Society of Medical Education & Research

2022, Volume 2, Issue 1, Page No: 36-42
ISSN: 3108-4826

Journal of Medical Sciences and Interdisciplinary Research

Assessing the Link between Gingival Phenotype and Periodontal Health

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Abstract

The identification of the gingival phenotype and its relationship to periodontal health is essential for providing effective treatment. This study investigated the prevalence of different gingival phenotypes and how they relate to various factors such as crown shape, papilla height (PH), keratinized tissue width (KTW), and other potential risk factors. A total of 90 participants, including 53 women and 37 men, participated in the study. The gingival phenotype was classified as thin or thick based on how much the periodontal probe could pass through the buccal gingival margin. Clinical data, including supracrestal gingival height (SGH), crown width to length ratio, PH, and KTW, were all measured and compared. No significant differences were found between the gingival phenotypes regarding SGH, crown width/length ratio, or periodontal parameters ($P > 0.05$). However, individuals with rectangular crowns had higher papilla height compared to those with square crowns ($P < 0.05$). The distribution of crown shapes was similar, with a higher prevalence of thick gingival phenotypes found among Turkish participants. No significant correlation was found between gingival phenotype and crown shape, periodontal health, or papilla height. Thick phenotypes were associated with a larger KTW, and crown shape in the maxillary anterior region was a factor in papilla height.

Keywords: Gingival phenotype, Periodontal health, Papilla height, Crown shape, Keratinized tissue width

Introduction

The periodontal phenotype consists of both the gingival phenotype and the thickness of the buccal bone plate, also known as the bone morphotype [1]. The gingival phenotype is primarily determined by two key factors: gingival thickness (GT) and the width of the keratinized tissue (KTW) [2]. This phenotype influences how periodontal tissues react to various factors such as bacterial infection, physical trauma, or chemical damage, and it plays a significant role in the success of periodontal treatments, the aesthetic outcomes of restorative procedures, and root closure techniques [3-6].

Studies have shown that multiple factors, including gingival thickness, keratinized tissue width, crown shape, and papilla height, contribute to the overall gingival phenotype [7-10]. The crown shape, in particular, is thought to influence the architecture of the gingiva, with evidence suggesting that square-shaped teeth, which have broader contact points and a more apical position, are commonly associated with a thick gingival phenotype. In contrast, thin gingival phenotypes are typically observed in teeth with triangular shapes, which tend to have smaller contact points and a more coronal position [13, 14]. Research by Chow et al. demonstrated that gingival thickness and the height of the interproximal papilla are closely linked, highlighting the importance of crown morphology in the appearance of the gingival papilla.

Access this article online https://smerpub.com/

Received: 11 February 2022; **Accepted:** 05 May 2022

How to cite this article: Dziewulska A, Czerniawska-Kliman L, Droździk A, Grocholewicz K. Assessing the Link between Gingival Phenotype and Periodontal Health. J Med Sci Interdiscip Res. 2022;2(1):36-42. https://doi.org/10.51847/kvIgh3rVkP

Historically, the width of keratinized gingiva was recommended to be at least 2 mm, with 1 mm of attached gingiva, to ensure periodontal health [15]. However, more recent studies have indicated that periodontal health can be maintained even without sufficient keratinized tissue, provided that patients follow proper oral hygiene practices [16]. As a result, understanding and accurately evaluating the gingival phenotype has become increasingly important, particularly in treatment planning for aesthetic procedures such as dental implants.

Several techniques exist for measuring gingival phenotype, including visual inspection, transgingival probing, periodontal probe transparency, cone-beam computed tomography, and parallel profile radiography [17, 18]. The periodontal probe transparency method, described by Kan *et al.* [19], is a simple, non-invasive technique that determines gingival phenotype based on the visibility of the periodontal probe through the gingival margin while probing the sulcus in the middle of the tooth. This method is highly reproducible, with an 85% agreement rate across measurements. However, differentiating between thin and thick gingival phenotypes can still pose a challenge in clinical settings.

Given the importance of gingival phenotype in treatment outcomes, it is essential to evaluate its prevalence and understand its correlation with other clinical parameters. This study aims to assess the distribution of gingival phenotypes and investigate how factors like crown shape and keratinized tissue width influence the gingival phenotype.

