p = 0.319$), implying that there is consistency across genders for lip thickness ratio. There was a significant difference between males and females in smile line ($\chi^2 = 8.544$, $p = 0.014^*$), upper lip curvature ($\chi^2 = 19.149$, $p = 0.000$**), and dental curvature ($\chi^2 = 25.186$, $p = 0.000$**). Females were more critical in detecting low smile line, flat upper lip curvature, downward and flat dental curvature although both male and female respondents detected high or low smile line, flat or downward upper lip curvature, and flat or downward dental curvature unattractive.

For professional subgroups, no statistically significant difference was found for dental curvature among DP, NDP, and LP subjects ($\chi^2 = 5.252$, $p = 0.262$). However,

**Table 5** Comparison of smile aesthetic variables between male and female subgroups

| Smile variables | Classification | Groups | | $\chi^2$ | p |
|---|---|---|---|---|---|
| | | Male $n$(%) | Female $n$(%) | | |
| Lip thickness ratio | 1:1 | $60_a$(9.4) | $60_a$(7.2) | $2.284^a$ | 0.319 |
| | 1:1.5 | $463_a$(72.5) | $619_a$(74.6) | | |
| | 1:2 | $116_a$(18.1) | $151_a$(18.2) | | |
| Smile line | low | $84_a$(13.1) | $78_b$(9.4) | $8.544^a$ | $0.014^*$ |
| | average | $501_a$(78.4) | $700_b$(84.3) | | |
| | high | $54_a$(8.5) | $52_b$(6.3) | | |
| Upper lip curvature | downward | $14_a$(2.2) | $9_a$(1.1) | $19.149^a$ | $0.000^{**}$ |
| | flat | $62_a$(9.7) | $37_b$(4.5) | | |
| | upward | $563_a$(88.1) | $784_b$(94.4) | | |
| Dental curvature | downward | $33_a$(5.2) | $17_b$(2.1) | $25.186^a$ | $0.000^{**}$ |
| | flat | $82_a$(12.8) | $60_b$(7.2) | | |
| | upward | $524_a$(82.0) | $753_b$(90.7) | | |

\* $p<0.05$, \*\* $p<0.01$

the perceived difference in lip thickness ratio ($\chi^2 = 10.542$, $p = 0.032^*$), smile line ($\chi^2 = 13.155$, $p = 0.011^*$), and upper lip curvature ($\chi^2 = 11.946$, $p = 0.018^*$) was statistically significant. Although all respondents perceived 1:1.5 lip thickness ratio, average smile line, and upward upper lip curvature as the most attractive, there still had statistically significant differences ($p<0.05$) between DPs and LPs (Table 6).

The mean values and standard deviations of the attractiveness ratings for smile images among professional subgroups are given in Table 7. No statistically significant difference was found for 1:1 and 1:1.5 lip thickness ratio, low and high smile line, downward and flat upper lip curvature, and flat dental curvature($p>0.05$). However, the difference between subgroups was statistically significant for 1:2 lip thickness ratio ($F = 4.659$, $p = 0.010^*$), average smile line ($F = 15.663$, $p = 0.000^{**}$), upward upper lip curvature ($F = 12.238$, $p = 0.000^{**}$), and downward and upward dental curvature ($p = 0.004^{**}$, $p = 0.000^{**}$). Analysis of the most important factor influencing smile aesthetics (Table 8) showed that there was a significant difference among the professional subgroups ($\chi^2 = 29.106$, $p = 0.000^{**}$).

