Original Article

A Novel Perspective for Predicting Gingival Biotype via Dentopapillary Measurements on Study Models in the Saudi Population: Cross-Sectional Study

RR Nagate, S Tikare, S Chaturvedi[1], NA AlQahtani, MA Kader, ST Gokhale

Departments of Periodontics and Community Dental Sciences and [1]Prosthetic Dentistry, College of Dentistry, King Khalid University, Abha, Saudi Arabia

Abstract

Background/Purpose: Gingival biotype (GB) is a crucial factor in predicting the success of soft tissue periodontal and peri-implant surgical interventions. Consequently, contemplating noninvasive, less time-consuming procedure to anticipate it has become a part and parcel of the current practice. This article presents a novel algorithm to detect GB in the Saudi population based on the dentopapillary measurements taken on laboratory models. In addition, it targets to allocate a range of values for thick and thin biotypes. **Materials and Methods:** Model analysis was done on 160 patients to measure eight gingival parameters, and an algorithm was developed according to the results of multiple and linear regression analyses. Applying the dentopapillary parameters to the algorithm revealed a prediction of the biotype. Finally, the resultant values and the exact thickness were reassessed directly in a sample of patients using a modified caliper. **Results:** The regression analysis revealed an algorithm predicting biotypes among patients based on their measured dentopapillary values. Discriminant analysis was used to allocate the values to thin and thick biotypes to further demystify that they coincide with <0.7 mm and >1.5 mm, respectively. However, gingival thickness between 0.7 and 1.5 mm was considered intermediate biotype. **Conclusion:** GB could be predicted based on the dentopapillary measurements taken on laboratory models, which may further reduce the chairside time and increase the success rate of the surgical procedures. Significant variations in the range of values of the thick and thin biotype were detected in the Saudi population compared to other races. **Clinical Significance:** The escalating invasion of interventional procedures in the dental practice necessitates measuring the GB as a predictor of procedure success. This study introduces an algorithm for detecting the GB and updates the range of values for thick and thin biotypes in the Saudi population that would consequently reduce chairside time.

Keywords: *Dentopapillary measurements, discriminant analysis, gingival biotype*

Date of Acceptance:
31-Oct-2018

Introduction

Aesthetic dentistry has gained significance over the last few decades with escalating expectations from patients on pleasing appearance, especially in the anterior maxillary region.[1] Gingival thickness (GT), also known as gingival biotype (GB), is decisive in upholding the periodontal health or dental aesthetics and function, and is also a predictor of periodontal, mucogingival, and peri-implant treatments.[2] Ochsenbein and Ross first depicted GB in 1969 as flat and highly

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_443_18

Address for correspondence: Dr. RR Nagate, Department of Periodontics and Community Dental Sciences, College of Dentistry, King Khalid University, Abha-61471, Saudi Arabia.
E-mail: rnagati@kku.edu.sa

How to cite this article: Nagate RR, Tikare S, Chaturvedi S, AlQahtani NA, Kader MA, Gokhale ST. A novel perspective for predicting gingival biotype via dentopapillary measurements on study models in the Saudi population: Cross-sectional study. Niger J Clin Pract 2019;22:56-62.

scalloped based on its anatomy.[3] Seibert and Lindhe in 1989 named it "periodontal biotype" and modified the previous classification to be either thick flat or delicate thin biotype.[4] GB depends on several factors such as race,[5,6] gender,[7] cervical convexity of the crown,[8] and the position of the alveolar crest.[9] In addition, it depends on its anatomical position; for instance, the GT is higher in the facial maxillary gingiva compared to the mandibular gingiva.[10] Similarly, canines and premolars have less GT compared to other teeth. Furthermore, GB increases from anterior backward in the mandibular and maxillary arches.[10,11]

GT is paramount in anticipating the outcomes of some procedures. For example, thin GT may lead to postoperative gingival recession and exposure of the root surface,[12] graft failure,[13] unpredictable postoperative soft tissue healing,[14] extensive bone resorption after tooth extraction, especially in apical and lingual directions,[14] exposure of restorative margins,[15] and mucogingival problems with various orthodontic treatments.[16] Affirmatively, the possibility of a gingival recession is even more associated with nonsurgical periodontal therapies in patients with thin GB.[17] On the other hand, thick GB areas show fewer incidences of gingival recession. Thus, before periodontal implantation or any mucogingival regenerative procedures, GT should be assessed to curtail the chances of procedure failure.[2]

