Pharmacophore

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

EVALUATION OF RELATIONSHIP BETWEEN GINGIVAL PHENOTYPE AND PERIODONTAL STATUS

Osman Babayiğit[1*], Fatma Uçan Yarkaç[1], Ümmühan Tekin Atay[2], Dilek Özkan Şen[1], Elif Öncü[3]

1. ***Department of Periodontology, Faculty of Dentistry, Necmettin Erbakan University, Konya, Turkey.***
2. ***Konya Application and Research Center, Başkent University, Konya, Turkey.***
3. ***Department of Periodontology, Faculty of Dentistry, Lokman Hekim University, Ankara, Turkey.***

ARTICLE INFO

Received:
22 Oct 2021
Received in revised form:
18 Jan 2022
Accepted:
19 Jan 2022
Available online:
28 Feb 2022

Keywords: Dental crown, Gingiva, Interdental papilla, Phenotype

ABSTRACT

Determining the gingival phenotype and knowing its relationship with clinical periodontal parameters is critical in terms of guiding the clinician and the treatment results. The present study evaluated the prevalence of gingival phenotype and its relationship with crown shape, papilla height (PH), keratinized tissue width (KTW), and risk factors. A total of 90 individuals, 53 females and 37 males were included in the study. Based on the transparency of a periodontal probe through the buccal gingival margin, was determined thin phenotype and thick phenotype groups. Sociodemographic data, oral hygiene status and clinical periodontal parameters, supracrestal gingival height (SGH), crown width/crown length ratio, PH, and KTW were evaluated. No statistical difference ($p>0.05$) was detected neither for the correlation between different phenotypes (thick/thin) and SGH nor for associating phenotypes and crown width/crown length ratio. Additionally, there was no statistically significant difference in periodontal parameters and PH between thick and thin phenotype groups ($p>0.05$). PH was higher for individuals with rectangular crown shapes compared to individuals with square crown shapes ($p<0.05$). It was found that the prevalence of rectangular and square crown shapes was equal and the thick gingival phenotype was higher in the Turkish population. There was no correlation between the gingival phenotype and crown shape, periodontal parameters, and papilla heights. It has been shown that individuals with a thick phenotype have higher KTW and the shape of the crown in the anterior region of the maxilla affects the height of the papilla.

To Cite This Article: Babayiğit O, Yarkaç FU, Atay UT, Şen DO, Öncü E. Evaluation of Relationship Between Gingival Phenotype and Periodontal Status. Pharmacophore. 2022;13(1):72-8. https://doi.org/10.51847/EcLKLy6nFz

Introduction

Periodontal phenotype is defined as the combination of gingival phenotype and buccal bone plate thickness (bone morphotype) [1]. The gingival phenotype refers to gingival thickness (GT) and keratinized tissue width (KTW) [2]. Gingival phenotype affects the reaction of periodontal tissue to physical, chemical, or bacterial damage, restoration and periodontal treatment results, root closure procedures, and overall tooth aesthetics [3-6].

In recent studies, it is stated that the gingival phenotype is affected by many factors such as gingival thickness, keratinized tissue width, papilla height, and crown shape [7-10]. It has been shown that the morphological features of the gingiva are affected by the crown form and the structure of the dental crown shows a significant function in the gingival architecture [11-13]. While the thick gingival phenotype is observed more frequently in square-shaped teeth with wider contact points and more apically located; it has been reported in many studies that the incidence of thin gingival phenotype is increased in triangular teeth with smaller contact points and more coronally located teeth [13, 14]. Chow *et al*. stated that the gingival papillae are related to the crown shape and gingival thickness, especially that there is a positive relationship between gingival thickness and the height of the interproximal tissue, and this affects the appearance of the papilla. In the past, it has been suggested that the width of the keratinized gingiva should be at least 2 mm and the attached gingiva should be 1 mm to ensure periodontal health [15]. Today, although there is no keratinized tissue, it has been stated that periodontal health can be