**Table 6** Comparison of smile aesthetic variables among professional subgroups

| Smile variables | Classification | Groups | | | Total $N$(%) | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|
| | | DP $n$(%) | NDP $n$(%) | LP $n$(%) | | | |
| Lip thickness ratio | 1:1 | $18_a$(5.6) | $33_a$(7.8) | $69_a$(9.5) | 120(8.17) | $10.542^a$ | $0.032^*$ |
| | 1:1.5 | $257_a$(79.3) | $316_{a,\,b}$(75.1) | $509_b$(70.3) | 1082(73.66) | | |
| | 1:2 | $49_a$(15.1) | $72_a$(17.1) | $146_a$(20.2) | 267(18.17) | | |
| Smile line | low | $22_a$(6.8) | $44_{a,\,b}$(10.4) | $96_b$(13.3) | 162(11.03) | $13.155^a$ | $0.011^*$ |
| | average | $284_a$(87.7) | $348_{a,\,b}$(82.7) | $569_b$(78.6) | 1201(81.76) | | |
| | high | $18_a$(5.5) | $29_a$(6.9) | $59_a$(8.1) | 106(7.21) | | |
| Upper lip curvature | downward | $4_a$(1.2) | $7_a$(1.6) | $12_a$(1.7) | 23(1.56) | $11.946^a$ | $0.018^*$ |
| | flat | $10_a$(3.1) | $26_{a,\,b}$(6.2) | $63_b$(8.7) | 99(6.74) | | |
| | upward | $310_a$(95.7) | $388_{a,b}$(92.2) | $649_b$(89.6) | 1347(91.70) | | |
| Dental curvature | downward | $7_a$(2.2) | $16_a$(3.8) | $27_a$(3.7) | 50(3.40) | $5.252^a$ | 0.262 |
| | flat | $27_a$(8.3) | $35_a$(8.3) | $80_a$(11.1) | 142(9.67) | | |
| | Upward | $290_a$(89.5) | $370_a$(87.9) | $617_a$(85.2) | 1277(86.93) | | |

\* $p<0.05$

**Table 7** Comparison of attractiveness ratings for smile variables among professional subgroups

| Smile variables | Classification | DP | NDP | LP | $F$ | p |
|---|---|---|---|---|---|---|
| | | Mean$\pm$SD | Mean$\pm$SD | Mean$\pm$SD | | |
| Lip thickness ratio | 1:1 | $2.45\pm0.99$ | $2.61\pm1.02$ | $2.57\pm1.09$ | 2.186 | 0.113 |
| | 1:1.5 | $4.21\pm0.89$ | $4.18\pm0.91$ | $4.09\pm0.97$ | 2.551 | 0.078 |
| | 1:2 | $2.95\pm1.09$ | $3.00\pm1.12$ | $3.15\pm1.09$ | 4.659 | $0.010^*$ |
| Smile line | low | $2.41\pm1.05$ | $2.51\pm1.02$ | $2.53\pm1.15$ | 1.334 | 0.264 |
| | average | $4.34\pm0.86$ | $4.14\pm0.99$ | $3.98\pm1.06$ | 15.663 | $0.000^{**}$ |
| | high | $2.53\pm1.05$ | $2.50\pm1.02$ | $2.56\pm1.07$ | 0.465 | 0.628 |
| Upper lip curvature | downward | $1.69\pm0.85$ | $1.70\pm0.82$ | $1.72\pm0.86$ | 0.150 | 0.861 |
| | flat | $2.37\pm0.90$ | $2.36\pm0.95$ | $2.31\pm0.94$ | 0.578 | 0.561 |
| | upward | $4.51\pm0.78$ | $4.36\pm0.83$ | $4.23\pm0.88$ | 12.238 | $0.000^{**}$ |
| Dental curvature | downward | $1.76\pm0.87$ | $1.90\pm0.98$ | $1.98\pm1.07$ | 5.676 | $0.004^{**}$ |
| | flat | $2.47\pm0.93$ | $2.42\pm1.02$ | $2.44\pm1.05$ | 0.212 | 0.809 |
| | upward | $4.44\pm0.83$ | $4.24\pm0.94$ | $4.13\pm0.98$ | 12.011 | $0.000^{**}$ |