Materials and Methods

This study involved 90 participants (53 females and 37 males) who visited the Department of Periodontology at Necmettin Erbakan University Faculty of Dentistry for various purposes. Participation was voluntary, with informed consent obtained from all individuals. The study adhered to the ethical principles outlined in the Declaration of Helsinki and received approval from the university's Faculty of Dentistry Ethics Committee (Ethics Decision No: 2021/01-16). Only participants without systemic diseases and who were deemed periodontally healthy after a thorough clinical evaluation were selected.

Exclusion criteria were established as follows: individuals with advanced periodontal disease (probing depth greater than 3 mm), gingival recession, bleeding on probing, plaque index above 20%, pregnant or breastfeeding women, those taking medications that could influence soft tissue thickness (such as cyclosporine A, phenytoin, or calcium channel blockers), the presence of dental restorations affecting tooth crown shape or occlusal surfaces, caries on interproximal surfaces, history of dental trauma altering tooth shape, prior orthodontic treatment, craniofacial asymmetry, previous periodontal surgeries involving the maxillary anterior teeth, or significant incisal wear, erosion, or attrition reaching the dentin layer.

Clinical Measurements

The clinical parameters were measured by a single examiner 1 week after the patients received oral hygiene instructions. A minimum of 3 weeks was allowed between non-surgical periodontal treatment and the clinical measurements. Calibration training was conducted at the start of the study to ensure consistency in measurements, with 96% agreement observed between the primary examiner and a second examiner within a 1 mm threshold. A subset of 50 patients was re-examined after 1 week, achieving a calibration agreement rate of 90%.

Gingival Phenotype Assessment

The gingival phenotype was categorized as thin or thick based on the visibility of the periodontal probe through the gingiva. A thin phenotype was identified if the probe outline was visible through the gingiva (score = 0), while a thick phenotype was assigned if the probe was not visible (score = 1) [19]. Gingival thickness was measured using a size 15 endodontic spreader with a rubber stopper, positioned vertically at the junction of the gingival margin and mucogingival line, and recorded with a periodontal probe.

Crown Shape Evaluation

To assess crown shape, the ratio of crown width to crown length (CW/CL) for the right central incisor was calculated, following the method described by Olsson and Lindhe [13]. The crown length was measured from the free gingival margin to the incisal edge, while crown width was measured from the mesial to the distal surface at the junction of the cervical and middle thirds of the tooth. A CW/CL ratio greater than 80% indicated a square crown shape, whereas a ratio below 80% indicated a rectangular shape. Crown shapes with ratios such as 8/8, 9/9, 7/8, and 8/9 were categorized as square, and

those with ratios like 8/10, 7/9, 7.5/9, and 8/11 were classified as rectangular [7].

Keratinized Tissue Width Measurement

Keratinized tissue width (KTW) was measured using a periodontal probe, from the most apical point of the mid-facial gingival margin of the maxillary anterior teeth to the mucogingival junction [20, 21].

Papilla Height Measurement

Papilla height (PH) was measured as the distance from the tip of the papilla to the junction of the adjacent gingival zeniths on the mesial and distal sides of the maxillary anterior teeth. The average of five measurements for each papilla was recorded for analysis [14]. All clinical measurements were performed by a trained examiner (O.B.).

Statistical Analysis

The study data were analyzed using SPSS version 22. Descriptive statistics were used to summarize the study's variables, presenting them in terms of means and percentages. The chi-square test was applied for comparisons between categorical variables. Power analysis, performed using the G*Power software (version 3.1, Heinrich Heine University, Düsseldorf, Germany), confirmed that the sample size was sufficient to detect meaningful differences. With 90 participants, a power of 0.91 was achieved, with an effect size (W) of 0.35 and a margin of error set at 0.05.

Results and Discussion

The study included 90 participants (37 males and 53 females) who sought treatment at the Department of Periodontology, Necmettin Erbakan University Faculty of Dentistry. A summary of the sociodemographic data and clinical periodontal parameters is provided in Table 1. The average age of the participants was 27 years (± 9.1), with the majority (54.4%) being under 25 years old. Upon evaluating the periodontal health and oral hygiene practices, it was found that more than half (54.4%) of the participants had suboptimal oral hygiene. Furthermore, 28.9% of the individuals showed a papilla height of less than 3 mm in the anterior maxillary 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

The study included 90 participants, where 58 displayed a thick gingival phenotype and 32 exhibited a thin phenotype. For keratinized tissue width, 6.7% of participants had less than 4 mm, 83.3% had widths ranging between 4 mm and 8 mm, and 10% had widths greater than 8 mm. However, no significant differences

were found between gingival phenotype, keratinized tissue width, crown shape, plaque index, gingival index, or papilla height (P > 0.05), as shown in Tables 2 and 3.

