The influence of gingival phenotype in the morphology of the central maxillary interdental papilla

Šimon Belák (simon.belakk@gmail.com)  
Palacký University, Olomouc  
https://orcid.org/0000-0002-7938-7353

Radovan Žižka  
Univerzita Palackeho v Olomouci Lekarska fakulta

Martin Starosta  
Univerzita Palackeho v Olomouci Lekarska fakulta

Jana Zapletalová  
Univerzita Palackeho v Olomouci Lekarska fakulta

Jiří Šedý  
Univerzita Palackeho v Olomouci Lekarska fakulta

Michal Štefanatný  
Univerzita Palackeho v Olomouci Lekarska fakulta

Research article

Keywords: Human, Gingival phenotype, Gingival thickness, Papilla height, Papilla width, Papilla fill

DOI: https://doi.org/10.21203/rs.3.rs-34256/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Background

Preservation of interdental papilla is an essential part of the functional and esthetic rehabilitation of dental treatment. It was described that thicker gingival tissues are more resistant to recession. The main objective of this investigation was to analyze if the gingival phenotype represents a potential risk factor affecting interdental papilla fill, height, or width in an esthetic region between central maxillary incisors. The secondary goals were: 1) analyze parameters describing papilla and the influence of a wide papilla basis for the vertical papillary dimension; 2) the correlation between different non-invasive measurements of gingival thickness; 3) comparison among both sexes.

Methods

Together, 54 periodontally healthy students (20–30 years old) were included in the study. Gingival thickness was measured using Pirop Ultrasonic Biometer. Phenotype was also assessed by gingival probe transparency. Papilla parameters - height and width of the interdental papilla were measured, and the degree of papilla recession was classified.

Results

No significant correlation between papilla height, width, or papilla fill and gingival probe transparency or gingival thickness was found. Both methods of assessments of gingival phenotype showed a significant relationship. There was a significant correlation of papilla height and papilla fill. Papillae, which filled the interdental space completely, seem to be shorter. A strong positive association between papilla height and papilla width was revealed. Papillae were significantly higher in males.

Conclusion

The appearance of interdental papillae could be influenced by various factors. Within the limitations of this study, results showed no significant correlation between the morphology of interdental papillae and soft tissue thickness. It seems that there is an influence of a wide papilla basis for its vertical dimension.

Introduction

The patient's demands on dental treatment are often very high. Patients do not seek only for functional rehabilitation, but also for the natural esthetic result. A balanced size, shape, position, and color of teeth are essential components of successful esthetic outcome and should be in harmony with surrounding soft tissues [1]. However, in some situations, specific problems with so-called "pink esthetic" occur, comprising the mucogingival conditions, such as excessive gingival display, uneven gingival contours, exposure of root surfaces or the loss of interdental papillae. In such cases, it is also essential to analyze the patient's smile line [2].
In exposed regions, the interdental papilla plays a vital role in the final esthetic outcome, especially if a high smile line is present. Physiologically, the interdental papilla in the anterior region has a pyramidal shape and fills the entire space under the contact point between two adjacent teeth. If a papilla does not fill the whole interdental space, a black triangle occurs. It is considered as an esthetic impairment, and it can also cause phonetic problems or food retention, which can adversely affect periodontal health [3]. Thus, clinicians should be able to adequately analyze the factors related to the interproximal papilla to prevent its loss.

Various situations can influence the morphology of interdental papillae, mainly periodontal attachment loss resulting in the recession and impairment of the volume of the alveolar bone relative to the interproximal contact [3]. Tarnow et al. observed that critical distance from the contact point/area to the alveolar bone crest is 5 mm [4]. Other investigations also revealed a significant correlation between increasing interdental distance and papilla recession [5–9] Soft tissue thickness in relation to interdental papillae was investigated in very few studies. There is an assumption that thicker gingival tissues are more resistant to physical trauma and have a lower risk of recession due to the better blood supply and adequate amount of dense fibrous tissue [10].