\* $p<0.05$, \*\* $p<0.01$

**Table 8** Comparison of the most important factor influencing smile aesthetics among subgroups

| Smile variables | DP $n$(%) | NDPn(%) | LP $n$(%) | Overall $N$(%) | $\chi^2$ | $p$ |
|---|---|---|---|---|---|---|
| Lip thickness ratio | 32$_a$(9.9) | 65$_a$(15.4) | 155$_b$(21.4) | 252(17.1) | 29.106$^a$ | 0.000$^{**}$ |
| Smile line | 109$_a$(33.6) | 112$_{a, b}$(26.6) | 179$_b$(24.7) | 400(27.2) | | |
| Upper lip curvature | 80$_a$(24.7) | 88$_a$(20.9) | 143$_a$(19.8) | 311(21.2) | | |
| Dental curvature | 103$_a$(32.8) | 156$_a$(37.1) | 247$_a$(34.1) | 506(34.5) | | |
| Total | 324(100) | 421(100) | 724(100) | 1469(100) | | |

** $p < 0.01$

## Discussion

A detailed examination of the smile characteristics is an essential part of treatment planning in dentistry especially when the patient has high aesthetic demands. This survey was designed to evaluate the smile aesthetics of the Chinese. As a reproducible smile for research, the posed smile is investigated in the study. Four smile-related characteristics were introduced: lip thickness ratio, the smile line (smile index), the upper lip curvature, and the smile arc (dental curvature). Based on the four smile variables, the perception of smile aesthetics was investigated across gender and occupation.

Compared to dental professionals, the rest of the participants were all less concerned about smile aesthetics. The common findings were: 1:1.5 lip thickness ratio, average smile line, upward upper lip curvature, and upward dental curvature parallel to the curvature of the lower lip to be the most attractive. However, there were still some differences between genders and professions. Unlike other surveys, this survey focused on designing questions related to soft-tissue aesthetics. This is because the public knows more about dental aesthetics but less about soft tissue aesthetics. There were 1469 valid survey responses, which were representative and could reflect the public's general view of smile aesthetics. As mentioned earlier, the public's evaluation standards of attractiveness and unattractiveness always tend to be the same, and the results of this survey showed the same tendency. The final results of the four smile-related variables of the study were in line with the original intention of the questionnaire design, as well as with the public's aesthetic standard.

Except for the ratio of lip thickness, the other three smile-related characteristics were statistically different across genders. Results revealed that Chinese males and females have similar smile aesthetic preferences for multiple variables. They preferred attractive smiles characterized by a 1:1.5 lip thickness ratio, average smile line with average smile index, upward upper lip curvature, and upward dental curvature parallel to lower lip curvature. The results demonstrate females were more sensitive to smile aesthetics and more critical in detecting imperfect smiles. Compared to males, females were less likely to choose low smile line, flat upper lip curvature, downward and flat dental curvature although both male and female respondents detected high or low smile line, flat or downward upper lip curvature, flat or downward dental curvature unattractive. In addition, females gave a higher rating for a charming smile than males.

The smile is characterized primarily by the relationship between the lips, gingiva, and teeth [22, 23]. There were significant differences in the evaluation of lip thickness ratio, smile line, and upper lip curvature across professional subgroups, which may be related to their aesthetic standards, professional backgrounds, and experiences. However, there was no statistically significant difference in smile arc, with all respondents finding upward dental curvature more aesthetically pleasing than flat or downward dental curvature. Significant differences were in the downward and upward dental curvature ratings across professional subgroups.

Currently, the cosmetic industry has designed a "Marquardt's Phi mask" using the golden ratio of "1:1618" to evaluate the delicate structure of facial features [25, 26], and it has been found that all recognized aesthetics conform to this ratio. Some people are not well informed about the aesthetics associated with lip tissue and concerned only with the aesthetics of the teeth. There is no reported literature on lip thickness related to smile aesthetics. In the present study, the lip thickness ratio of 1:1.5 was found to be the most attractive. The ratio of 1:1.5 is closer to the golden ratio of 1:1618 than the ratios of 1:1 and 1:2. In a way, this may indirectly confirm the golden ratio. Follow-up studies should further validate this idea.