Table 2. Comparison of crown shape, PI, GI, KTW, and PH values by gingival phenotype

		Gingival phenotype		P-value
		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 examining the crown shapes of the maxillary teeth, an equal number of participants had rectangular and square crown shapes. It was found that the shape of the teeth in the maxillary anterior region influenced papilla height (**Table 3**). Participants with rectangular crowns had papilla heights of 3 mm or higher, while those with square crowns had papilla heights of less than 3 mm (P < 0.05).

Table 3. Comparison of crown shape and papilla height (PH) values by keratinized tissue width (KTW), and comparison of PH values by crown shape

Keratinized tissue width (KTW)	Square/Quadrate	Rectangular	P-value
< 4 mm	1 (16.7%)	5 (83.3%)	0.235
4.1-8 mm	39 (52.0%)	36 (48.0%)	
> 8 mm	5 (55.6%)	4 (44.4%)	
Papilla height (PH)	< 3 mm	≥ 3 mm	P-value
Square/Quadrate	0 (0%)	6 (100%)	0.267
Rectangular	23 (30.7%)	52 (69.3%)	
Crown shape	Square/Quadrate	Rectangular	P-value
Papilla Height (PH)	< 3 mm	19 (42.2%)	0.005*
	≥ 3 mm	26 (57.8%)	84.4%

An analysis of gingival phenotype, keratinized tissue width, and papilla height according to gender and age showed no significant differences (**Table 4**).

Table 4. Comparison of gingival phenotype, keratinized tissue width (KTW), and papilla height (PH) values by gender and age

Gender	Female	Male	P-value
Gingival phenotype	Thick (28) (75.7%)	Thick (30) (56.6%)	0.063
	Thin (9) (24.3%)	Thin (23) (43.4%)	
Keratinized tissue width (KTW)	< 4 mm (1) (1.9%)	< 4 mm (5) (13.5%)	0.550
	4.1-8 mm (45) (84.9%)	4.1-8 mm (30) (81.1%)	
	> 8 mm (7) (13.2%)	> 8 mm (2) (5.4%)	
Papilla height (PH)	< 3 mm (16) (30.2%)	< 3 mm (10) (27.0%)	0.745
	≥ 3 mm (37) (69.8%)	≥ 3 mm (27) (73%)	
Age (years)	< 25	≥ 25	P-value
Gingival phenotype	Thick (29) (59.2%)	Thick (29) (70.7%)	0.254

	Thin (20) (40.8%)	Thin (12) (29.3%)	
Keratinized tissue width (KTW)	< 4 mm (3) (6.1%)	< 4 mm (3) (7.3%)	0.973
	4.1-8 mm (41) (83.7%)	4.1-8 mm (34) (82.9%)	
	> 8 mm (5) (10.2%)	> 8 mm (4) (9.8%)	
Papilla height (PH)	< 3 mm (10) (20.4%)	< 3 mm (16) (39.0%)	0.520
	≥ 3 mm (39) (79.6%)	≥ 3 mm (25) (61.0%)	

In this study, the gingival phenotype, papilla height, and keratinized tissue width were evaluated as they are essential factors for restorative and periodontal treatments. The findings indicate that 35% of the participants exhibited a thin gingival phenotype, and neither age, gender, nor crown shape influenced the gingival phenotype.

The evaluation of gingival phenotype plays a crucial role in the planning of periodontal treatments, as it can significantly affect the success of these procedures [22]. Previous studies on gingival thickness have highlighted its variation across different areas of the mouth. Kydd *et al.* [23] found that the gingival thickness between the central and lateral incisors averaged just under 3 mm, while it increased to slightly above 3 mm between the premolars and molars. In a 2015 study, Shah *et al.* [22] recorded gingival thicknesses of 1.11 mm, 1.01 mm, and 0.82 mm for the maxillary anterior teeth, revealing substantial differences in thickness across the different teeth. These findings are in agreement with other research that shows gingival thickness varies by location in the mouth [24-26]. Consistent with Kydd *et al.*'s results [23], our study also showed that posterior teeth have thicker gingiva.

