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Research article

The gingival phenotypes and related clinical periodontal parameters in a cohort of Pakistani young adults

Yousuf Moosa [a], Lakshman Samaranayake [b,c], Pagaporn Pantuwadee Pisarnturakit [a,*]

[a] Department of Community Dentistry, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand
[b] Faculty of Dentistry, University of Hong Kong, Hong Kong
[c] Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand

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ABSTRACT

Objective: To evaluate the gingival phenotypes of healthy young adult Pakistanis attending a dental institution.
Methods: A cross-sectional study of gingival phenotype, probing depth (PD), papilla height (PH), gingival width (GW), gingival thickness (GT), crown width (CW) and crown length (CL) of maxillary central incisors was conducted in 510 healthy, Pakistani young adults, aged 20–35 years, attending a regional dental hospital in Pakistan. The K-means clustering technique was employed to delineate clusters based on the characteristics of the periodontal phenotypes. The resultant data was compared with the available international findings.
Results: Three quarters (76 %) of the 510 patients examined exhibited a thick gingival phenotype, and the remainder a thin phenotype. The K-means clustering deployed the individual into three different clusters 1, 2 and 3, with varying ratios of PD, GW, CW/CL, with significant variations across the three clusters ($p < 0.05$). Our data where a vast majority of the cohort exhibited a thick gingival phenotype is comparable to most of the populations sampled in other regions of the world.
Conclusion: Taken together the current data, a first for a Pakistani population, indicate that healthy, young adult Pakistanis had differing gingival phenotypes and crown forms, with the thick gingival phenotype predominating. These results are similar to reports from most other regions of the world. However, a larger study with a broader swathe of the Pakistani population is required to derive country specific data on the subject.

Clinical relevance

Scientific rationale for study: Gingival phenotypes are found to vary across population groupings. This is Pakistan's first report on gingival phenotypic distribution. Although data on gingival phenotypes is accessible in the literature, data from Asian regions is scarce and lacking. To establish a reliable worldwide data set of gingival phenotypes, it is crucial to collect information from the Asian community.

Principal findings: Our findings exhibited a variety of gingival phenotypes and crown morphologies, with a thick gingival phenotype predominating.

* Corresponding author.
E-mail address: pagaporn.p@chula.ac.th (P.P. Pisarnturakit).

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Clinical implication: As the evaluation of the gingival phenotype during surgical treatment planning is crucial to achieve optimal treatment outcomes, our data would be of considerable clinical value.

1. Introduction

The clinical features of the healthy marginal periodontium, which is the tissue surrounding the teeth where the gingivae meets the tooth, can vary significantly depending on the patient and the type of tooth [1]. In addition, anatomically different teeth may have thicker or thinner gingival tissue or variations in the depth of the surrounding healthy gingival pocket. Understanding these differences is essential for periodontal, implant, prosthetic and orthodontic treatment outcomes particularly in the aesthetic zones of the mouth.

The terms genotype, biotype and the phenotype are somewhat loosely used in the literature. In general, the term biotype focuses on the expression of traits, while genotype focuses on the underlying genetic information that determines those traits [2]. On the other hand, phenotype refers to particular attributes of the biotype, and in our case the gingival phenotype is considered as the thickness of gingivae and the width of the attached gingivae, and the topography of the gingival margins (e.g scalloped or not).

Gingival phenotype is a critical element that influences the success of dental treatment, notably periodontal therapy, including root covering procedures, and placement of dental implants [3–6]. As a result, it is critical to assess the gingival phenotype prior to therapeutic procedures for better outcomes and prognosis, as different gingival phenotypes react differently to inflammation and surgical or restorative therapy [7].

The gingival phenotypes are classified into two categories either as “thick-flat” and “thin-scalloped”. Thus, gingivae that are ±1.5 mm thick are regarded as the thick phenotype, whilst gingivae less than 1.5 mm thick regarded as thin [8].