The aesthetic evaluation of the smile line was consistent in the present study, all respondents chose the average smile to be the most attractive, while there were professional differences in the evaluation of the low smile line and average smile line. The high smile line was considered to be the most unacceptable smile line. A smile with high smile line or exposed gingiva may be due to periodontal causes (e.g., shortened incisor heights) or a vertically maxillary excess, which is usually observed in bimaxillary anterior protrusions. The findings of Tjan et al. [4]. showed that smiles with the crowns of the maxillary anterior teeth fully exposed (average smile line), the incisal curvature of the incisal edges of the teeth of the 13–23 being parallel to the curvature of the lower lip, and the smiles with exposure of the 14–24 are judged the most attractive. Reasonable gingival exposure is

acceptable and, to a certain extent, can be considered a sign of youth [27].

The DPs rated the aesthetics of the average smile line the highest, which significantly differed from the ratings for the other groups revealed through ANOVA. This may be related to the fact that the DPs are more concerned with dental health and smile aesthetics. Passia et al. [28] also showed that the smile line is universally applicable to smile aesthetics and is a good guide for both dental and nondental professionals. In the majority of cases, orthodontists and orthognathic surgeons prefer a smile with average smile line. This was corroborated in our earlier study on orthognathic surgery for the improvement of the posed smile in patients with dentofacial deformity [29]. It was found that the patients with Class II dentofacial deformity who exhibited high smile line preoperatively, the smile line was modified to average or low following orthognathic surgery.

The smile index reflects the transverse and vertical relationships of a smile [11]. The aesthetic smile index is generally considered to be greater than 5.0 and less than 7.5 [20]. A smile index greater than 7.5 indicates the aging of a smile due to the greater width and the smaller interlabial gap. A smaller smile index indicates greater exposure of the teeth and gingiva. In this study, the average smile index was 6.0, 9.03 for the low smile line, and 4.65 for the high smile line. While keeping the width of the smile constant, the position of the upper lip determines the smile index. In patients with Class II dentofacial deformity characterised by high smile line, the smile height tends to be larger and the smile index is smaller. After orthognathic surgery, a decrease in smile height and an increase in smile index are evident as the high smile line improve.

The result that upward upper lip curvature was more appealing than flat and downward curvatures is in accordance with the findings of Dong et al. [30]. And the downward upper lip curvature was the most unattractive. According to Hulsey [5] and Khan [21], an upward upper lip curvature was the most prevalent feature in the subjects of their studies and the ideal curvature of the upper lip could be obtained when the positions of both commissures are elevated above the central portion of the upper lip. It has been documented that the curvature of the upper lip cannot be altered by orthodontic treatment, so an ideal smile is difficult to achieve in patients with downward lip curvature [31]. In the previous study, we found that the upper lip curves of different dentofacial deformity have their own characteristics. Especially for Class II and Class III dentofacial deformity, a significant number of patients present a downward upper lip curvature. Following orthognathic surgery, the downward curvature of the upper lip is transformed into upward or flat. To some extent, this means that the upward curvature of the upper lip

is aesthetically pleasing to both the surgeon and the patient [29].

The smile arc is one of the most important references in smile aesthetics [20, 32]. D M Sarver et al. [33] defined the smile arc as the relationship between the curvature of the incisal edges of the maxillary incisors and cuspids and the curvature of the lower lip during a posed smile. In the present study, a consonant smile arc that parallels the lower lip curvature was perceived as more attractive than a non-consonant smile. These findings are in agreement with Hulsey [5] and Zapata et al. [34]. The consonant smile arc was most commonly observed whereas the reverse smile arc was least frequent [4, 21, 30]. There were significant differences in the rating for dental curvature across professional subgroups, and these findings have important implications for research and clinical practice in lip-teeth aesthetics to help dentists and patients better understand and meet the aesthetic needs of different professions. DPs with dentistry backgrounds rated the upward dental curvature (consonant smile arc) higher than the other subgroups. This may be related to the variation in the importance and professional perception of smile aesthetics across professions. The smile arc was accepted by 34.5% of the participants as the most important component and should be planned while formulating an aesthetic treatment. In cases of orthognathic treatment, the maxilla is rotated to ensure the achievement of parallel smile arc, especially if the smile arc is flat or reversed. This is also related to the aesthetic evaluation of the smile arc by the orthognathic surgeon [29].