For proper assessment, some methods have been aptly described, including probe transparency,[7] transgingival probing,[18] histological sections,[19] cone-beam computed tomography (CBCT),[20,21] ultrasonography,[11,18] modified caliper,[22] and visual assessment.[22] Little evidence has endorsed analyzing the relation between dental papillae and the GB.[23,24] Nonetheless, the aforementioned methods have some drawbacks such as invasiveness, subjective bias, massive cost of the procedures, and time consumption.[25] Accordingly, chairside or laboratory procedures, that are less time-consuming, minimally invasive, and cost-effective, are more likely to be efficacious. Alterations in GB with ethnic and racial changes were observed in Caucasian race by few authors.[5,6,26] Recently, in a pilot study, gingival profiles in Asian populations were assessed.[27] Differences in the gingival biotype was also observed in Korean young adults with other population.[28] However, evidence is lacking regarding GB variation among Saudi inhabitants, as well as comparison with other populations.

This study aims to recapitulate an algorithm based on which GB values can be anticipated in the Saudi population, whose GB would be reclassified via the dentopapillary assessment. The study hypothesizes that the novel algorithm predicts the GB accurately based on the dentopapillary complex analysis applied to laboratory models.

Materials and Methods

The current single-center cross-sectional observational study was conducted at the Department of Periodontology from March 2017 to March 2018. Patient recruitment was launched in January 2018 after obtaining ethical clearance from the Institutional Review Board (SRC/ETH/2016-17/038) and written informed consents from patients. The recruited patients were department visitors who were assessed strictly to conform to the inclusion and exclusion criteria; ultimately, a total of 160 subjects were enrolled, in a proportionate male-to-female ratio. Initial oral prophylaxis was given and oral hygiene instructions were given to enrolled patients. Impressions on the adopted models and clinical parameters were assessed for 1 week after ensuing the oral prophylaxis.

Inclusion criteria

Saudi nationals with plaque index (PI)[29] and gingival index (GI)[30] scores <1 in maxillary anterior teeth, and sound maxillary central incisors that were void of any fractures and restorations.

Exclusion criteria

Patients with missing permanent maxillary central incisor/s, spacing, crowding, gingival pigmentation, and those with proclined teeth, especially in maxillary anterior region, were excluded. In addition, patients with high frenal attachment, trauma, or any other pathologies in the maxillofacial region, history of orthodontic treatment in the past 6 months, and positive pregnancy status were also excluded. For habits of medical importance, those with a habit of smoking or mouth breathing, together with patients on previous or current antihypertensive, anticonvulsant, and immune-suppressant medications were all excluded.

Evaluation of variables

Laboratory measurements

For each patient, a diagnostic model was designed by pouring dental stone into an irreversible hydrocolloid impression (3M ESPE, Express STD Regular set heavy body VPS Impression Material) [Figure 1]. A special digital caliper (Derby, France) was used for the following measurements [Figure 2]:

a. Central incisor crown width (CW): the CW of both the central incisors was measured at the junction of the middle and cervical thirds of the labial portion of the tooth where teeth is approximate
b. Central incisor crown length (CL): the CL of both central incisors was measured from the free gingival margin, at the gingival zenith, and to the incisal edge; also known as crown height (CH)

c. Interdental papillary width (PW): the interdental papillary width, the width between the two central incisors, was measured via a line joining the gingival zeniths of these incisors
d. Interdental papillary height (PH): the PH was calculated from the base to the tip of the papillae between the approximated surfaces of the teeth
e. CW/CH: the ratio of the width of the crown to its height
f. Average crown area (ACA): the area of the crown was calculated as CH × CW for each tooth; afterward, an average was calculated
g. PW/PH: the ratio of papillary width to the papillary height
h. Papillary area (PA): an imaginary line joining the gingival zeniths forms the base, and a line from gingival zenith to the tip of the papilla forms the side of an imaginary triangle on both sides. Hence, the surface area of each papilla was calculated as 1/2 CW × CH assuming it is a triangle (1/2 base × height).

