Relationship of Gingival Phenotypes and Faciolingual Thickness, Papilla Height, and Gingival Angle in a Chinese Population

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The objective of this study was to determine the normal values of faciolingual thickness (FLT) of the papilla base, papilla height (PH), and gingival angle (GA) among Chinese adults and the association of FLT with the gingival phenotype. The periodontal phenotypes of 105 volunteers were confirmed by Kan et al.'s periodontal probe transmission method and classification. All volunteers received complete supragingival scaling and were recalled after 1 week for clinical examination and for recording various periodontal indices, including Plaque Index, Gingival Index, and periodontal depth. The FLT, PH, and GA of maxillary anterior teeth were measured, and their associations were analyzed. The mean FLT of papilla between the right canine (CA) and lateral incisor (LI) was 8.11 ± 0.64 mm; between the right LI and central incisor (CI) was 7.77 ± 0.64 mm; between the right CI and left CI was 8.49 ± 0.66 mm; between the left CI and LI was 7.62 ± 0.63 mm; and between the left LI and CA was 8.17 ± 0.63 mm. The thin-phenotype group showed a greater PH and FLT than the thick phenotype group. Inversely, the GA of the thick-phenotype group was greater than the corresponding values for the thin-phenotype group. In Chinese residents, the high and thick papilla are associated with the thin phenotype, while the low and thin papilla are associated with the thick phenotype. The GA is negatively correlated with PH. A weak correlation exists between the GA and FLT of papilla. Int J Periodontics Restorative Dent 2021;41:127–134. doi: 10.11607/prd.4429

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The demand for good esthetics and physical appearance in clinical dentistry has increased remarkably in recent years. Gingival characteristics are one of the most important components required for achieving the esthetic outcome and satisfying patient expectations.1 For example, the scalloped contour of the gingival margin is an important parameter for determining gingival esthetics and the gingival biotype that are correlated with the outline of gingival margins.2,3 Therefore, an accurate evaluation of a patient’s gingival biotype is crucial for a number of clinical procedures in the esthetic zone, such as implant placement.4 There is a recent consensus among the American Academy of Periodontology and the European Federation of Periodontology for using the term gingival “phenotype” instead of “biotype,”5 since “biotype” refers to a group of organs having a similar specific genotype while “phenotype” indicates a dimension that may change through time depending upon environmental factors and clinical intervention and can be site-specific. Therefore, in consideration of the clinical presentation of the teeth and periodontium, the authors have used the term “phenotype” in this article.

The patient’s phenotype may determine the response of the periodontium to implant placement.
and likely affect the treatment plan in terms of implant type and size to maximize esthetics.\textsuperscript{6} Different gingival phenotypes may affect the buccal recession of gingiva following implant treatment.\textsuperscript{7–9} For example, a thin gingival phenotype results in comparatively more gum recession.\textsuperscript{10} On the basis of gingival thickness, there are two phenotypes (thin and thick phenotypes). Visually distinguishing between the gingival phenotypes is challenging; previous studies reported a correct diagnosis of thin phenotypes in less than half of the examined patients.\textsuperscript{7,11} In addition, it has been proposed that different gingival phenotypes have various dental and periodontal characteristics, such as crown length, gingival angle (GA), and papilla height (PH), that may influence the esthetic outcomes during dental treatment. Chow et al.\textsuperscript{12} revealed that the appearance of gingival papillae relates to gingival thickness (gingival phenotype) and crown shape. A gingival phenotype can be depicted in terms of the GA and height of the interdental papilla.\textsuperscript{1}

Although the faciolingual thickness (FLT) has been suggested as a probable factor affecting the papilla fill and adjacent implant restorations,\textsuperscript{13} the scientific literature describing various aspects of the FLT is very scarce. It was Kim et al.\textsuperscript{2} who first reported FLT measurements of the papilla base in 2011 and observed no association with interdental papilla or PH. Later on, Chang et al.\textsuperscript{14} reported that the faciolingual dimensions remarkably affected the complete papilla fill. However, very few studies reported its association with gingival phenotype, PH, or GA. The present authors’ null hypothesis was that there is no correlation between the FLT and gingival phenotypes. Therefore, the present study aimed to determine the normal values of FLT of the papilla base, PH, and GA among Chinese adults. Furthermore, the association between FLT and gingival phenotype were also assessed. An additional aim of this study was to compare the FLT of the papilla base, PH, and GA of the present Chinese patients to previous data.