Corresponding Author: Osman Babayiğit; Department of Periodontology, Faculty of Dentistry, Necmettin Erbakan University, Konya, Turkey. E-mail: osmanbabayigit95@gmail.com.

preserved if adequate oral hygiene measures are applied by the patient [16]. As a result, the correct evaluation of the gingival phenotype of the patients is critical during treatment planning and before implant treatment in the aesthetic field.
In measuring the gingival phenotype; different techniques such as visual inspection, periodontal probe transparency, transgingival probing, ultrasonic devices, parallel profile periapical radiography, and cone-beam computed tomography are used [17, 18]. Among these techniques, periodontal probe transparency is a non-invasive method of measuring the gingival phenotype and is a highly reproducible method with 85% agreement between records. In this method, defined by Kan *et al*. the phenotype is defined as thin or thick according to the visibility of the periodontal probe from the gingival margin while probing the sulcus on the middle face of the tooth [19]. However, clinically, patients with a thin gingival phenotype cannot be accurately identified due to difficulties in visually distinguishing the gingival phenotypes. Approaching and evaluating the gingival phenotype is an issue that should be considered in treatment planning for any patient. Therefore, it is essential to have information about the incidence of the gingival phenotype in the general population and its correlation to other known clinical parameters. The present study evaluated the gingival phenotype incidence and its connection with crown shape and keratinized tissue width and risk factors.

Materials and Methods

A total of 90 individuals, 53 females and 37 males who applied to Necmettin Erbakan University Faculty of Dentistry, Department of Periodontology for various reasons, were included in this study. Participation in the study was on a voluntary basis, and the consent of those who decided to participate in the research was obtained. The research protocol was conducted following the guidelines of the Declaration of Helsinki and was accepted by the Necmettin Erbakan University Faculty of Dentistry Ethics Committee for Non-Pharmaceutical and Medical Device Clinical Research (Ethics Decision No: 2021/01-16). Individuals without any systemic disease who were diagnosed with periodontally healthy after routine clinical periodontal examination agreed to participate in the study and were included in the study. Exclusion criteria among volunteers who agreed to participate in the study; the presence of advanced periodontal disease, probing depth more than 3 mm, presence of gingival recession, bleeding and visual plaque index greater than 20% on probing, being in pregnancy or breastfeeding period, using any medication that may affect the thickness of periodontal soft tissues (cyclosporine A, phenytoin or calcium channel blockers), presence of restorations affecting the crown shape and the occlusal edge of the tooth, presence of caries on the interproximal surface or at the enamel-cementum junction, history of tooth trauma that caused the shape of the incisors to change, history of orthodontic treatment, craniofacial asymmetry, history of periodontal surgery involving the teeth in the maxillary anterior region and the presence of incisal abrasion, erosion or attrition reaching dentin were determined. Sociodemographic data, oral hygiene status, tooth brushing habits, gingival phenotype, crown shape, keratinized tissue width, and papilla height values of the individuals included in the study were recorded.

Clinical Measurements
Clinical parameters were measured by the same operator 1 week after oral hygiene motivation was given to the patients. A period of at least 3 weeks was given between non-surgical periodontal hygiene treatment and measurement of clinical parameters. At the start of the study, the examiner received calibration training for the measurements. Data were compared to another examiner up to 1 mm, and agreement was 96%. To ensure accuracy and reliability in measuring clinical parameters, the examiner re-examined 50 patients 1 week later, and 90% calibration was achieved.

Assessment of Gingival Phenotype
The gingival phenotype was categorized as thin or thick, according to the visibility of the periodontal probe. If the outline of the periodontal probe is reflected from the gingiva, the phenotype is thin (Score: 0); if the periodontal probe did not reflect on the gingiva, the phenotype was determined as thick (score: 1) [19].
For measuring gingival thickness, a size 15 endodontic spreader with a rubber stopper was placed vertically at a point in the middle of the gingival margin and mucogingival junction, and this measurement was recorded with a periodontal probe.