Some authors found that the thick periodontal phenotype was observed with significantly greater papillary fill [11,12], but with decreased papillary height [13,14]. On the other hand, there are also opposite results published, where the thin periodontal phenotype presented a significantly higher presence of entire papilla fill [15]. Only the recent study found papilla width as an independent influencing factor of periodontal biotype [16]. Many other investigations revealed no statistically significant correlation between the gingival phenotype and the morphology of interdental papillae [1,17,18].

To date, it is not clear whether the gingival phenotype represents a significant factor associated with the morphology of interdental papilla and if there are any differences among both sexes. The main objective of this investigation was to analyze if the gingival phenotype represents a potential risk factor affecting interdental papilla fill, height, or width in an esthetic region between central maxillary incisors. The secondary goals were: 1) analyze parameters describing papilla and the influence of a wide papilla basis for the vertical papillary dimension; 2) the correlation between different non-invasive measurements of gingival thickness; 3) comparison among both sexes. We decided to include only central maxillary incisors as reference area because differences between phenotypes are the most explicit for these teeth and because this region is the most exposed part of the dental arch and act as the most challenging area in the way of esthetic [19–21].

Materials And Methods

Participants

All clinical measurements were performed between April 2017 to August 2017 in the Department of Periodontology and Oral Medicine at the Institute of Dentistry and Oral Sciences in Olomouc, Czech Republic. Together 57 undergraduate students of dentistry (32 females, 22 males, in the range 20-30
years of age) were enrolled in this study. All participants were thoroughly educated in the field of oral hygiene. All subjects were required to have state of Gingival health on intact periodontium according to new classification scheme [22]: no clinical attachment level loss, probing pocket depth (assuming no pseudo pockets) $\leq 3$ mm, no bleeding on probing at examined sites [23]. Exclusion criteria were following:

1. medication intake or suffering from any disorder classified at Systemic diseases and conditions that affect the periodontal supporting tissues [24];
2. pregnant or lactating females;
3. severe smokers (10 and more cigarettes per day);
4. lack of keratinized tissue width ($\leq 2$ mm) in the region of upper central.

Three subjects were excluded because of insufficient data obtained due to absence on the second appointment.

Data collection

All measurements were performed by one experienced and previously calibrated examiner (Š.B.). Intraexaminer reproducibility was achieved by reassessing 20 random subjects to find the accuracy between repeated measures.

First, the gingival thickness was measured using a non-invasive Pirop Ultrasonic Biometer (Echo-Son, Krancowa, Poland) with the A-scan probe (tip diameter 1.7 mm) with 20 MHz frequency and 1540 m/s ultrasonic impulse velocity and accuracy up to 0.01 mm. A chlorhexidine gel was applied on the tip of the probe, which was gently applied on the reference point on the intersection between the mid-facial longitudinal axis of the left central upper incisor and the horizontal axis of the keratinized mucosa at the midpoint of mucogingival and para-marginal groove (Figure 1). Each assessment was based on ten automatic measurements. These were averaged and displayed on the screen of the device. The standard deviation of the mean value from ten automatic measurements did not exceed 0.05 mm.

On the next appointment scheduled a month later, intraoral photography of the anterior maxillary region was taken in a standardized manner - unified shooting conditions and camera setting parameters. A pressure-sensitive periodontal probe, with a controlled ($\sim 0.25$ N) force to the apical end (Carl Martin 973/SP, Solingen, Germany), was placed in the center of the facial aspect of gingival sulcus of left central maxillary incisor to assess the gingival probe transparency [25]. If the periodontal probe was visible through gingival sulcus, the phenotype was categorized as a thin. If the periodontal probe was not visible, the phenotype was assessed as a thick (Figure 2,3).

Papilla fill between central maxillary incisors was assessed from photographs using classification proposed by Nordland and Tarnow [26]. It is based on three anatomical landmarks: coronal part of the proximal cementoenamel junction (CEJ), the apical extent of the facial CEJ, and interdental contact point/area. The classification is following: (a) Normal – papilla fills entire interdental space up to contact point/area. (b) Class 1 – the tip of the interdental papilla is located between the contact point/area and
the level of CEJ on the proximal surface of the tooth. (c) Class 2 – the tip of the interdental papilla is located on or more apically to the level of CEJ on the proximal surface of the tooth but coronally to the level of the facial CEJ. (d) Class 3 – a tip of the interdental papilla is located on or apically to the level of the facial CEJ (Figure 4).