Materials and Methods

Subjects

The present clinical study included a total of 105 adult volunteers (49 men and 56 women; age range: 19 to 25 years; mean age: 22.4 ± 0.8 years) who were recruited from the Department of Stomatology at the Xiamen Medical College in Xiamen, China. The following criteria were applied to all participants: (1) presence of complete permanent dentition with overbite and overjet within the physiologic range; (2) good oral hygiene with no obvious signs of any periodontal conditions, including gingival recession, hyperplasia, bleeding on probing, suppuration, or any other clinical signs of inflammation; (3) no attrition, spacing, or crowding in the anterior teeth; and (4) probing depths of ≤ 3 mm and intact interdental papillae. Subjects were excluded if they (1) had a past dental history of restorative, periodontal, and orthodontic treatment; (2) were suffering from any systemic or familial disease; (3) were using medication likely to affect the periodontium; and/or (4) were women who were lactating, pregnant, or expecting to become pregnant during the study period. The institutional research ethics committee of Xiamen Medical College approved the research protocol. All participants signed an informed consent to participate in this study.

Methods

All volunteers received a complete supragingival scaling using an ultrasonic scaler (P5 Newton, Acteon, Satelec). Volunteers were recalled 7 days later and examined clinically to record various periodontal indices, including Plaque Index, Gingival Index, and periodontal depth. All volunteers in the present study had a bleeding on probing rate ≤ 10%. The periodontal phenotype was assessed by measuring various parameters such as the PH, GA, and FLT of the papilla base according to Kan et al.’s\textsuperscript{15} periodontal probe transmission method and classification. A Williams periodontal probe (Hu-Friedy) was stretched into the gingival sulcus following topical anesthesia (Prime Gel, Prime-Dent). The visibility of the probe’s outline determined a thin phenotype, while nonvisibility determined a thick phenotype (Fig 1).

The authors used study casts to determine the PH, GA, and FLT of the anterior maxilla. For this purpose, impressions for the study subjects’ maxillae were taken using an irreversible hydrocolloid impression.
material (Aroma Fine Plus, GC) and immediately poured in dental stone (New Plastone II, Yellow, GC). A digital caliper (Mitutoyo) with a sensitivity of 0.01 mm was used to determine the PH, GA, and FLT, as shown in Figs 2 and 3.

Briefly, the PH was calculated as the space from the papilla tip to a line joining the most apical point of the gingival margins of both adjacent teeth. The mean PH values of each phenotype group and of both groups were used to obtain an individual tooth position value for statistical analysis.

An angle made by the intersection of two lines joining the most apical point of gingival margins to the tip of the papilla of two adjacent teeth (Fig 2) was referred to as the GA. The spaces between the most apical point of the gingival margins to the papilla’s left and right tips (b and c) and the line joining the tips of adjacent papillae (a) were used for the GA calculation through cosine function using the following equation:

\[
\text{GA} = \cos^{-1}\left(\frac{b^2 + a^2 - c^2}{2ab}\right)
\]

The papilla’s FLT was measured from the right canine to the left canine by calculating the distance between the palatal and facial midpoints from the line joining the most apical margins of the two teeth (Fig 3).

Fig 1 Periodontal probing to assess gingival phenotype. Nonvisibility of the probe suggested a thick gingival phenotype.

Fig 2 A schematic presentation of the method used to measure the papilla height (PH) and gingival angle (GA). The PH was calculated as the space from the papilla tip to a line joining the most apical point of the gingival margins of both adjacent teeth. The angle made by the intersection of line a and line b was referred to as the GA. The spaces between the most apical point of the gingival margins to the papilla’s left and right tips (lines b and c) and the line joining the tips of adjacent papillae (line a) were used for the GA calculation through cosine function.