Measurements of Crown Shape
Crown shape was determined regarding Olsson & Lindhe's measurement [13]. To determine the crown shape by dividing it into 2 groups, the ratio of crown width/crown length (CW/CL) of the right central incisor was calculated.
The definition of crown length is the distance between the free gingival margin and the incisal edge of the crown. The crown width is the distance between the mesial and distal tooth surfaces at the border between the cervical and middle parts of the tooth.
Since the 80:100 ratio seems ideal, a CW/CL above 80% is considered a wide square and below 80% a narrow rectangle [20]. In our study, the ratios considered as quadrate or square were calculated as 8\8 - 9\9 - 7\8 - 8\9, while the ratios considered as rectangular were calculated as 8\10 - 7\9 - 7.5\9 - 8\11 [7].

Measurements of Keratinized Tissue Width
Keratinized tissue width (KTW) was measured with a periodontal probe from the gingival border at the most apical point of the mid-facial margin of the maxilla anterior teeth to the mucogingival margin [21].

Measurements of Papilla Height

Papilla height (PH) was evaluated as the distance from the papilla tip to the junction of two adjacent gingival zenith points using identical periodontal probes in the mesial and distal teeth of the maxilla anterior region. The mean value of the five measured papilla heights was calculated [14]. Measurements of all parameters were performed by an experienced clinician (O.B.).

Statistical Analysis

SPSS V22 package program was used within the scope of the research. Descriptive data and variables of the study are specified as mean and percentage. The Chi-square test was used to compare the parameters at the categorical level.

According to the results of the power analysis performed to test the adequacy of the sample size, the chi-square test was performed using the G Power program (G * Power 3.1 software; Heinrich Heine University, Düsseldorf, Germany) α (margin of error) = 0.05, 0 when the sample is 90 people. It was determined that a 0.91 power (1-β) value was achieved at a 0.35 effect (W).

Results and Discussion

Results

A total of 90 people, 37 males, and 53 females, who applied to the Necmettin Erbakan University Faculty of Dentistry Department of Periodontology clinic were included in the study. Sociodemographic data and clinical periodontal status of the individuals incorporated within the research are outlined in **Table 1**. The mean age of the participants was 27±9.1, and 54.4% of the study population consisted of individuals under the age of 25. When the periodontal status and oral hygiene habits of the patients were evaluated, it was determined that 54.4% of the individuals had inadequate oral hygiene. It was observed that 28.9% of the participants had <3 mm, papilla height in the maxilla anterior region.

Table 1. Characteristics of the study sample

		N	%
Gender	Male	37	41.1
	Female	53	58.9
Age	<25 years	49	54.4
	≥25 years	41	45.6
Gingival Phenotype	Thick	58	64.4
	Thin	32	35.6
Crown Shape	Rectangular	45	50.0
	Square/Quadrate	45	50.0
Oral Hygiene	Poor	49	54.4
	High	41	45.6
Plaque Index	0-1	62	68.9
	2	23	25.6
	3	5	5.6
Gingival Index	1	58	64.4
	2	27	30.0
	3	5	5.6
Keratinized Tissue Width (KTW)	<4 mm	6	6.7
	4.1-8 mm	75	83.3
	>8 mm	9	10
Papilla Height (PH)	<3 mm	26	28.9
	≥3 mm	64	71.1

When the gingival phenotypes and keratinized tissue widths were examined, 58 individuals had a thick gingival phenotype, 32 individuals had a thin gingival phenotype, 6.7% of the participants had a keratinized tissue width of less than 4 mm, 83.3% of them were between 4 and 8 mm and 10% of them were wider than 8 mm. There was no statistically significant difference between gingival phenotypes and keratinized tissue width, crown shape, plaque index, gingival index and papilla heights ($p>0.05$) **(Tables 2 and 3)**.