The height and width of interdental papilla between central maxillary incisors were measured from the intraoral photography. Image calibration was done using markers from a periodontal probe placed parallelly in the gingival sulcus of the tooth 21, in Planmeca Romexis dental imaging software (Planmeca, Helsinki, Finland). Papilla height was measured as a distance from the tip of the papilla to the connecting line of the gingival zeniths of central maxillary incisors (Figure 1). The width of the interdental papilla was determined as the distance between the intersections of the longitudinal axis, which divides the central incisors into a mesial and a middle third and marginal gingiva (Figure 1).

Statistical analysis

IBM SPSS Statistics version 22 software was used to analyze the data. Quantitative variables were reported as mean ± standard deviation (SD); categorical variables were reported as absolute and relative frequencies. The correlation between quantitative data was assessed using Spearman's correlation analysis. The relationship between enumeration data was evaluated using the Chi-square test. The correlation between quantitative and categorical variables was assessed using the Mann-Whitney U test. The remeasurements of papilla height and gingival thickness were controlled by the Dahlberg formula and the Intraclass correlation coefficient (ICC). Cohen's kappa coefficient was used to measure intra-rater agreement for the transparency and papilla fill parameters. The normality of the data was verified using the Shapiro-Wilk test. A significance level of less than 0.05 was considered statistically significant.

Results

The Cohen kappa value showed a substantial agreement (0.61) between original and control measurements of gingival probe transparency. ICC for the gingival thickness parameter (0.933) also showed an excellent match, but the Dahlberg error rate of variation was higher than 5%. The ICC coefficient for papilla height (0.985) and papilla width (0.935) revealed an excellent match, and also low Dahlberg error rate indicates a very good match of both measurements. Papilla fill showed absolute agreement in both measures. There was no statistically significant systematic shift between measurements.

The age of the participants was 26 ± 1.5 years. Table 1 lists distribution, the mean values, and standard deviation of the clinical data of 54 participants included in this study.

Papilla characteristics in different gingival phenotype based on gingival probe transparency are shown in Table 2. In the thick phenotype group, papilla recession was seen in 34.3% of cases, while in the thin phenotype group, it was 60%. However, a statistically significant correlation was not confirmed, also for papilla height or width.
Table 3 shows the correlation of gingival thickness with papilla characteristics. No statistically significant relationship between papilla height, width, or fill was found.

The relationships among papilla characteristics are shown in Table 4 and Table 5. There was a significant correlation between papilla fill and papilla height ($P = 0.028$). Papillae classified as normal, filling entire interdental space seem to be shorter than papillae from class 1. No significant relationship between papilla fill and width was found. Spearman's correlation analysis revealed a strong positive correlation between papilla height and papilla width ($r = 0.738$, $P < 0.0001$).

The relationship between different assessments of the gingival phenotype (Table 6) was statistically significant ($P < 0.001$). Mean gingival thickness for the group assessed as the thick was greater compared to the thin phenotype group.

Differences in measured parameters among gender were statistically significant only in papilla height ($P = 0.01$). Mean papilla height was greater in the male group compared to the female group. Other parameters revealed no statistical difference (Table 7).

**Discussion**

Preservation of interdental papilla is an essential part of the functional and esthetic rehabilitation of dental treatment. It has been described that the morphology of interdental papilla is strongly related to bone volume in the interproximal space [4–9]. In addition to the recession of interdental papilla related to periodontal disease, recession can also occur in healthy gingiva due to anatomical and physiological predispositions [1]. Therefore, the gingival phenotype and characteristics of interdental papilla were examined only in periodontally healthy patients. Also, contact points may vary in different regions, which may influence the shape of interdental papilla. For this reason, we studied the only papilla between central maxillary incisors to have a homogeneous sample.