The limitation of this study is that only female smiles were used as original photographs; hence, the results may not be generalizable. However, this was done to avoid an excessive number of photographs being rated, which could have led to aesthetic fatigue for the raters. Future assessments of smile aesthetics should include photographs of both male and female smiles. Moreover, given that the questionnaire was collected via an online platform, a substantial but randomized sample size was attained expeditiously. Consequently, it was challenging to conduct a subsequent questionnaire to verify the consistency of the raters. In future studies, we can consider reducing the sample size appropriately, selecting a dental professional population of respondents, and conducting repeated assessments to make the findings more reliable.

## Conclusion

The evaluation of smile aesthetics involves various important variables, such as the lip thickness ratio, smile line, upper lip curvature, and smile arc. The general public has a relatively consistent perception of attractive smiles, and clinical treatment usually tends to align with the aesthetic

preferences of public acceptance. The evaluation of smile aesthetics differs across genders and professions. In some ways, females and DPs are more critical of smile aesthetics, and DPs are also focused more on smile aesthetics than lay-persons. Therefore, it is essential to design treatment plans according to each person's unique needs.

**Data availability** No datasets were generated or analysed during the current study.

## Declarations

**Competing interests** The authors declare no competing interests.

**Ethical Approval** This study was approved by the Ethics Review Board of the Stomatological Hospital of the Fourth Military Medical University (IRB-REV-2022110). We declare that all methods in the study were performed in accordance with the guidelines and regulations of the Institutional Review Board. The images in the questionnaire of this study were open-source and localized images of the face and did not involve facial privacy.

**Consent to participate** Not applicable. The questionnaire was conducted anonymously and without involving patient privacy.

## References

1. Zhang D, Zhao Q, Chen F (2011) Quantitative analysis of human facial beauty using geometric features[J]. Pattern Recogn 44(4):940–950

2. Musa M, Awad R, Mohammed A et al (2023) Effect of the ethnic, profession, gender, and social background on the perception of upper dental midline deviations in smile esthetics by Chinese and black raters[J]. BMC Oral Health 23(1):214

3. Sharma N, Rosenstiel SF, Fields HW Smile characterization by, white US et al (2012) U.S. Asian Indian, and Indian populations[J]. The Journal of Prosthetic Dentistry, 107(5): 327–335

4. Tjan AH, Miller GD, The JG (1984) Some esthetic factors in a smile[J]. J Prosthet Dent 51(1):24–28

5. Hulsey CM (1970) An esthetic evaluation of lip-teeth relationships present in the smile[J]. Am J Orthod 57(2):132–144

6. Van der Geld P, Oosterveld P, Van Heck G et al (2007) Smile attractiveness. Self-perception and influence on personality[J]. Angle Orthod 77(5):759–765

7. Blatz MB, Chiche G, Bahat O et al (2019) Evolution of aesthetic Dentistry[J]. J Dent Res 98(12):1294–1304

8. Goldstein RE (1969) Study of need for esthetics in dentistry[J]. J Prosthet Dent 21(6):589–598

9. Machado AW (2014) 10 Commandments of smile esthetics[J]. Dent Press J Orthod 19(4):136–157

10. Impact of assessing smile (2020) Parameters as part of orthodontic treatment planning - a survey based analysis[J]. J World Federation Orthodontists 9(3):117–122