The gingival phenotype is known to differ in diverse population groups [9]. Although there is data available in the literature on the gingival phenotypes of young, male, Caucasian adults [10–13]. Data from the Asian regions are sparse and wanting. Hence it is important to derive information from the Asian community to develop an appropriate universal data set of gingival phenotypes.

The aim of this study, therefore, was to explore the gingival phenotype of healthy young adult Pakistanis attending a dental institution and how they may relate to clinical periodontal parameters. The opportunity was taken to compare our data with the currently available information on the phenotypes from different regions of the World.

2. Materials and methods

A cross-sectional study design was performed in 510 individuals between the ages of 20 and 35 who visited the outpatient department of Periodontics of the Muhammad Dental College, between January 2, 2023 to April 15, 2023, the approval for the study was obtained from the Institutional Review Board of Muhammad Dental College (Ref: no.: MDC/009/2023). The sample size (n) was calculated using the formula:

$$n = \frac{z^2 \text{ x } p \text{ x } [1 - p]}{e^2}$$

where;

z = 1.96 for a confidence level (α) of 95 %,

p = proportion (50 % expressed as a decimal 0.05),

e = margin of error (0.05)

Thus, n = 1.962 × 0.5 x (1–0.5) / 0.052 = 384.16 ≈ 385 385

However, total number of individuals included in the study was 510.

The inclusion criteria for the study were periodontally healthy individuals with complete attachment and having all the anterior teeth in the maxillary and mandibular arches. The exclusion criteria were subjects with orthodontic appliances, those with fillings or fixed prosthodontic restorations involving the incisal edge of their anterior maxillary teeth, those taking any medications that affect the periodontium, and those with clinical signs of periodontal disease, which was defined as moderate to severe gingivitis where moderate gingivitis denoted by redness, edema, and glazing, accompanied by bleeding upon probing, progressing to severe gingivitis characterized by pronounced redness and edema, ulceration with a tendency for spontaneous bleeding, and the presence of gingival pockets exceeding 3 mm in depth.

The study was based solely on clinical evaluations devoid of invasive procedures. The specifics of the clinical procedures were explained to all participants and their written consent was obtained prior to the study. Clinical examination and data gathering were done in the periodontics clinic, which adhered to standardized infection control procedures.

After taking the medical and dental histories to exclude relevant diseases, the following clinical periodontal parameters were recorded, namely the probing depth (PD), crown width/crown length ratio (CW/CL), papilla height (PH), gingival thickness (GT), and gingival width (GW). A highly trained, calibrated examiner used a UNC-15 periodontal probe as the primary tool for measuring each of these variables [14].

The distal, mid-facial, and mesial features of each central incisor was measured, and the mean recorded as PD. The central incisor CW/CL ratio was determined by measuring CL as the distance between the free gingival margin and the incisal edge of the crown, and CW taken as the mesiodistal width in most bulbous region of the incisor (Fig. 1A).

Then PH of both central incisors was assessed at their mesial and distal aspects (Fig. 1A). This parameter was the distance between the tip of the papilla and the imaginary line joining the mid-facial edge of two neighboring teeth [15]. Depending on the transparency of the UNC-15 periodontal probe, GT was assessed and classified as thick or thin at the site level (Fig. 1B–C) as described by Kan et al. [16]. GW was measured mid-facially by measuring the distance between the mucogingival margin and the free gingival margin (Fig. 1A). The mean values from both central incisors were taken as the reading for each of these parameters [17].

3. Statistics

The intra-examiner reproducibility of the foregoing procedure when evaluated in a pilot study in four different subjects, and assessed on two separate occasions, 24 hours apart, were reproducible ($p > 0.05$). The data were analyzed using the statistical package of social sciences (SPSS) through version 20 software. The chi-square test and the independent *t*-test were used to evaluate significant differences in the phenotypes. K-means clustering was utilized to elicit groups with various traits and the means of the three clusters were compared using a one-way ANOVA. The linear correlation between clinical periodontal parameters was assessed using Pearson's correlation. P values less than 0.05 were considered significant.