Two different non-invasive methods of phenotype assessment were performed, the most commonly used in similar studies-gingival probe transparency [14,17–19,27,28] and also less standard method-ultrasonic measurement [29–31] of an accurate thickness of gingival tissues. A comparison of both methods showed a significant correlation. Thus, such a straightforward way of phenotype assessment by gingival probe transparency is as reliable as different methods, which are often more time-consuming or require some additional costs for appliances.

Despite the fact that the papilla recession was present in 34.3% cases with thick phenotype and in 60% cases with thin phenotype, there was no statistically significant correlation between interdental papilla of central maxillary incisors and gingival phenotype. This result supports previously published studies by Kim et al. [1] and Singh et al. [17]. Some authors assume that a thick phenotype is more resistant to physical trauma and has a lower risk of papilla recession due to the better blood supply and adequate amount of dense fibrous tissue [10]. Thick phenotype is also associated more with square-shaped tooth crowns with contact point located more apically and requires less tissue to fill the interproximal space.
[20,21]. This assumption confirmed Chow et al. [12], who observed that gingival tissues were significantly thicker when the papilla was competent. Opposite results published De Lemos et al. [15], who noted a significantly higher presence of papillae in the thin phenotype group. However, in this study, the phenotype was assessed only visually, what may have introduced unnecessary method error by subjective opinion. Most of the other authors studied the correlation between phenotype and papilla height as the only papilla descriptive parameter. Results found that increased papillary height is associated with a thin phenotype [13,14,27,28], what may be influenced by different tooth shape [13,19,21,28,32]. As the tooth becomes triangular, what is more typical for thin periodontal phenotype subjects, the contact point can be seen more coronally, and longer papillae appear. This study failed to find an influence on papilla width with different gingival phenotype, in both types of phenotype assessment. Yin et al. [16] recently published that papilla width has a significant influence on phenotype, making the gingival papilla of the maxillary central incisor of the thin biotype narrower. They assessed papilla width as the distance between the gingival zeniths of the two adjacent teeth. The incongruity in measurement methods of papilla width may be the major reason for different results. However, there are few studies on the correlation between the phenotype and papilla width, and more research needs to be provided.

We have also compared papilla characteristics – papilla fill, height and width between each other. Results showed that papillae assessed as normal, which fill whole interdental space seem to be shorter than papillae from class 1, where a slight reduction of papilla fill is present. Papilla height has previously been found to be significantly greater in the group, where papilla was present in the study by Chang et al. [33]. However, this result was not confirmed in the study by Kim et al. [34]. Both of them measured papilla height on radiographs using radiopaque material as the distance from the crest of the bone to the tip of the papilla. It can be speculated if different measurement method of papilla height may be the major factor contributing to the discrepancy in these results, or as reported by Chow et al. [12], who confirmed that papilla height decreased 0.012mm with each year of increasing age, there may play some role the enrolment of participants from different age groups. In our study, there was no significant relationship between papilla fill and papilla width, but a significant correlation was found between papilla height and width. It seems that there is a positive influence of a wide papilla basis for its vertical dimension.

Mean papilla height was greater in the male group compared to the female group. Chow et al. have reported the same results [12], what is in contrast with the study by Joshi et al. [14]. Many other authors observed thin phenotype more frequently in females [14,19,35]; however, in this study, no correlation was found. We assume that the greater height of interproximal papillae found in the male group was due to different tooth forms and position of the contact point, which could be the reason for the only difference among gender in this study.

The small sample size without any groups with different age limits the assessment of gingival phenotype and its correlation with papilla characteristics. Therefore, in future studies, it is recommended to expand the sample size. Also, it is advisable to evaluate other potential risk factors, such as the tooth form or tooth angulation, which seem to be one of the significant factors influencing interdental papillae by the
different shape and position of the contact point. Finally, another potential factor, buccolingual tooth position, which may affect the gingival phenotype and thickness of alveolar bone, should be added in future studies to provide more convincing evidence.