Table 2. Comparison of Crown Shape, PI, GI, KTW, and PH values by Gingival Phenotype

		Gingival Phenotype		*p*
		Thick	**Thin**	
Crown Shape	Rectangular	29 (50)	16 (50)	0.587
	Square/Quadrate	29 (50)	16 (50)	
Plaque Index (PI)	0-1	43 (74.2)	19 (59.4)	0.078
	2	14 (24.1)	9 (28.1)	
	3	1 (1.7)	4 (12.5)	
Gingival Index (GI)	0-1	41 (70.7)	17 (53.1)	0.060
	2	16 (27.6)	11 (34.4)	
	3	1 (1.7)	4 (12.5)	
Keratinized Tissue Width (KTW)	<4 mm	4 (6.9)	2 (6.3)	0.262
	4.1-8 mm	46 (79.3)	29 (90.6)	
	>8 mm	8 (13.8)	1 (3.1)	
Papilla Height (PH)	<3 mm	18 (31)	8 (25)	0.545
	≥3 mm	40 (69)	24 (75)	

When the crown shapes of the teeth of the participants in the maxilla region are evaluated, the number of individuals with rectangular crowns was equal to the number of individuals with square crowns. It has been determined that the crown shapes of teeth in the anterior region of the maxilla affect papilla heights **(Table 3)**. The papilla heights of individuals with rectangular crown shapes are 3 mm and higher, while the papillary heights of individuals with the square crown shape are lower than 3 mm ($p<0.05$).

Table 3. Comparison of Crown Shape and PH values by KTW and comparison of PH values by Crown Shape

		Keratinized Tissue Width (KTW)			p
		<4	**4.1-8**	**>8**	
Crown Shape	Square/Quadrate	1 (16.7)	39 (52.0)	5 (55.6)	0.235
	Rectangular	5 (83.3)	36 (48.0)	4 (44.4)	
Papilla Height (PH)	<3 mm	0 (0)	23 (30.7)	3 (33.3)	0.267
	≥3 mm	6 (100)	52 (69.3)	6 (66.7)	
		Crown Shape			**p**
		Square/Quadrate		**Rectangular**	
Papilla Height (PH)	<3 mm	19 (42.2)		7 (15.6)	0.005*
	≥3 mm	26 (57.8)		38 (84.4)	

As a result of the evaluation of gingival phenotype, keratinized tissue width, and papilla height according to gender and age, a statistically insignificant difference was found **(Table 4)**.

Table 4. Comparison of Gingival Phenotype, KTW, and PH values by Gender and Age

		Gender		p	Age		p
		Female	**Male**		**<25**	**≥25**	
Gingival Phenotype	Thick	28 (75.7)	30 (56.6)	0.063	29 (59.2)	29 (70.7)	0.254
	Thin	9 (24.3)	23 (43.4)		20 (40.8)	12 (29.3)	
Keratinized Tissue Width (KTW)	<4 mm	1 (1.9)	5 (13.5)	0.550	3 (6.1)	3 (7.3)	0.973
	4.1-8 mm	45 (84.9)	30 (81.1)		41 (83.7)	34 (82.9)	
	>8 mm	7 (13.2)	2 (5.4)		5 (10.2)	4 (9.8)	
Papilla Height (PH)	<3 mm	16 (30.2)	10 (27.0)	0.745	10 (20.4)	16 (39.0)	0.520
	≥3 mm	37 (69.8)	27 (73)		39 (79.6)	25 (61.0)	

Gingival phenotype, papillae height, and keratinized tissue width have become an important topic of interest in restorative and periodontology from both an epidemiological and therapeutic perspective. In this study, the gingival phenotype of the

maxillary anterior teeth in 90 individuals who applied to our clinic and the factors affecting the phenotype was investigated. It was observed that 35% of the individuals had a thin gingival phenotype and age, gender, and crown shape did not affect the gingival phenotype.