GT measurement by caliper method

Clinical measurements were recorded 1 week after administering the oral prophylaxis; the free marginal gingiva was measured using a special modified caliper [Figure 3] that had a calibration of 1/10th mm and a rounded sharp tip to make it tissue friendly. Also, the extension arms anticipated to go through the gingival sulcus were trimmed, and the tips of the periodontal probe were fused to make it slender and avoid complications associated with stretching. Finally, the spring was removed to make the caliper recalibrated and tension-free. At this point, the GT was measured by inserting an extension arm parallel to the long axis of central incisor and the second arm in contact with the labial aspect of gingiva without pressure [Figure 4]. Before inserting the caliper into the sulcus, the dentist checked for any evident obstructions.

Elimination of bias

Clinical and model-related measurements conformed to guidelines given to the examiners who were assigned the same 20 patients and models each to re-examine after 1 week. Intraexaminer reliability was assessed via Cohen's Kappa Coefficient Test that revealed to be 0.98 for gingival thickness score with r-value equaling 0.8 for GB assessment.

Assessment of sample size

A pilot study was done to decide the sample size. A correlation of (r = 0.3021) was found between GT and PA. The calculated sample size was n = 137. However, a sample size of 160 subjects was considered to minimize error and achieve 95% power, and a Level of significance was set at 5%.

Statistical analysis

Data were collected and entered into an MS Excel sheet and were further analyzed using STATA (9.2) software. The study variables were correlated with gingival thickness (GT) by Pearson's correlation analysis. Student's *t*-test was used to compare the mean scores of the various dentopapillary parameters according to gender. Further, multiple and stepwise regression analysis was performed for developing the equation for predicting GT based on study variables. Discriminant function analysis was performed to categorize group patients into thick or thin GB based on gingival thickness measurements ($P < 0.05$).

GT values from the algorithm were compared with GT values obtained using a modified caliper in 20 patients to check its validity.

Results

A total of 160 subjects (80 males and 80 females) were enrolled in the study, with age ranging from 18 to 35 years. Multiple linear regression analysis was performed with GT as the dependent variable, and the other eight gingival parameters as the independent variables. The CA and the PW/PH ratio was statistically significant only in the models (R^2 = 0.8075, F(8,151) = 79.220, $P < 0.05$) [Table 1]. Furthermore, stepwise multiple linear regression revealed six out of the eight parameters to be significantly associated with GT (R^2 = 0.8072, F(6,153) = 106.82, $P < 0.05$) [Table 2], and the following linear regression equation was applied:

Gingival thickness (Y) = 7.5546 − 0.5521 × ACH − 1.0740× ACW + 0.1095 × C-Area − 0.2841 × PH − 0.6174 × PW/PH + 0.0656 × P-Area.

Table 1: Multiple linear regression of gingival thickness by different parameters

Independent parameters	Regression coefficient	Standard error of regression coefficient	*t*	*P*-level
Intercept	12.491	12.78	0.977	0.33
ACH	−1.064	1.284	−0.828	0.408
ACW	−0.764	0.957	−0.798	0.425
ACW/ACH	−4.507	11.635	−0.387	0.699
C-Area	0.124	0.046	2.662	0.008*
PH	−0.254	0.158	−1.605	0.110
PW	0.032	0.117	0.274	0.784
PW/PH	−0.624	0.189	−3.293	0.001*
P-Area	0.051	0.06	0.857	0.392

*P<0.05; Correlation coefficient (R) = 0.8986; Coefficient of determination (R^2) = 0.8075; F(8,151) = 79.220; Significance (P) <0.05; Std. Error of estimate=0.16052; ACH=Average crown height; ACW=Average crown width; ACW/ACH=Average crown width/Average crown height; C-Area=Crown area; PH=Papillary height; PW=Papillary width; PW/PH=Papillary width/papillary height; P-Area=Papillary area