Conclusion

The appearance of interdental papillae could be influenced by various factors. Within the limitations of this study, results showed no significant correlation between the morphology of interdental papillae and soft tissue thickness. It seems that there is an influence of a wide papilla basis for its vertical dimension.

Abbreviations

PH: papilla height,
PW: papilla width
GT: gingival thickness

Declarations

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

All risks and benefits of the associated procedures were explained to all participants who signed informed consent before enrollment into the study. The study was approved by the Ethical Committee of Palacky University and University Hospital in Olomouc with reference number 29/17 and was conducted following the Helsinki Declaration.

The authors would like to thank professor Ricardo Faria Almeida for assistance with the preparation of this paper.

ŠB and MS participated in conception and design of the work and data collection. Statistical analysis was done by JZ. MŠ participated in collecting data. The original draft was written by ŠB and RŽ. Review and editing of the draft did JŠ. All authors made a substantial contribution to this study and/or manuscript, and all have reviewed the final paper prior to its submission. The authors read and approved the final manuscript.

No potential conflict of interest relevant to this study was reported.

This study was self-funded by the authors and their institutions.
Consent for publication:

Not applicable.

References

1. Kim JH, Cho YJ, Lee JY, Kim SJ, Choi J Il. An analysis on the factors responsible for relative position of interproximal papilla in healthy subjects. J Periodontal Implant Sci. 2013;43(4):160–7.

2. Reddy MS. Achieving gingival esthetics. J Am Dent Assoc. 2003;134(3):295–304.

3. Sharma AA, Park JH. Esthetic considerations in interdental papilla: Remediation and regeneration. J Esthet Restor Dent. 2010;22(1):18–28.

4. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol. 1992;63(12):995–6.

5. Martegani P, Silvestri M, Mascarello F, et al. Morphometric Study of the Interproximal Unit in the Esthetic Region to Correlate Anatomic Variables Affecting the Aspect of Soft Tissue Embrasure Space. J Periodontol. 2007;78(12):2260–5.

6. Belák Š, Starosta M, Zapletalová J. Prediction of the Interdental Papilla Presence between the Upper Central Incisors Based on the Distance from the Contact Point to the Crest of Bone and Interdental Distance (in czech). Česká Stomatol / Prakt Zub lékařství. 2017;3(117):68–73.

7. Cho HS, Jang HS, Kim DK, et al. The Effects of Interproximal Distance Between Roots on the Existence of Interdental Papillae According to the Distance From the Contact Point to the Alveolar Crest. J Periodontol. 2006;77(10):1651–7.

8. Chen MC, Chan CP, Tu YK, et al. Factors influencing the length of the interproximal dental papilla between maxillary anterior teeth. J Dent Sci. 2009;4(3):103–9.

9. Zetu L, Wang HL. Management of inter-dental/inter-implant papilla. J Clin Periodontol. 2005;32(7):831–9.

10. Kois JC. Predictable single-tooth peri-implant esthetics: five diagnostic keys. Compend Contin Educ Dent. 2004;25(11):895–6, 898, 900 passim; quiz 906–7.

11. Joshi K, Baiju CS, Khashu H, Bansal S, Maheswari IB. Clinical assessment of interdental papilla competency parameters in the esthetic zone. J Esthet Restor Dent. 2017;29(4):270–5.

12. Chow YC, Eber RM, Tsao YP, Shotwell JL, Wang HL. Factors associated with the appearance of gingival papillae. J Clin Periodontol. 2010;37(8):719–27.

13. Stellini E, Comuzzi L, Mazzocco F, Parente N, Gobbato L. Relationships between different tooth shapes and patient's periodontal phenotype. J Periodontal Res. 2013;48(5):657–62.

14. Joshi A, Suragimuth G, Zope SA, Ashwinirani SR, Varma SA. Comparison of gingival biotype between different genders based on measurement of dentopapillary complex. J Clin Diagnostic Res. 2017;11(9):40–5.
15. De Lemos AB, Kahn S, Rodrigues WJ, Barceleiro MO. Influence of periodontal biotype on the presence of interdental papillae. Gen Dent. 2013;61(6):20–4.