Fig 3 Measuring the faciolingual thickness (FLT) of the papilla using study casts. Lines used for the measurement of FLT in maxillary anterior teeth. The FLT was measured in the maxillary anterior area (from the right canine to the left canine) by calculating the distance between the palatal and facial midpoints from the line joining the most apical margins of the two teeth.
The data were normalized, and all measurements were performed by one examiner (C.Z.). The data were analyzed using SPSS version 17.0 (IBM). All data are presented as mean ± standard deviation and assessed according to the gingival phenotype using independent-sample t-test. The relationship between the double variants was analyzed using Pearson correlation analysis, considering P < .05 as statistically significant.

**Results**

The study sample (n = 105 patients) was composed of 46 thin phenotypes and 59 thick phenotypes. There were no significant differences between the genders in any of the parameters. The gingival phenotype characteristics FLT, PH, and GA were calculated separately for thick and thin phenotype populations. Pearson correlation revealed a statistically significant correlation between the two different phenotype groups.

Figure 4 shows the mean FLT of the subjects by papilla position and phenotype. The FLT of the papilla between the right canine and lateral incisor (CA/LI), right lateral and central incisors (LI/CI), right and left central incisors (CI/CI), left CI/LI, and left LI/CA for the thin-phenotype group was 8.33 ± 0.57 mm, 8.04 ± 0.53 mm, 8.69 ± 0.57 mm, 7.84 ± 0.60 mm, and 8.42 ± 0.52 mm, respectively; and for the thick-phenotype group was 7.92 ± 0.66 mm, 7.53 ± 0.64 mm, 8.32 ± 0.69 mm, 7.44 ± 0.60 mm, and 7.98 ± 0.65 mm, respectively. The FLT for the maxillary anterior interdental papillae was greater in the thin-phenotype than the thick-phenotype group (P < .05).

Figure 5 shows the mean PH of the subjects by papilla position and phenotype. For the thin-phenotype group, the PH between the right CA/LI, right LI/CI, CI/CI, left CI/LI, and left LI/CA was 3.89 ± 0.80 mm, 3.69 ± 0.79 mm, 4.44 ± 0.70 mm, 3.73 ± 0.81 mm, and 3.88 ± 0.81 mm, respectively; and for the thick-phenotype group, the measurements were 3.49 ± 0.72 mm, 3.23 ± 0.66 mm, 3.62 ± 0.29 mm, 3.21 ± 0.67 mm, and 3.36 ± 0.71 mm, respectively. The PH for the maxillary anterior interdental papilla was greater in the thin-phenotype than the thick-phenotype group (P < .05).
pillae was larger for the thin-phenotype than the thick-phenotype group ($P < .05$).

The mean FLT and PH of the papilla between the teeth (CI and LI, and LI and CA) was compared for the right and left sides. The FLT from the papilla between the left and right central incisors in both groups (thin: $8.69 \pm 0.57$ mm; thick: $8.32 \pm 0.69$ mm) decreased between the CI/LI (thin: $7.96 \pm 0.52$ mm; thick: $7.48 \pm 0.57$ mm), then increased for the canine’s mesial papilla (thin: $8.37 \pm 0.35$ mm; thick: $7.98 \pm 0.48$ mm) ($P < .001$; Figs 4 and 5).

Figure 6 shows the mean GA of the subjects by papilla position and phenotype. For the right side, the GA was $83.43 \pm 20.9$ degrees (thin) and $90.41 \pm 12.85$ degrees (thick) for the CA; $96.31 \pm 15.78$ degrees (thin) and $98.67 \pm 15.17$ degrees (thick) for the LI; and $93.22 \pm 9.84$ degrees (thin) and $99.43 \pm 11.21$ degrees (thick) for the CI. For left side, the GA was $95.13 \pm 12.76$ degrees (thin) and $102.24 \pm 13.38$ degrees (thick) for the CI; $95.72 \pm 17.49$ degrees (thin) and $92.11 \pm 11.13$ degrees (thick) for the LI; and $90.87 \pm 12.17$ degrees (thin) and $88.87 \pm 11.23$ degrees (thick) for the CA. The average GA of the maxillary anterior teeth of the thick-phenotype group was larger compared to the thin-phenotype group. However, the comparison was only statistically significant for central incisors ($P < .05$).