4. Results

Out of the 510 patients examined, 250 were male and 260 were female (Fig. 2), with an age range from 20 to 35 years. Our data indicated that approximately three-quarters (76 %) of the Pakistani cohort exhibited thick gingival phenotypes, with 189 males and 198 females in this category. Conversely, 24 % had thin gingival phenotypes, comprising 61 males and 62 females. Notably, the data indicated no significant gender-based disparity in the prevalence of gingival phenotypes.

Table 1 shows the periodontal clinical parameters in participants based on distinct gingival phenotypes. Significant differences in keratinized gingiva (GW), crown width/crown length (CW/CL) and probing depth (PD) between the thin and thick gingival phenotypes were noted ($p < 0.05$). Thus, the mean width of the keratinized gingiva (GW) of the incisors with a thin gingival phenotype was $3.99 + 1.18$ mm, in comparison to the thick gingival phenotype, which was $4.33 + 1.16$ mm ($p = 0.004$).

Furthermore, all clinical periodontal parameters including the keratinized gingiva (GW), probing depth (PD) and papillary height, and the crown width/length (CW/CL of the thick gingival phenotype group were significantly larger than that of the thin gingival phenotype group ($p < 0.05$), except for the papillary height.

The K- means clustering gingival phenotypes revealed three discrete clusters (C1, C2 and C3). In terms of the gingival thickness, C1 comprised 27.8 % of the samples with the thick gingival phenotype, and 12.9 % of the thin gingival phenotype. C2 comprised 23.5 % of the samples with the thick gingival phenotype, and 4.7 % of the thin gingival phenotypes. The C3 comprised 24.5 % of the samples with the thick gingival phenotype, and 6.4 % of the thin gingival phenotypes. This illustrates that the distribution of the thin and thick phenotypes differ significantly across the clusters ($p < 0.05$).

The periodontal clinical parameters including crown/width tooth morphology evaluated by K means clustering also revealed three clusters. A large proportion of our cohort fell into cluster C1 (40 %), which exhibited traits between the cluster C2 (28 %) with broad teeth, PH and wider GW, and the cluster C3 (31 %) with narrow teeth and short PH with considerable GW. All measured periodontal clinical parameters between these three clusters demonstrated significant differences ($p < 0.05$) (Table 2).

The Pearson correlation analysis performed to examine the relationship between each clinical parameter indicated that gingival width (GW) had significant correlations with PD, and PH with CW/CL and PD, respectively ($p < 0.05$) as shown in Table 3.

5. Discussion

The term periodontal phenotype was proposed by the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions (Jepsen et al., 2018) [18] to indicate the gingival phenotype (GP) and the bone morphotype. GP comprises two components, the gingival thickness (GT) and width of keratinized gingiva (GW). The practical value of the GP stems from the fact that its assessment should be part of the treatment planning and risk evaluation prior to dental interventions, including soft tissue manipulation, in the aesthetic zone, in particular.

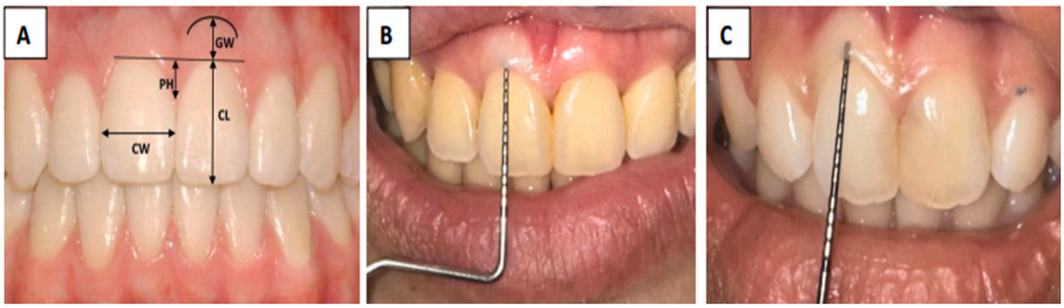

Fig. 1. (A) Dimensions of the gingival phenotypes as evaluated in the current study; Papillary height (PH), Gingival width (GW), Crown width (CW) and Crown length (CL). (B) a thick gingival phenotype, and (C) a thin phenotype.