16. Yin XJ, Wei BY, Ke XP, et al. Correlation between clinical parameters of crown and gingival morphology of anterior teeth and periodontal biotypes. BMC Oral Health. 2020 Feb 19;20(1):59. doi:10.1186/s12903-020-1040-x.

17. Singh J, Rathod VJ, Rao PR, Patil AA, Langade DG, Singh RK. Correlation of gingival thickness with gingival width, probing depth, and papillary fill in maxillary anterior teeth in students of a dental college in Navi Mumbai. Contemp Clin Dent. 2016;7(4):535–8.

18. Fischer KR, Richter T, Friedmann A, Fickl S. On the relationship between gingival morphotypes and different crown shape assessments in young Caucasians. Clin Oral Investig. 2016;20(8):2185–90.

19. De Rouck T, Eghbali R, Collys K, De Bruyn H, Cosyn J. The gingival biotype revisited: Transparency of the periodontal probe through the gingival margin as a method to discriminate thin from thick gingiva. J Clin Periodontol. 2009;36(5):428–33.

20. Olsson M, Lindhe J, Marinello CP. On the relationship between crown form and clinical features of the gingiva in adolescents. J Clin Periodontol. 1993;20(8):570–7.

21. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. J Clin Periodontol. 1991;18(1):78–82.

22. Lang NP, Bartold PM. Periodontal health. J Clin Periodontol. 2018;45:9–16.

23. Chapple ILC, Mealey BL, Van Dyke TE, et al. Periodontal health and gingival diseases and conditions on an intact and a reduced periodontium: Consensus report of workgroup 1 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Clin Periodontol. 2018;45:68–77.

24. Jepsen S, Caton JG, Albandar JM, et al. Periodontal manifestations of systemic diseases and developmental and acquired conditions: Consensus report of workgroup 3 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Clin Periodontol. 2018;45:219–29.

25. Kan JYK, Rungcharassaeng K, Morimoto T, Lozada J. Facial Gingival Tissue Stability After Connective Tissue Graft With Single Immediate Tooth Replacement in the Esthetic Zone: Consecutive Case Report. J Oral Maxillofac Surg. 2009;67(3):40–8.

26. Nordland WP, Tarnow DP. System for Loss of Papillary Height. J Periodontol. 1998;69(10):1124–6.

27. Fischer KR, Grill E, Jockel-Schneider Y, Bechtold M, Schlagenhauf U, Fickl S. On the relationship between gingival biotypes and supracrestal gingival height, crown form and papilla height. Clin Oral Implants Res. 2014;25(8):894–8.

28. Peixoto A, Marques TM, Correia A. Gingival biotype characterization—a study in a Portuguese sample. Int J Esthet Dent. 2015;10(4):534–46.

29. Schwarz F, Claus C, Becker K. Correlation between horizontal mucosal thickness and probing depths at healthy and diseased implant sites. Clin Oral Implants Res. 2017;28(9):1158–63.
30. Younes F, Eghbali A, Raes M, De Bruyckere T, Cosyn J, De Bruyn H. Relationship between buccal bone and gingival thickness revisited using non-invasive registration methods. Clin Oral Implants Res. 2016;27(5):523–8.

31. Puzio M, Blaszcyszyn A, Hadzik J, Dominiak M. Ultrasound assessment of soft tissue augmentation around implants in the aesthetic zone using a connective tissue graft and xenogeneic collagen matrix – 1-year randomised follow-up. Ann Anat. 2018;217:129–41.

32. Avinash B, Bhagyalakshmi A, Raghunath N, Shivalinga B, Garg N. Gingival biotype and its relation to incisors’ inclination and dentopapillary complex: An in vivo study. Int J Orthod Rehabil. 2017;8(1):11–8.

33. Chang LC. Assessment of Parameters Affecting the Presence of the Central Papilla Using a Non-Invasive Radiographic Method. J Periodontol. 2008;79(4):603–9.

34. Kim SA, Choi SS, Byun SJ, Chang M. Analysis of the embrasure dimensions between maxillary central incisors in relation to the topography of the interdental papilla. J Periodontal Implant Sci. 2011;41(6):273-8.