Evaluation of gingival phenotype has become important in periodontal treatment planning, affecting treatment outcomes [22]. In studies evaluating gingival thickness in the literature, it is stated that gingival thickness varies in different parts of the mouth. Kydd *et al*. found that the mean gingival thickness between the lateral and the central incisors was just under 3 mm, and just more than 3 mm between the premolars and molars [23]. In 2015, Shah *et al*. stated that in their study comparing the average gingival thickness of the maxillary anterior teeth, observed gingival thicknesses of 1.11 mm, 1.01 mm, and 0.82 mm, respectively. They also showed that there was a statistically substantial difference between the thicknesses of the gums of the teeth [22]. In another study evaluating the gingival phenotype, the view that gingival thickness differs was supported [24-26]. In this study, similar to the study by Kydd *et al*. it was observed that the gingival thickness was higher in the posterior teeth region.

The gingival phenotype represents the width of the keratinized tissue and the thickness of the tissue. Olsson *et al*. also stated that the gingival phenotype is thick in individuals with large width of keratinized tissue, and a thin phenotype in individuals with a small width of keratinized tissue [13]. Shah *et al*. reported a strong association between KTW and gingival phenotype [22]. According to this study, the mean width of keratinized tissue of the central incisor, lateral incisor, and canine was documented as 4.38 ± 1.18, 5.18 ± 1.25, 4.16 ± 1.16 mm, respectively [23]. The outcomes of our research revealed that the width of the keratinized tissue is between 4.1 and 8 mm, which is accepted as adequate keratinized gingiva in most individuals in the Turkish population. Keratinized tissue widths in maxillary anterior teeth were found to be slightly higher in our study compared to the studies by Shah *et al*. However, supporting the work of Shah *et al*., it was determined that the widths of keratinized tissue were the largest for lateral incisors, followed by the central incisor and canine. These findings support the idea that more careful treatment planning should be done in patients with a thin gingival phenotype.

Many factors such as age, gender, and crown shape can affect the gingival phenotype. Although many studies in the literature have shown that the gingival thickness in men is higher than in women, also studies argue that there is a similar gingival thickness in both genders [27-29]. Stipetić *et al*. found that males have significantly thicker mucosal tissues than females [28]. Shah *et al*. reported that there was no significant difference between men and women in terms of gingival thickness [22]. It has been reported that the width of the keratinized tissue differs in men and women, unlike the gingival thickness. De rouck *et al*. reported that women have less width of keratinized tissue than men [30]. According to the results of our study, when male and female individuals were compared, it was seen that women had more keratinized gingiva than men, but the gingival thickness was similar in men and women. Moreover, it was observed that the width of the keratinized tissue did not differ with age. In the literature, it has been stated that the width of the attached gingiva in men and the basal bone are in continuous growth throughout the adult age with the enlargement over time, but there is no such growth in women [31, 32]. Ainamo *et al*. in 1981, reported that the width of keratinized tissue in men was greater than in women [31]. The findings of our study do not support the literature, which might be elucidated by the fact that the literature survey is in a wider age range and the population in our study is smaller [33].

The crown shape of the maxillary central incisors influences the periodontal characteristics typical of numerous gingival phenotypes, and there is thought to be a correlation between the crown shape and the phenotype [11]. In a study by Ochsenbein and Ross, they said that long, conical teeth tend to have thin periodontal tissue, and wide square teeth tend to have thick, straight periodontal tissue [34]. Olsson *et al*. reported that there was no statistically significant difference between thick and thin gingival phenotypes based on the crown shape defined by the CW/CL ratio [13]. In our study, it was observed that the crown shape did not affect the gingival phenotype, the rectangular crown shape was associated with the thinner gingival phenotype, and the square crown shape was associated with the thicker (1.5–2.0 mm) gingival phenotype. In line with the differences in the findings of studies examining the relationship between crown shape and gingival phenotype, Fischer *et al*. stated that the CW/CL ratio is not a reliable parameter to evaluate the gingival phenotype, and according to the available data, thin and wide teeth can be found in a gingival phenotype [21].

