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Assessment of dynamic smile and gingival contour in young Chinese people

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Objectives: This study aimed to classify the dynamic smile and to quantify the gingival line (GL), as well as apico-coronal displacement of the gingival zenith (GZ), in the maxillary anterior dentition in a young Chinese population. **Methods:** Two-hundred young Chinese subjects (100 men and 100 women; 20–35 years of age) with healthy dentogingival tissue were recruited. The dynamic smile process was captured using a digital camera. The smile type, GL type, the vertical distance of the GZ between the canine and the central incisor on the same side and the GZ of the lateral incisor–GL relationship were measured using a self-developed smile-analysis method. The kappa statistics was used to examine the reliability of the data recorded by the rater. The Pearson chi-square test was used to analyse the differences between subjects regarding the frequencies of smile type and GL type at $\alpha = 0.05$. **Results:** Data revealed that 45.5% of subjects had a high smile and 45.5% had an average smile; 58.2% of the subjects presented an upwards GL. The GZ of canine teeth was 0.33 mm apical to the corresponding central incisor and no significant difference between both sides of the GZ was observed. The GZ of the lateral incisor was located coronal to the GL in 87.9% of samples. The vertical distance between the GZ of the lateral incisor and the GL was 0.59 mm and no statistically significant difference was detected. **Conclusions:** The most common findings were a high or average smile type, combined with an upward GL. In the majority of subjects, the GZ of the lateral incisor is coronal to the GL. The apico-coronal displacement of the GZ showed bilateral symmetry.

Key words: *Young Chinese, smile type, anterior aesthetic zone, gingival zenith, gingival line*

INTRODUCTION

The aesthetics of a smile has become increasingly important in the practice of modern restorative dentistry and is synonymous with a natural and harmonious appearance. An attractive and pleasing smile clearly enhances the acceptance of an individual in our society by improving the initial impression in interpersonal relationships[1–4].

Tjan *et al*[1]. classified smiles into three types according to teeth and gingival tissue display during smiling. In his study, the essential factors were the lip–tooth–gingiva relationship, tooth characteristics and the surrounding gingival morphology. These factors are also the anatomical foundation of aesthetic dentistry and the key factors for treatment planning.

The contour of the gingival tissue surrounding the teeth also plays an important role in providing an optimal aesthetic appearance in the maxillary anterior sextant and affects the harmonious appearance of a smile. Consequently, any dental procedure performed in this zone will be an aesthetic challenge because of its visibility[5]. The physiological gingival architecture has been described as one that consists of knife-edged gingival margins tightly adapted to the teeth, interdental grooves and cone-shaped interdental papilla[6]. Such parabolic architecture is critically outlined by the zenith, which is defined as the most apical point of the gingival marginal scallop. The zenith on the maxillary central incisors and canines was described as located at the same height, and that on the lateral incisors was described as slightly coronal[7]. Extensive studies have been performed on Caucasian subjects to establish the mechanism, characteristics and factors influencing a smile; in contrast, there is very little such data for Asian populations[8,9]. The appearance of the smile varies with each race, along with different perspectives of beauty. It is necessary to establish sci-

entific analytical methods to identify the smile-correlative elements in young Chinese people and to input information, thus obtained, into a database, permitting progressive identification of the necessary features. This can serve as a guideline in clinical treatment planning and for future research.

The aim of this study was to investigate the features of gingival tissue in young Chinese subjects. The null hypothesis of this study was that there were no significant differences in gingival features between the high-smile type of young male and female Chinese subjects.

METHODS

Sampling and selection criteria

Two-hundred young Chinese volunteer subjects (100 men and 100 women; 20–35 years of age) were recruited from the Peking University Health Science Center. All were of native Han nationality. The research proposal was conducted in full accordance with the World Medical Association Declaration of Helsinki and was approved by the Institutional Review Boards of Peking University Medical Ethics Committee (PKUSSIRB 2012083). Written informed consent was obtained from the participants in accordance with the guidelines of the committee for the subject selection process.

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 dentin; no gingival recession; no bleeding on probing; and marginal tissue knife-edged in form, firm in consistency and pink in colour[10].

Recording and measurement during spontaneous smiling

Details of the method and test set up to record dynamic smiles have been reported in a previous study[11]. The video clip was downloaded to a computer and processed using video-editing software (Sony Vegas Pro 10.0; Sony Creative Software Inc., Middleton, WI, USA). The dynamics of smiling could be reviewed frame by frame. Two video frames, including an oral lip-scale frame and a full-smile frame, were selected (*Figure 1*). These frames were converted into a JPEG file and renamed in Windows XP Professional (Microsoft, Redmond, WA, USA) with the subjects' code numbers. Each image file was opened and saved using a program (SmileQuant; School of Stomatology, Peking University, Beijing, China) for analytical use. Open-smile categories were used to classify dynamic smiles[1] (*Figure 2*).