35. Bhat V, Shetty S. Prevalence of different gingival biotypes in individuals with varying forms of maxillary central incisors: A survey. J Dent Implant. 2013;3(2):116–21.

Tables

Table 1. Distribution of measured parameters

| Parameters          | Gender       | Papilla fill | Phenotype (transparency) | Papilla height | Papilla width | Gingival thickness |
|---------------------|--------------|--------------|--------------------------|----------------|--------------|------------------|
| Gender              | Female       | Normal       | Thick                    | 4.93 ± 1.06    | 6.25 ± 0.72  | 0.96 ± 0.25      |
|                     | Male         | Class 1      | Thin                     |                |              |                  |
|                     |              |              |                          |                |              |                  |
|                     |              |              |                          |                |              |                  |
Data are reported as N (%) out of total N=54 (100 %) or as mean ± standard deviation.

Table 2. Papilla characteristics in different gingival phenotype (transparency)

|               | Thick         | Thin          | \( P \)-value |
|---------------|---------------|---------------|---------------|
| Papilla height| 4.89 ± 1.07   | 4.81 ± 1.04   | 0.505         |
| Papilla width | 6.35 ± 0.68   | 6.0 ± 0.77    | 0.250         |

Data are reported as N (%) out of total N=54 (100 %) or as mean ± standard deviation.

Table 3. Correlation of gingival thickness with papilla characteristics

| Gingival thickness | \( P \)-value |
|--------------------|---------------|
| Papilla height     | 0.097         | 0.484         |
| Papilla width      | 0.175         | 0.205         |

Data are reported as Spearman's coefficient of rank correlation (\( r \)) or as mean ± standard deviation

Table 4. Correlation of papilla fill with papilla height and width

|               | Normal         | Class 1        | \( P \)-value |
|---------------|----------------|----------------|---------------|
| Papilla height| 4.98 ± 1.07    | 4.81 ± 1.04    | 0.505         |
| Papilla width | 6.35 ± 0.68    | 6.0 ± 0.77     | 0.250         |
Data are reported as mean ± standard deviation

### Table 5. Correlation of papilla height and width

| Papilla width | Papilla height | P-value |
|---------------|----------------|---------|
| r             | 0.738          | <0.0001 |

Data are reported as Spearman's coefficient of rank correlation (r)

### Table 6. Relationship between different assessments of gingival phenotype – transparency and thickness

| Gingival thickness | Thick       | Thin       | P-value   |
|--------------------|-------------|------------|-----------|
|                    | 1.047 ± 0.233 | 0.748 ± 0.155 | <0.0001  |

Data are reported as mean ± standard deviation.

### Table 7. Gender distribution

| Phenotype (transparency) | Female       | Male         | P-value |
|--------------------------|--------------|--------------|---------|
| Papilla height           | 4.63 ± 1.02  | 5.37 ± 0.96  | 0.010   |
| Papilla width            | 6.13 ± 0.75  | 6.43 ± 0.64  | 0.106   |
| Gingival thickness       | 0.939 ± 0.290| 1.001 ± 0.184| 0.137   |
| Normal                   | N = 17 (56.7%)| N =12 (60.0%)| 0.815   |
| Class 1                  | N =13 (43.3%)| N = 8 (40.0%)|          |
| Phenotype (transparency) |              |              |         |
| Thick                    | N = 21 (65.6%)| N = 18 (81.8%)| 0.192   |
| Thin                     | N = 11 (34.4%)| N = 4 (18.2%)   |         |

Data are reported as N (%) out of total N=54 (100 %) or as mean ± standard deviation.
Figure 1

Reference point for ultrasonic measurement of gingival thickness (GT), papilla height (PH) and papilla width (PW).
Figure 2

Gingival probe transparency: thick gingival phenotype.
Figure 3

Gingival probe transparency: thin gingival phenotype.
Figure 4

The assessment of papilla fill proposed by Nordland and Tarnow [26]: a) Normal b) Class 1 c) Class 2 d) Class 3.