In recent studies, it has been argued that PH is also affected by the gingival phenotype [13, 21, 35]. It was stated that the gingival phenotype was positively correlated with the height of the interproximal papilla and thus the papilla appearance. The study by Olsson *et al*. supports the view that there is a positive relationship between PH and gingival phenotype [13]. Chow *et al*. examined the gingival papillae presence concerning crown shape and gingival phenotype and argued that the thin gingival phenotype is associated with fewer papillae height, and the thick gingival phenotype is associated with higher papillae height [36]. In the study by Kan *et al*., a significantly higher interproximal papilla height was observed in the thick gingival phenotype group compared to the thin gingival phenotype group [19]. The findings of our study agree with the literature, that there is a higher papilla height in the thick gingival phenotype associated with the thin gingival phenotype. Additionally, in our study, it was observed that age and gender had no effect on papillary height.

Conclusion

Within the limits of this study, it was found that the prevalence of rectangular and square crown shapes was equal and the thick gingival phenotype was higher in the Turkish population in our study. There was no correlation between the gingival phenotype and crown shape, clinical parameters, and papilla heights. It has been shown that individuals with a thick phenotype have

higher KTW and the shape of the crown in the anterior region of the maxilla affects the height of the papilla. Further studies with wide-ranging populations are needed to confirm the results of our study. Future research is needed to develop a classification system to analyze gingival phenotype parameters in order to predict the esthetic consequences of approaches in treatments in various fields of dentistry.

Acknowledgments: The authors would like to acknowledge all the patients who participated in this study.

Conflict of interest: None

Financial support: None

Ethics statement: The study protocol was approved by the Necmettin Erbakan University Faculty of Dentistry Ethics Committee for Non-Pharmaceutical and Medical Device Clinical Research (Ethics Decision No: 2021/01-16).

References

1. Jepsen S, Caton JG, Albandar JM, Bissada NF, Bouchard P, Cortellini P, 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 Suppl 20:219-29.
2. Müller HP, Eger T. Masticatory mucosa and periodontal phenotype: a review. Int J Periodontics Restorative Dent. 2002;22(2):172-83.
3. Jing WD, Xu L, Xu X, Hou XJ, Li XT. Association between Periodontal Biotype and Clinical Parameters: A Cross-sectional Study in Patients with Skeletal Class III Malocclusion. Chin J Dent Res. 2019;22(1):9-19.
4. Rasperini G, Codari M, Paroni L, Aslan S, Limiroli E, Solís-Moreno C, et al. The influence of gingival phenotype on the outcomes of coronally advanced flap: A prospective multicenter study. Int J Periodontics Restorative Dent. 2020;40(1):e27-e34.
5. Kim DM, Bassir SH, Nguyen TT. Effect of gingival phenotype on the maintenance of periodontal health: An american academy of periodontology best evidence review. J Periodontol. 2020;91(3):311-38.
6. Imber JC, Kasaj A. Treatment of gingival recession: When and how? Int Dent J. 2021;71(3):178-87.
7. Alhajj WA. Gingival phenotypes and their relation to age, gender, and other risk factors. BMC Oral Health. 2020;20(1):87.
8. Barootchi S, Tavelli L, Zucchelli G, Giannobile WV, Wang HL. Gingival phenotype modification therapies on natural teeth: A network meta-analysis. J Periodontol. 2020;91(11):1386-99.
9. Vlachodimou E, Fragkioudakis I, Vouros I. Is there an association between the gingival phenotype and the width of keratinized gingiva? A systematic review. Dent J. 2021;9(3):34.
10. Belák Š, Žižka R, Starosta M, Zapletalová J, Šedý J, Štefanatný M. The influence of gingival phenotype on the morphology of the maxillary central papilla. BMC Oral Health. 2021;21(1):1-8.
11. Weisgold AS. Contours of the full crown restoration. Alpha Omegan. 1977;70(3):77-89.
12. Jennes ME, Sachse C, Flügge T, Preissner S, Heiland M, Nahles S. Gender- and age-related differences in the width of attached gingiva and clinical crown length in anterior teeth. BMC Oral Health. 2021;21(1):287.
13. Olsson M, Lindhe J. Periodontal characteristics in individuals with a varying form of the upper central incisors. J Clin Periodontol. 1991;18(1):78-82.
14. 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.
15. Joshi A, Suragimath G, Zope SA, Ashwinirani SR, Varma SA. Comparison of Gingival Biotype between different Genders based on Measurement of Dentopapillary Complex. J Clin Diagn Res. 2017;11(9):40-5.
16. Barriviera M, Duarte WR, Januário AL, Faber J, Bezerra AC. A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography. J Clin Periodontol. 2009;36(7):564-8.
17. Greenberg J, Laster L, Listgarten MA. Transgingival probing as a potential estimator of alveolar bone level. J Periodontol. 1976;47(9):514-7.
18. Müller HP, Heinecke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. J Clin Periodontol. 2000;27(9):621-6.
19. Kan JY, Rungcharassaeng K, Umezu K, Kois JC. Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. J Periodontol. 2003;74(4):557-62.
20. Marinello CP, Meyenberg KH, Zitzmann N, Lüthy H, Soom U, Imoberdorf M. Single-tooth replacement: some clinical aspects. J Esthet Dent. 1997;9(4):169-78.
21. 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.