A significant positive correlation between FLT and PH was observed (Table 1). Pearson correlation coefficients between the FLT and PH in the right CA/LI, right LI/CI, left CI/right CI, left LI/CI, and left CA/LI were $0.460, 0.540, 0.503, 0.427$, and $0.422$, respectively ($P < .05$). The GA showed a negative correlation, indicating a strong association between GA and PH, as an increased GA was correlated with a decreased PH. Besides, the distal PH showed more relevance to GA compared to the mesial PH. The GA and FLT also showed a negative correlation. The negative correlation observed for central incisors was statistically significant ($P < .05$), and the distal FLT was more correlated with GA than the mesial FLT. A weak negative correlation was observed between the GA of other maxillary anterior teeth and FLT; however, the correlation was not statistically significant ($P > .05$; Table 2).

### Table 1 Pearson Correlation Coefficients Between FLT and PH

<table>
<thead>
<tr>
<th>Papilla position</th>
<th>$r$</th>
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<tbody>
<tr>
<td>Right CA/LI</td>
<td>0.460**</td>
</tr>
<tr>
<td>Right LI/CI</td>
<td>0.540**</td>
</tr>
<tr>
<td>Left CI/Right CI</td>
<td>0.503**</td>
</tr>
<tr>
<td>Left LI/CI</td>
<td>0.427**</td>
</tr>
<tr>
<td>Left CA/LI</td>
<td>0.422**</td>
</tr>
</tbody>
</table>

FLT = faciolingual thickness; PH = papilla height; CA = canine; LI = lateral incisor; CI = central incisor.

**$P < .01$. 

Fig 6 Comparison of the gingival angle (GA) of various teeth and different gingival phenotypes. CA = canine; LI = lateral incisor; CI = central incisor.
Discussion

This clinical study investigated the normal range of FLT, PH, and GA among Chinese residents and the association of FLT with gingival phenotypes. For this purpose, the authors used periodontal probing and Kan et al’s classification to confirm the gingival phenotype of the participants and the FLT, PH, and GA of the maxillary anterior teeth. The present study used the periodontal probing method to assess the gingival phenotype. Periodontal probing has a number of benefits, such as being noninvasive, quick, and the least traumatic. Meanwhile, it showed no statistically significant difference with the direct measurement and therefore can be regarded as an objective clinical method.

It was reported in this study that the thin-phenotype group showed a greater PH compared to the thick-phenotype group for all measurements (right CA/LI, right LI/CI, CI/CI, left CI/LI, and left LI/CA). These findings are in agreement with results reported previously. A study conducted by De Rouck et al on a group of periodontally healthy individuals from Brussels reported that the maxillary central incisors and associated soft tissues in the thin-phenotype patients showed higher papillae compared to the thick-phenotype patients.

Like PH, the FLT for the maxillary anterior interdental papillae was greater in the thin-phenotype group than in the thick-phenotype group. Therefore, the hypothesis was rejected.

The FLT of the papilla between central incisors was 8.69 mm, which is in line with the Korean residents (8.6 mm) but smaller than the Indian population (10.32 mm). Therefore, FLT may be associated with race.

The present results showed an association of mean PH values with different gingival phenotypes: The increase in PH led to a corresponding increase in the FLT that was more obvious in the thin-phenotype group than the thick-phenotype one. Therefore, the gingival contour may turn into a flatter outline by increasing the FLT. On the contrary, Kim et al reported no particular correlation of the FLT with the PH among Korean residents. Such a difference in findings may be attributed to the use of different experimental and analytical methods; in Kim et al’s study, the PH was measured from the papilla’s tip to the level of the crestal bone using digital radiographs, while the present study used study casts to measure the PH precisely from the papilla’s tip to a line joining the most apical point of the gingival margins of both adjacent teeth.