Measurement of gingival contour in high-smile-type subjects

- Software development. To correlate the feature of dentogingival tissues with smile aesthetics, an analytical program, named SmileQuant, was developed and used for dentogingival tissue measurement. In this study, 22 smile aesthetic-related landmarks were used (*Figure 3*). The true values of the relationship between landmarks were adjusted automatically, using this program.

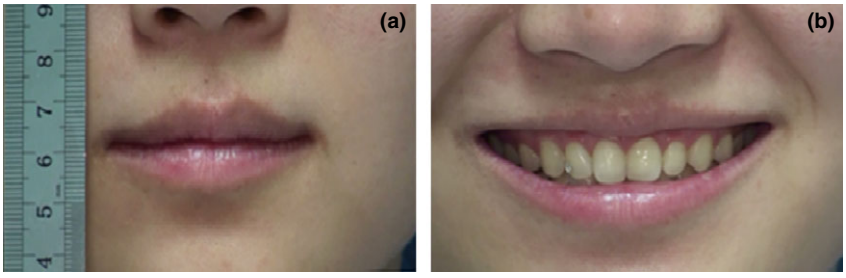

Figure 1. Two major images captured from dynamic smile video records. (a) Oral lip-scale frame and (b) full-smile frame.

Figure 2. Open-smile categories. (a) High-smile type. (b) Average-smile type. (c) Low-smile type.

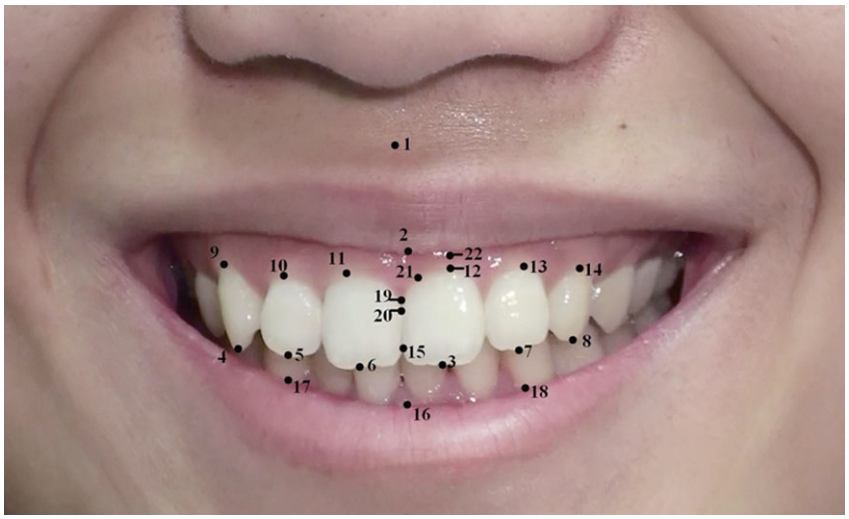

Figure 3. Twenty-two landmarks were defined. Point 1, midpoint of philtrum; point 2, lowest point of the lower edge of the upper lip; point 3, incisal edge of the maxillary central incisor (if the lower lip contacted the upper central incisor when smiling, marking the lowest contact point as landmark 3); points 4, 5, 6, 7, 8, intersection points of the upper long axis of the incisors and the incisor edge and the canine cusp, respectively; points 9, 10, 11, 12, 13, 14, gingival zenith (GZ) of upper anterior teeth; point 15, the most incisal point of the upper central incisors contact area; point 16, centre of the upper edge of the lower lip, corresponding to point 15; points 17 and 18, points corresponding vertically to points 5 and 7 on the upper edge of the lower lip; point 19, interdental papilla tip of the upper central incisors; point 20, apex of the upper central incisors contact area; point 21, the most outstanding point on the gingival margin equivalent to the line linking points 12 and 22; point 22, the point corresponding to point 12 on the boundary between free gingiva and attached gingiva.

Figure 4. Classification of the gingival line (GL). (a) Straight type. (b) Upward type. (c) Downward type.

- Gingival contour assessment. The gingival zenith (GZ) is defined as the most apical point of the marginal gingival scallop, and the GZ points of anterior maxillary teeth were marked accordingly[5]. 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[12]. Dentogingival tissue contours were assessed only in subjects with a high-smile type. Three categories of the GL location were classified according to the relationship and differences in distance between the GZ point of the central incisor and canine at the same side: straight GL type (both the GZ points of the central incisor and canine are parallel to the horizon); upward GL type (the canine GZ point is located apically to the central incisor); and downward GL type (the canine GZ point is coronal to the central incisor) (*Figure 4*). The distance between the lateral incisor GZ point and the GL (LID) was determined automatically using the software (*Figure 5*).