22. Shah R, Sowmya NK, Mehta DS. Prevalence of gingival biotype and its relationship to clinical parameters. Contemp Clin Dent. 2015;6(Suppl 1):167-71.
23. Kydd WL, Daly CH, Wheeler JB. The thickness measurement of masticatory mucosa in vivo. Int Dent J. 1971;21(4):430-41.
24. Müller HP, Eger T. Gingival phenotypes in young male adults. J Clin Periodontol. 1997;24(1):65-71.
25. Goaslind GD, Robertson PB, Mahan CJ, Morrison WW, Olson JV. Thickness of facial gingiva. J Periodontol. 1977;48(12):768-71.
26. Egreja AM, Kahn S, Barceleiro M, Bittencourt S. Relationship between the width of the zone of keratinized tissue and thickness of gingival tissue in the anterior maxilla. Int J Periodontics Restorative Dent. 2012;32(5):573-9.
27. Müller HP, Schaller N, Eger T, Heinecke A. Thickness of masticatory mucosa. J Clin Periodontol. 2000;27(6):431-6.
28. Stipetić J, Hrala Z, Celebić A. Thickness of masticatory mucosa in the human hard palate and tuberosity dependent on gender and body mass index. Coll Antropol. 2005;29(1):243-7.
29. Vandana KL, Savitha B. Thickness of gingiva in association with age, gender, and dental arch location. J Clin Periodontol. 2005;32(7):828-30.
30. 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.
31. Ainamo J, Talari A. The increase with age of the width of attached gingiva. J Periodontal Res. 1976;11(4):182-8.
32. Lang NP, Löe H. The relationship between the width of keratinized gingiva and gingival health. J Periodontol. 1972;43(10):623-7.
33. Ainamo A, Ainamo J, Poikkeus R. Continuous widening of the band of attached gingiva from 23 to 65 years of age. J Periodontal Res. 1981;16(6):595-9.
34. Ochsenbein C, Ross S. A reevaluation of osseous surgery. Dent Clin North Am. 1969;13(1):87-102.
35. Yingzi X, Zhiqiang L, Peishuang W, et al. Relationship of Gingival Phenotypes and Faciolingual Thickness, Papilla Height, and Gingival Angle in a Chinese Population. Int J Periodontics Restorative Dent. 2021;41(1):127-34.
36. 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.