Table 2 Pearson Correlation Coefficients Between GA and PH and FLT in the Anterior Maxilla

<table>
<thead>
<tr>
<th>Tooth position</th>
<th>Papilla position</th>
<th>GA and PH</th>
<th>GA and FLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right CA</td>
<td>Mesial</td>
<td>-0.438**</td>
<td>-0.254</td>
</tr>
<tr>
<td>Right LI</td>
<td>Distal</td>
<td>-0.506**</td>
<td>-0.182</td>
</tr>
<tr>
<td>Right CI</td>
<td>Mesial</td>
<td>-0.445**</td>
<td>-0.104</td>
</tr>
<tr>
<td>Left CI</td>
<td>Mesial</td>
<td>-0.632**</td>
<td>-0.283</td>
</tr>
<tr>
<td>Left LI</td>
<td>Mesial</td>
<td>-0.630**</td>
<td>-0.242</td>
</tr>
<tr>
<td>Left CA</td>
<td>Mesial</td>
<td>-0.661**</td>
<td>-0.227</td>
</tr>
</tbody>
</table>

GA = gingival angle; PH = papilla height; FLT = faciolingual thickness; CA = canine; LI = lateral incisor; CI = central incisor.

*P < .05.

**P < .01.
Subepithelial connective tissue grafts have been shown to affect the building of the PH for thin phenotypes in implant treatment. According to the present results, the FLT also influences the PH in that increasing the FLT thickens the PH. The loss of gingival PH may lead to open gingival embrasures (ie, a “black triangle”), therefore affecting the esthetic appearance. In order to avoid the presentation of black triangles and gingival recession, which is prone to appear in implant therapy (especially in the thin phenotype), the dimensions should be increased in the faciolingual direction for the papilla base to raise the PH. In periodontal treatment, the removal of the buccal alveolar bone should be treated with caution to restore the FLT at the base of the gingival papilla. In contrast, insufficient gingival PH may need lead to the formation of a black triangle.

In terms of GA, the present results showed smaller GAs in the thin-phenotype group compared to corresponding locations in the thick phenotype group. These findings are consistent with Olsson et al, who reported similar results among Swedish individuals. Olsson et al were the first to introduce the perception of GA and reported the association of a narrower GA with a thin phenotype, whereas a broader GA was reported to be associated with a thick phenotype. However, AlQahtani et al reported contrary findings among Saudi Arabian residents. These differences reported by various researchers may be associated with racial, ethnic, and gender variations among the study populations. For instance, the experimental group in the study by AlQahtani et al was comprised of mainly male participants (n = 300; ~95%), while only 15 (~5%) were women. An inadequate number of female participants and an association of gender with gingival thickness may be responsible for such variations.

A statistically significant negative correlation was observed between GA and PH, and the distal aspect of the PH had more relevance to GA compared to the mesial aspect. Contrarily, a previous study reported that a positive correlation exists between the GA and PH among a Portuguese sample population. The present authors observed no significant correlation between the GA and FLT for the maxillary anterior region except for the central incisors. Similar to PH, the distal FLT was more correlated with the GA of the central incisors than the mesial FLT. However, there is a dearth of scientific literature on FLT, lacking clinical evidence for its association with GA and PH, thus warranting the need for further analysis.

A limitation of this study is the limited sample size from one region of China. The inclusion of a larger representative sample representing all regions of China is suggested for the confirmation of the results in the present study. In addition, the authors focused on the correlation between the FLT and the gingival phenotype and other papilla parameters; other aspects, such as the ratio of the crown width to crown length, were not included. Further studies including all these parameters are needed to validate these findings.

Conclusions

Among the sampled Chinese residents, high and thick papilla are associated with thin phenotypes, while the low and thin papilla are associated with thick phenotypes. GA is negatively correlated with the PH, while the distal aspect of the FLT is relatively more correlated with the GA than the mesial aspect; however, the correlation between the GA and the FLT of the papilla is weak. Considering that a statistically significant association was observed between the PH and FLT, increasing the papilla’s height in the faciolingual direction can be beneficial, especially in individuals with a thin phenotype who are prone to gum recession and black triangles.

Acknowledgments

The authors declare no conflicts of interest.

References