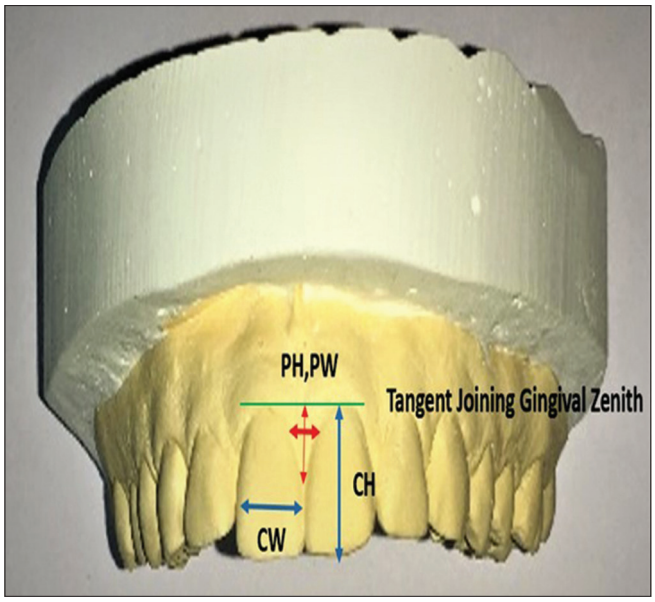

Figure 1: Illustrations showing the way to measure the dentopapillary parameters

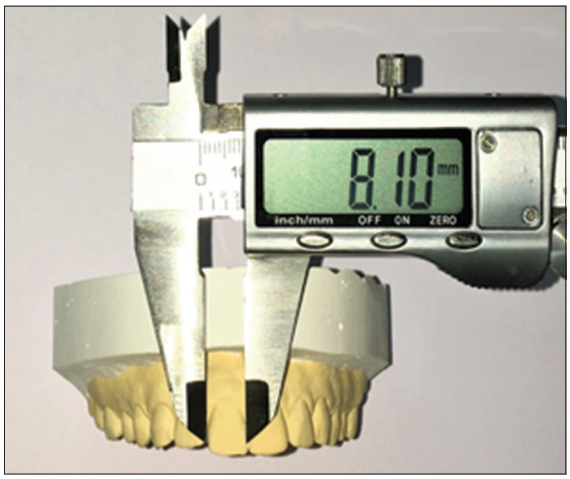

Figure 2: Measuring the dentopapillary parameters on the study models with digital caliper

Figure 3: Modified caliper with periodontal probe attachments

Figure 4: Measuring gingival thickness with the modified caliper

Table 2: Step-wise multiple linear regression with gingival thickness as dependent variable

Independent parameters	Regression coefficient	Standard error of regression coefficient	*t*	*P*-level
Intercept	7.554	3.189	2.368	0.019*
ACH	−0.552	0.300	−1.876	0.05*
ACW	−1.074	0.354	−3.031	0.002*
C-Area	0.109	0.034	3.222	0.001*
PH	−0.284	0.110	−2.578	0.01*
PW/PH	−0.617	0.187	−3.285	0.00*
P-Area	0.065	0.029	2.244	0.026*

*P<0.05; Correlation coefficient (R) = 0.8984; Coefficient of determination (R^2) = 0.8072; F(6,153) = 106.82; Significance (P) <0.05; Std. Error of estimate=0.15958; ACH=Average crown height; ACW=Average crown width; C-Area=Crown area; PH=Papillary height; PW/PH=Papillary width/papillary height; P-Area=Papillary area

On analyzing the data on the GB by discriminant function analysis, the equation for the canonical correlation coefficients was:

Discriminant function equation = 4.822 − 4.572 × gingival thickness in millimeters.

The centroid value for the thin biotype was −1.0680 and beyond, whereas that of the thick biotype was 1.8280 and beyond. These centroid values, when compared with actual gingival thickness measurements, deems the thin biotype coinciding with <0.7 mm, and the thick biotype coinciding with >1.5 mm, a gingival thickness between 0.7 and 1.5 mm as an intermediate biotype [Table 3]. Moreover, the GT revealed a statistically significant correlation (P < 0.05) compared to the other parameters considered in the study [Table 4]. Similarly, a strong positive correlation was observed with ACH, ACW, and CA, whereas the correlation was moderately negative with ACW/ACH ratio and PW/PH ratio [Table 4]. The

Table 3: Classification of biotype based on gingival thickness scores by discriminant function analysis