11. Ackerman JL, Ackerman MB, Brensinger CM et al (1998) A morphometric analysis of the posed smile[J]. Clin Orthod Res 1(1):2–11

12. Darwin C (1998) The expression of the emotions. Man and Animals[M]. Oxford University Press

13. Ekman P (1973) Darwin and facial expression: A century of research in review.[M]. Academic, Oxford, England, p 273

14. Tweed CH (1945) A philosophy of orthodontic treatment[J]. Am J Orthod Oral Surg 31(2):74–103

15. Holdaway RA (1983) A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I[J]. Am J Orthod 84(1):1–28

16. Bookstein FL (1992) Morphometric tools for landmark data: geometry and Biology[M]. 1st edn. Cambridge University Press

17. Koidou VP, Chatzopoulos GS, Rosenstiel SF (2018) Quantification of facial and smile esthetics[J]. J Prosthet Dent 119(2):270–277

18. Ker AJ, Chan R, Fields HW et al (1939) Esthetics and smile characteristics from the layperson's perspective: a computer-based survey study[J]. Journal of the American Dental Association 2008, 139(10): 1318–1327

19. Chen Yhui, Cheng Y ling, Cheng H et al (2020) Comparison of smile esthetics among celebrities, dentists, and dental students in a Han Chinese population[J]. The Journal of Prosthetic Dentistry, 123(6): 845–849

20. Sabbah A (2022) Smile analysis: diagnosis and treatment Planning[J]. Dental Clin N Am 66(3):307–341

21. Khan M, Kazmi SMR, Khan FR et al (2020) Analysis of different characteristics of smile[J]. BDJ Open 6:6

22. Garber DA, Salama MA (2000) The aesthetic smile: diagnosis and treatment.[J]. Periodontology. 1996, 11: 18–28

23. Brandão RCB, Brandão LBC (2013) Finishing procedures in orthodontics: dental dimensions and proportions (microesthetics)[J]. Dent Press J Orthod 18(5):147–174

24. Abu Alhaija ESJ, Al-Shamsi NO, Al-Khateeb S (2011) Perceptions of Jordanian laypersons and dental professionals to altered smile aesthetics[J]. Eur J Orthod 33(4):450–456

25. Holland E (2008) Marquardt's phi mask: pitfalls of relying on fashion models and the golden ratio to describe a beautiful Face[J]. Aesthetic Plast Surg 32(2):200–208

26. Bookstein FL (1997) Landmark methods for forms without landmarks: morphometrics of group differences in outline shape[J]. Med Image Anal 1(3):225–243

27. Vig RG, Brundo GC (1978) The kinetics of anterior tooth display[J]. J Prosthet Dent 39(5):502–504

28. Passia N, Blatz M, Strub JR (2011) Is the smile line a valid parameter for esthetic evaluation? A systematic literature review[J]. Eur J Esthetic Dentistry: Official J Eur Acad Esthetic Dentistry 6(3):314–327

29. Zhong B, Zhou G, Yang Y et al ( 2025) Improvement of smile characteristics in dentofacial deformity patients following orthognathic surgery[J]. J Cranio-Maxillofacial Surg, 53(3), 271–278

30. Dong JK, Jin TH, Cho HW et al (1999) The esthetics of the smile: a review of some recent studies[J]. Int J Prosthodont 12(1):9–19

31. Sabri R (2005) The eight components of a balanced smile[J]. J Clin Orthodontics: JCO 39(3):155–167 quiz 154

32. Contemporary orthodontics (2019) Sixth edition[J]. Br Dent J 226(11):828

33. Sarver DM (2001) The importance of incisor positioning in the esthetic smile: the smile arc[J]. American journal of orthodontics and dentofacial orthopedics: official publication of the American association of orthodontists, its constituent societies, and the American board of orthodontics. 120(2):98–111

34. Zapata O, Barbosa D, Carvajal A et al (2023) Finishing analysis of dental outcome (FADO) as a new guide in orthodontic Treatment[J]. Cureus 15(2):e34808