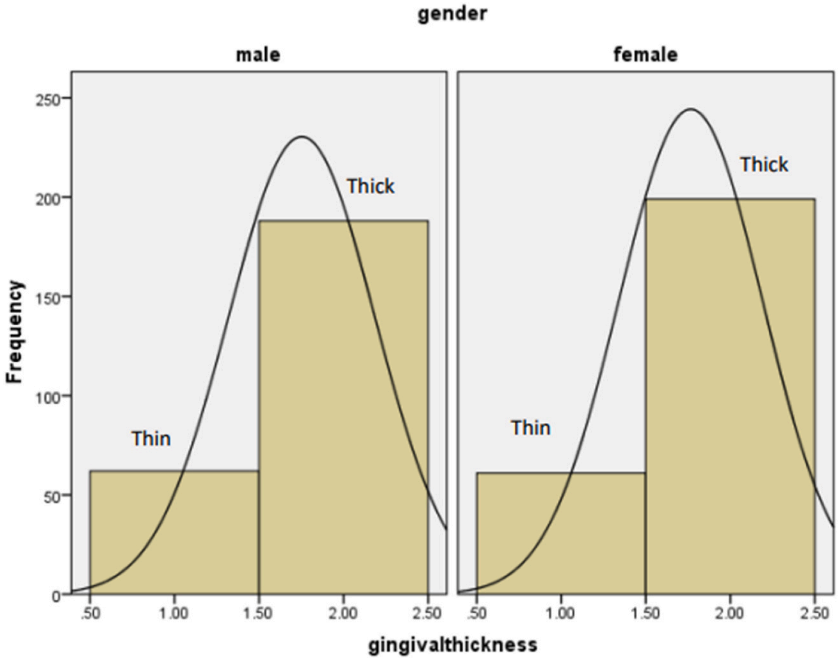

Fig. 2. Frequency of Gingival Phenotypes among genders.

Table 1
Comparison of periodontal clinical parameters between different gingival phenotypes.

Periodontal clinical parameters	Total (N = 510)		Gingival Phenotype				*P*-value[a]
			Thick (N = 387)		Thin (N = 123)		
	Mean	SD	Mean	SD	Mean	SD	
Probing Depth (PD)	2.64	0.64	2.67	0.62	2.53	0.69	0.017[a]
Crown Width/Crown Length (CW/CL)	0.78	0.05	0.79	0.05	0.77	0.04	0.014[a]
Gingival Width (GW)	4.25	1.17	4.33	1.16	3.99	1.18	0.004[a]
Papillary Height (PH)	5.45	1.04	5.47	1.03	5.41	1.05	0.606

[a] Independent *t*-Test, α = 0.05.

Table 2
K means cluster Analysis of the gingival phenotypes and clinical parameters.

Periodontal clinical parameters	Cluster 1 Mean	Cluster 2 Mean	Cluster 3 Mean	*P*-value
Number of Subjects (n, %)	208 (40 %)	144 (28 %)	158 (31 %)	–
Probing Depth (PD)	2.55	2.68	2.73	0.021[a]
Crown Width/Crown Length (CW/CL)	0.80	0.81	0.75	<0.001[a]
Gingival Width (GW)	3.26	5.56	4.37	<0.001[a]
Papillary Height (PH)	5.98	6.02	4.25	<0.001[a]
Thin Gingival Phenotype (n, %)	66 (12.9 %)	24 (4.7 %)	33 (6.4 %)	0.003[a]
Thick Gingival Phenotype (n, %)	142 (27.8 %)	120 (23.5 %)	125 (24.5 %)	

[a] ANOVA, α = 0.05.