Biotype	Centroid value	Gingival thickness cut-off values
Thin	<−1.068	<0.7 mm
Intermediate	Between −1.068 to 1.828	0.8 to 1.5 mm
Thick	>1.828	>1.5 mm

Table 4: Correlation between gingival thickness with dentogingival measurements

	r	*t*	*P*
Gingival Thickness×ACH	0.885	23.954	0.001*
Gingival Thickness×ACW	0.856	20.878	0.001*
Gingival Thickness×ACW/ACH	−0.493	−7.137	0.001*
Gingival Thickness×C-Area	0.883	23.724	0.001*
Gingival Thickness×PH	0.531	7.876	0.001*
Gingival Thickness×PW	0.237	3.070	0.005*
Gingival Thickness×PW/PH	−0.532	−7.904	0.001*
Gingival Thickness×P-Area	0.510	7.454	0.001*

*P<0.05; ACH=Average crown height; ACW=Average crown width; ACW/ACH=Average crown width/Average crown height; C-Area=Crown area; PH=Papillary height; PW=Papillary width; PW/PH=Papillary width/papillary eight; P-Area=Papillary area

Table 5: Comparison of mean scores of various dentogingival measurements by gender

Parameters	Male		Female		*t*	*P*
	Mean	SD	Mean	SD		
Gingival thickness	0.95	0.37	0.95	0.34	0.110	0.912
ACH	9.91	0.79	9.88	0.66	0.300	0.764
ACW	8.39	0.56	8.32	0.48	0.901	0.368
ACW/ACH	0.85	0.02	0.84	0.02	1.650	0.109
C-Area	83.61	12.26	82.46	10.26	0.643	0.520
PH	3.82	1.16	4.09	0.95	−1.594	0.112
PW	4.39	0.40	4.12	0.61	3.298	0.001*
PW/PH	1.22	0.27	1.06	0.27	3.856	0.011
P-Area	8.56	3.26	8.53	2.68	0.067	0.946

*P<0.05; ACH=Average crown height; ACW=Average crown width; ACW/ACH=Average crown width/Average crown height; C-Area=Crown area; PH=Papillary height; PW=Papillary width; PW/PH=Papillary width/papillary height; P-Area=Papillary area; SD=Standard deviation

mean PW was significantly higher in males compared to females (P < 0.05), whereas the rest of the gingival parameters did not show any significant difference between both genders [Table 5].

Discussion

According to concurrent results, it is evident that the dentopapillary complex values on laboratory models can anticipate the GB. Furthermore, according to the depicted algorithm, chairside time for assessing GB can be reduced. The GB in the range of 0.7–1.5 mm is shown to be the average biotype in the Saudi population. GBs with <0.7 and >1.5 values could be taken as thin and thick biotypes, respectively.

In the current study, eight dental and gingival parameters were evaluated on the study models and compared with GT values measured by modified caliper, which revealed a significant association. These results are consistent with a previous study by Malhotra *et al*. (2013) that propped the role of dentopapillary assessment in GT detection in the Indian population.[23] This study assessed GT based on the transparency of the periodontal probe and compared that with five parameters assessed in the study models. Although gingival transparency is the gold standard for assessing the GB,[31] its sensitivity and specificity are still questionable.[22,32] Again, it may depend on the experience of the examiner.[33] Alves *et al*. (2018) reported that the transparency method can be accurate only if GT is > 0.6 mm and > 1.2 mm.[34] Hence, in the current study, the GT was measured with a modified caliper to crosscheck the values obtained from the algorithm.

Discriminant function analysis was applied in the current study to obtain the group centroid values for thin and thick biotypes. Regardless of the ambiguities associated with gingival transparency, it was, however, used in this study as a baseline classification for discriminant analysis due to the lack of appropriate classification. Previously, De Rouck *et al*. (2009) have attempted to distinguish the thin GB from the thick variant by assessing cluster analysis and the prevalence of the gingival parameters in each cluster. They endorsed that a cluster with quadratic teeth, broader keratinized tissue, and flat gingival margins may lead to thick gingival biotype; however, discrimination analysis was missing in this study.[35]