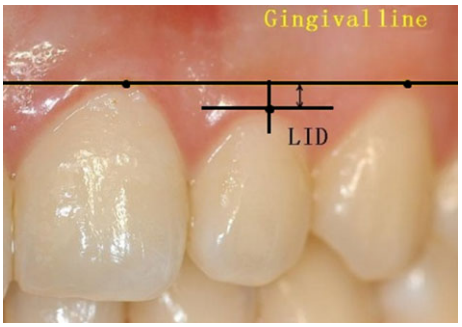

Figure 5. LID: the distance between the gingival zenith (GZ) of the lateral incisor and the gingival line (GL).

Statistical analysis

All hypotheses were tested statistically at $\alpha = 0.05$. The kappa statistic was used to examine the reliability of the data, recorded by the rater, obtained from 20 male and 20 female subjects at two time points (times

1 and 2) with an intervening period of 1 week. The Pearson chi-square test was used to analyse the differences between male and female subjects in the frequencies of smile type and GL type at $\alpha = 0.05$.

RESULTS

The age of the subjects was 25.0 ± 2.0 years for men and 24.8 ± 2.2 years for women (mean and standard deviation). During spontaneous smiling, the majority of smile types were high smile and average smile, with the same percentage (45.5%) obtained for both. The distribution of smile types in all samples is shown in *Table 1*. Significant differences were found in the percentage of smile types between different gender groups ($P < 0.05$). To assess the reliability of separate measurements, 40 subjects (20 men and 20 women) were selected randomly and four basic characteristics were measured at two time points, with a 1-week intervening interval. The first and the second measurements of these characteristics are listed in *Table 2*. The correlation coefficient (r) varied between 0.900 and 0.940. No statistically significant differences were obtained between data obtained at different time points ($P > 0.05$). The frequencies of GL types in high smile are shown in *Table 3*. There was a significantly higher percentage of the downwards GL type and a significantly lower percentage of the upwards GL type in men compared with women ($P < 0.05$). To assess the spatial relationship between canine and central incisor GZ points, differences in vertical distance were calculated and the results are shown in *Table 4*. Female subjects had significantly larger differences in vertical distance than male subjects ($P < 0.05$). The relationship between the lateral incisor GZ point and the GL are shown in *Table 5*. In the majority of participants (87.9%), the lateral incisor GZ was located coronal to the GL. The total mean distance from the GZ of the lateral incisor to the GL was 0.59 ± 0.54 mm (data shown in *Table 6*).

Table 1 Distribution of smile types in 200 young Chinese subjects

Subjects	High smile *n* (%)	Average smile *n* (%)	Low smile *n* (%)
Men ($n = 100$)	38 (38.0[a])	48 (48.0)	14 (14.0[b])
Women ($n = 100$)	53 (53.0[a])	43 (43.0)	4 (4.0[b])
Total ($n = 200$)	91 (45.5)	91 (45.5)	18 (9.0)

Within a column, percentage values with the same lower-case letter are statistically different ($P < 0.05$).

Table 2 Correlated comparison between the first and second measurements made (with a 1-week intervening period) of four characteristics in 40 subjects (20 men and 20 women)

Characteristic	First time point	Second time point	*r* Value
Vertical distance of GZ between canine and central incisor (right)	1.00 ± 0.72	1.07 ± 0.71	0.911
Vertical distance of GZ between canine and central incisor (left)	1.11 ± 0.81	1.18 ± 0.75	0.940
Distance from GZ of lateral incisor to GL (right)	0.61 ± 0.42	0.61 ± 0.39	0.922
Distance from GZ of lateral incisor to GL (left)	0.50 ± 0.36	0.51 ± 0.34	0.900

GL, gingival line; GZ, gingival zenith.

Table 3 Frequencies of gingival line types in high-smile type

Subjects	Gingival line (*n*)	Straight *n* (%)	Upward *n* (%)	Downward *n* (%)
Men ($n = 38$)	76	6 (7.9)	34 (44.7[a])	36 (47.4[b])
Women ($n = 53$)	106	10 (9.4)	72 (67.9[a])	24 (22.6[b])
Total ($n = 91$)	182	16 (8.8)	106 (58.2)	60 (33.0)

Within a column, percentage values with the same lower-case letter are statistically different ($P < 0.05$).

Table 4 Vertical differences between canine and central incisor gingival zeniths (GZs)

Subjects	Right*n* ($\bar{x}$ ± SD)	Left*n* ($\bar{x}$ ± SD)	Bilateral*n* ($\bar{x}$ ± SD)
Men	38 (−0.23* ± 1.29)[a]	38 (0.14 ± 1.30)[b]	76 (−0.04 ± 1.30)[c]
Women	53 (0.51 ± 1.17)[a]	53 (0.69 ± 1.07)[b]	106 (0.60 ± 1.18)[c]
Total	91 (0.20 ± 1.27)	91 (0.46 ± 1.19)	182 (0.33 ± 1.23)

$\bar{x}$, average of x.
SD, standard deviation.
Unit: mm.
Within a column, number values with the same lower-case letter are statistically different ($P < 0.05$).
*A minus value indicates that the GZ of the canine is located coronal to the GZ of the central incisor.