Table 3
Pearson correlation among each of the evaluated clinical parameters.

Periodontal clinical parameters	PD	CW/CL	GW	PH
Probing Depth (PD)	–	−0.002	0.116[a]	−0.127[a]
Crown Width/Crown Length (CW/CL)	–	–	−0.001	0.465[a]
Gingival Width (GW)	–	–	–	−0.001

[a] Correlation is significant at p-value <0.05.

The clinical characteristics of healthy gingivae mirror the underlying periodontal architecture [19] so much so that its specific clinical features are intimately related to the subjacent anatomy, including the tooth itself. In clinical terms, individuals with thick phenotypes have a better success rate with immediate implants of anterior teeth [17,20]. On the other hand, gingival recession is common after implant therapy in individuals with thin phenotypes [21,22].

In addition, the fluctuations in gingival and bone architecture have a significant impact on outcomes particularly in treatment that require a good aesthetic outcome, such as full-coverage crown restorations. Hence, the gingival phenotype should be evaluated and identified at the beginning of a treatment plan for optimal results, and also to inform the patient his/her gingival phenotype for the sake of transparency.

Gingival thickness may be measured using a variety of techniques including direct manual measurement, probe transparency technique, ultrasonic devices, and cone-beam computed tomography scans. Inserting a periodontal probe into the gingival sulcus and examining the transparency is the popular, simple, straightforward method used by many investigators (Table 4). Hence, we selected this simple technique to assess the gingival phenotype as described in numerous previous reports. The target teeth were the central maxillary incisors because variances in gingival phenotypes are most visible in these teeth [10,15], in addition to easy of accessibility for measuring the gingival dimensions.

Our data tend to indicate that those with thick gingival phenotypes have broader band of keratinized gingiva, implying that these individuals have a relatively smaller likelihood of gingival recession in the event if tissue manipulation for periodontal surgical procedures.

The k-cluster analysis of our data indicated the cohort fell into three different clusters. A significant population of individuals with a thick gingival phenotype, characterized by a wider papilla between young adults included in this study belonged to Cluster 1.

Cluster 2, on the other hand, is characterized by a considerable number of thick gingival phenotype with a larger and shorter crown shape, a high papilla height, and a wider zone of keratinized gingiva. A study [13] discovered that participants with a thicker gingival phenotype had a more obvious quadratic tooth form and broader gingiva. However, we were unable to confirm this in our study.

Cluster 3 group which comprised slender tooth shape, small papilla height, and a considerable width of keratinized gingiva. This was similar to those described in previous studies [23–25] and fall into the category of the “thin scalloped phenotype” coined by Seibert and Lindhe [26]. However, based on our findings, only a small proportion of the young adults sampled in this study fall into this cluster.

Moreover, the Pearson correlation analysis between each gingival phenotype revealed significant negative correlation between keratinized gingiva (GW) and CW/CL PH ($p < 0.05$) which corroborates the studies of Stein et al. [27] and Ghazali et a [28].

A comprehensive survey of the literature showed, to date, there are 15 studies similar to ours on the gingival phenotype prevalence assessment from various geographic locales [11–13,23,24,29–38] (Table 4). Only one of these used an ultrasonic device, and another four used transgingival probing, whilst the remaining ten studies used probe visibility method which we utilized here. Hence, we believe that our data is comparable with most of the available studies. Moreover, the sample size in these studies varied from 31 to 800 (mean = 227) and our sample size of 510 is very representative of the majority of these studies. Furthermore, 11 of the 15 cohorts form disparate geographic regions exhibited the thick gingival phenotype as in our studies. Hence it is tempting to speculate that a majority of the human population worldwide is endowed with the thick, rather than the thin gingival phenotype.