The gingival phenotype is a combination of both tissue thickness and the width of keratinized tissue. Olsson and Lindhe [13] suggested that a wider area of keratinized tissue is associated with a thicker gingival phenotype, while a narrower area corresponds to a thinner phenotype. Shah *et al.* [22] found a strong link between keratinized tissue width (KTW) and gingival phenotype. In their research, the KTW measurements for the central incisor, lateral incisor, and canine were 4.38 ± 1.18 mm, 5.18 ± 1.25 mm, and 4.16 ± 1.16 mm, respectively [23]. In our study, the KTW for the Turkish population was found to range from 4.1 to 8 mm, which is considered adequate keratinized gingiva for most individuals. This range is slightly higher compared to Shah et al.'s findings, but we also observed that the lateral incisors had the largest KTW, followed by the central incisors and canines. This supports the notion that patients with a thinner gingival phenotype require more careful treatment planning.

Various factors such as age, gender, and crown shape can influence the gingival phenotype. While some studies suggest that men typically have thicker gingiva than women, others argue that the difference is negligible between the sexes [27-29]. Stipetić *et al.* [28] found that men had significantly thicker gingival tissues compared to women. On the other hand, Shah et al. found no substantial difference in gingival thickness between men and women [22]. There is also evidence that the width of keratinized tissue differs by gender. De Rouck *et al.* [30] found that women generally have less keratinized tissue than men. However, our study revealed that women had more keratinized tissue than men, but the gingival thickness was similar in both genders. Additionally, we observed no significant age-related differences in the width of keratinized tissue. Some literature suggests that men continue to experience growth in the width of their attached gingiva and basal bone throughout adulthood, while this growth is not observed in women [31, 32]. Ainamo and Talari [31] found that men had wider keratinized tissue than women in 1981. Our study does not support this finding, which could be due to the narrower age range and smaller sample size in our study [33].

The crown shape of the maxillary central incisors may have an impact on the periodontal characteristics associated with different gingival phenotypes. The relationship between crown shape and phenotype is well-documented [11]. Ochsenbein and Ross suggested that long, conical teeth are typically associated with thinner periodontal tissues, while broader, square-shaped teeth are linked to thicker tissues [34]. Olsson and Lindhe [13] reported no significant difference in gingival phenotype thickness when analyzing crown shape using the CW/CL ratio. In our study, we found no significant relationship between crown shape and gingival phenotype; however, rectangular crowns were more often associated with thinner gingiva, while square crowns were linked to thicker gingiva (1.5–2.0 mm). These results align with the idea that the CW/CL ratio is not a reliable method for

evaluating gingival phenotype, as both thin and thick gingiva can be found with various crown shapes [21].

Recent studies also suggest that papilla height (PH) is influenced by the gingival phenotype [13, 21, 35]. It has been found that thicker gingival phenotypes tend to have higher papillae, while thinner phenotypes are linked to shorter papillae. Olsson and Lindhe [13] supported the idea that there is a positive relationship between papilla height and gingival phenotype. Chow *et al.* [36] examined the link between crown shape, gingival phenotype, and papilla height and found that a thin gingival phenotype is associated with shorter papillae, whereas a thick gingival phenotype is associated with taller papillae. Kan *et al.* [19] observed that individuals with a thick gingival phenotype had significantly higher interproximal papillae compared to those with a thin phenotype. Our study corroborates these findings, showing that a thick gingival phenotype corresponds to higher papillae. We also found that age and gender did not significantly affect papilla height.

Conclusion

This study revealed that rectangular and square crown shapes are equally prevalent in the Turkish population, with a higher frequency of the thick gingival phenotype observed. No significant relationship was found between gingival phenotype and crown shape, clinical parameters, or papilla heights. The study also demonstrated that individuals with a thicker gingival phenotype tend to have a greater keratinized tissue width (KTW) and that the crown shape of the maxillary anterior teeth influences papilla height. To further confirm these findings, additional research involving larger and more diverse populations is needed. Additionally, future studies should aim to develop a classification system to assess gingival phenotype parameters, which would help predict the aesthetic outcomes of various dental treatments.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

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