Table 5 Relationship between the gingival zenith (GZ) of the lateral incisor and the gingival line (GL)

Subject	Sample	Apical to GL *n* (%)	On GL *n* (%)	Coronal to GL *n* (%)
Men ($n = 38$)	76	11 (14.5)	0 (0)	65 (85.5)
Women ($n = 53$)	106	8 (7.5)	3 (2.8)	95 (89.6)
Total ($n = 91$)	182	19 (10.4)	3 (1.6)	160 (87.9)

DISCUSSION

Regarding smile analysis, Ackerman *et al.*[13] used digital video clips and the SmileMeshTM computer application to measure the smile index and found that this technique can provide repeatable smile and reliable data. The software used in this study was developed

Table 6 Distance between the lateral incisor gingival zenith and the gingival line (LID)

Subject	Right LID n ($\bar{x} \pm$ SD)	Left LID n ($\bar{x} \pm$ SD)	Bilateral LID n ($\bar{x} \pm$ SD)
Men	38 (0.60 ± 0.63)	38 (0.60 ± 0.63)	76 (0.60 ± 0.63)
Women	53 (0.62 ± 0.37)	53 (0.54 ± 0.55)	106 (0.58 ± 0.47)
Total	91 (0.61 ± 0.50)	91 (0.57 ± 0.58)	182 (0.59 ± 0.54)

$\bar{x}$, average of x.
SD, standard deviation.
Unit: mm.

to apply point-to-point measurement instead of using a mesh measurement. The results of an intra-examiner reliability test obtained highly repeatable data at different time points (*Table 2*). Smile type reflects the lip–tooth–gingiva relationship. This study, on the smile type of 200 young Chinese subjects, showed that high-smile type, average-smile type and low-smile type are present in 45.5%, 45.5% and 9%, respectively, of subjects. In general, young Chinese women displayed more gingiva than young Chinese men. These results correspond with results previously published by Dong *et al.*[14] However, the results of the present study are different from those reported by Tjan *et al.*[1], on American youths, in which 69% of study subjects were classified with an average smile. Facial morphological differences according to ethnic group reported that Asians had horizontally wider and smaller anterior–posterior facial dimensions than Caucasians[15]. In addition, the dolichocephalic head form is commonly seen among Caucasians, whereas Asians have mostly a brachycephalic head form[16].

The appearance of the gingival tissues surrounding the teeth plays an important role in smile aesthetics[5]. In the present study, 45.5% (38 men and 53 women) of study subjects with a high-smile type displayed the gingival tissue of maxillary anterior teeth in the full smile, and in 58.2% the GZ of the canine was apical to that of the central incisor. These results are in accordance with data reported by Charruel *et al.*[12]. The average vertical distance between the GZ of the left or right canine and that of the corresponding central incisor is 0.33 mm. The null hypothesis was rejected because data from gingival measurements indicate that the value is gender dependent ($P < 0.05$, *Table 4*), with lower and minus values of vertical differences seen in male subjects.

The majority of the population (87.9%) evaluated in the present study had the GZ points of lateral incisor teeth positioned coronal to the ipsilateral GL. The average vertical distance between the lateral incisor GZ and the GL was 0.59 mm. This is in agreement with previous concepts supported in the literature that the gingival margin of lateral incisor teeth can range from 0.5 to 2 mm coronal to the GL[17–19]. Ten per cent of the study population presented with the GZ points located apically to the neighbouring teeth. This result is in contrast to the results from other studies[5,12,20,21].

The results of the present study are derived from direct, quantitative measurements and qualitative descriptive statistics of a small, but well-defined, population. It was revealed that the gingival profile in the maxillary anterior sextant was not a universal finding, as previously reported[18,22]. The data obtained in this study can be used clinically, in conjunction with other subjective and objective aesthetic parameters, during diagnosis, in treatment planning and in reconstructing a natural smile, especially for Chinese patients.

CONCLUSIONS

Within the limitations of this study, the following conclusions may be drawn:

- A high or average smile type, combined with an upward GL, is the most common finding in young Chinese people.
- In the majority of subjects, the GZ of the lateral incisor is coronal to the GL.
- The apico-coronal displacement of the GZ showed bilateral symmetry.
- These data can be useful for clinical assessment of aesthetic parameters in the Asian population.

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Conflicts of interest

None declared.

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