The impact of various confounding elements, particularly those related to race and genetics, on the thickness of the gingival phenotype has been noted in recent research. For instance, Vanketesh et al. pointed out noticeable differences in the gingival thickness in the canine and premolar areas in Asians and Caucasians, suggesting that these disparities could be largely due to racial characteristics [39]. Therefore, it is important to develop a detailed understanding of how racial disparities impact gingival thickness and facial aesthetics, across different global regions.

Our study has some limitations. First, the sample was not randomized as a select group of individuals who attended a dental institution was chosen for the study. Second, although the patients had satisfactory oral hygiene, the age range was not representative of the Pakistani population in general. Lastly, a larger sample size from different regions of Pakistan would have generated better country specific data.

Thus, future workers in various jurisdictions should sample a broader swathe of the population to yield better representative data. In addition, it will be useful to compare the age specific data of populations as well. In clinical terms, a study of gingival phenotype and implant placement aesthetics in the various sub-groups will be of interest.

6. Conclusion

Taken together the current data indicate that our study population of healthy, young adult Pakistanis had differing gingival phenotypes and crown forms, with thick gingival phenotype predominating. These results are similar to reports from most other regions of the world. A minority, 24 % of individuals, had a thin translucent gingival phenotype and a low CW/CL ratio whereas those with wide keratinized gingiva had a high CW/CL ratio ($p < 0.05$). The evaluation of the gingival phenotype during treatment planning is crucial to achieve better treatment outcomes particularly for surgical maneuvers necessitating tissue manipulation in the aesthetic zones of the mouth.

Data availability statement

The data that supports the findings of this study are available from the corresponding author upon reasonable request.

Table 4
Comparison of the prevalence of Gingival Phenotypes in the current study and others in different geographic regions.

Reference	Number of Subjects	Country	Study Design	Thick Gingiva %	Thin Gingiva %	Assessment Method
Current Study	*510*	*Pakistan*	*Cross-sectional*	*76 %*	*24 %*	*Probe visibility*
Y. Shao et al. [29]	31	China	Cross-sectional	59.68 %	40.32 %	Probe visibility, Transginigval probing, CBCT
Y. Zhang et al. [30]	167	China	Cross-sectional	53 %	47 %	Probe visibility
F.A. da Costa et al. [31]	50	Brazil	Cross-sectional	43 %	57 %	Probe visibility
A. Joshi et al. [24]	800	India	Cross-sectional	45.8 %	54.1 %	Probe visibility
A. Peixoto et al. [32]	50	Portuguese	Cross-sectional	56 %	30 %	Probe visibility
O. Alkan et al. [33]	181	Turkey	Cross-sectional	70.2 %	29.8 %	Transginigival probing
D.R. Cook et al. [11]	60	United States	Cross-sectional	56.6 %	43.3 %	Probe visibility
S. Subedi et al. [34]	225	Nepal	Cross-sectional	55.11 %	44.89 %	Probe visibility
K.H. Zawawi et al. [35]	200	Saudi Arabia	Cross-sectional	55.5 %	44.45 %	Probes visibility
G. Matarese et al. [12]	76	Italy	Cross-sectional	56.6 %	43.4 %	Probe visibility
J. O. García-Cortés et al. [36]	550	Mexico	Cross-sectional	31.5 %	68.4 %	Probe visibility
M. Assiri et al. [37]	80	Saudi Arabia	Cross-sectional	51.2 %	48.8 %	Probe visibility
H. Barakat et al. [38]	500	Syria	Cross-sectional	58.4 %	41.6 %	Transginigival probing
H.P. Muller et al. [13]	42	Germany	Cross-sectional	33 %	77 %	Ultrasonic device

CRediT authorship contribution statement

Yousuf Moosa: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Lakshman Samaranayake:** Writing – review & editing, Visualization, Validation, Formal analysis. **Pagaporn Pantuwadee Pisarnturakit:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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