Similarly, discriminant analysis for dentopapillary parameters was assessed in Lee *et al*. (2013) in the Korean population in whom the PL was found to be a discriminant factor for determining the GB.[35] These results were further ratified by Mandaloy *et al*. (2016).[36] In the current study, results of the discriminant analysis were similar to the previously indicated studies.[36,37] Further, the analysis was used to allocate patients into thick or thin GBs based on the values obtained from the algorithm. Patients with <0.7 mm and >1.5 mm were grouped as thin and thick biotypes, respectively, while the remaining patients were allocated to the intermediate variety. Unlike these values, some previous studies[14,35] depicted the thin and thick variants to be ≤1.5 mm and ≥2 mm, respectively. This might be attributed to the precise tools used in the current study to measure GT, i.e., the novelty of the algorithm and the usage of a modified caliper. Changes in the range of thick and thin

GB in Saudi population can also be attributed to race and ethnicity-related deviations in GB. These observations could be ratified with previous studies[23,24,28] where GB was assessed in Indian and Korean population based on dentopapillary complex. Because racial dissimilarities in GB were observed by a few authors,[5,6,18] the current study was specifically conducted in the Saudi population. The current study results alarm the clinicians to keep the ranges of thick and thin biotypes of Saudi population in mind before attempting any periodontal or peri-implant procedures because the values are different from other populations.

Several authors have also observed the changes in the GB with gender.[24,38,39] Some liked the thicker biotype to the male gender and the thinner one to females. Similar results were observed by Joshi *et al*. (2017) and De Rouck *et al*. (2009). However, our study revealed no significant difference in GB between the genders.[24,35] Again, this might be due to substituting the previously used probe transparency and the radiographic methods[24] for the more sensitive modified caliper method in the current study.

Limitations of the study and future directions

The GB variations ensuing prosthetic restorations or restorative cement were not assessed in this study. The algorithm proposed in this study is applicable only to the Saudi population and particularly to adults; it may not be applicable in the pediatric dental care. A further multicenter study is also required to examine the GB variations with race, ethnicity, and age variations.

Conclusion

Despite the limitations, this study can draw the conclusion that gingival biotype is predictable using the dentopapillary complex parameters in models; in addition, it introduces a novel algorithm applicable in the Saudi population, which may further reduce the chair-side time to evaluate the GB. Group centroid values have shown thick and thin GBs in the Saudi population, and have illustrated different ranges compared to ranges seen in other population.

Acknowledgements

We would like to appreciate and acknowledge Dr. Shivaling Javali and Dr. Vijay Apparaju for their constant support in the statistical analysis and literature search.

Financial support and sponsorship

Research fund and other supports were provided by Maxillo-Facial Research Centre, College of Dentistry, King Khalid University, Saudi Arabia. Reference number: MRMC-01-017-010.

Conflicts of interest

There are no conflicts of interest.

References

1. Laney WR. The emphasis on esthetics. Int J Oral Maxillofac Implants 2001;16:625.
2. Baldi C, Pini-Prato G, Pagliaro U, Nieri M, Saletta D, Muzzi L, *et al*. Coronally advanced flap procedure for root coverage. Is flap thickness a relevant predictor to achieve root coverage? A 19-case series. J Periodontol 1999;70:1077-84.
3. Ochsenbein C, Ross S. A reevaluation of osseous surgery. Dent Clin North Am 1969;13:87-102.
4. Seibert J, Lindhe J. Esthetics and periodontal therapy. In: Textbook of Clinical Periodontology. Copenhagen: Munksgaard; 1989. p. 477-514.
5. Müller HP, Heinecke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. J Clin Periodontol 2000;27:621-6.
6. Lee SA, Kim AC, Prusa LA, Kao RT. Characterization of dental anatomy and gingival biotype in Asian populations. J Calif Dent Assoc 2013;41:31-3, 36-9.
7. 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;36:428-33.
8. Morris ML. The position of the margin of the gingiva. Oral Surg Oral Med Oral Pathol 1958;11:969-84.
9. Kois JC. Predictable single tooth peri-implant esthetics: Five diagnostic keys. Compend Contin Educ Dent Jamesburg NJ 1995 2001;22:199-206; quiz 208.
10. Goaslind GD, Robertson PB, Mahan CJ, Morrison WW, Olson JV. Thickness of facial gingiva. J Periodontol 1977;48:768-71.
11. Eger T, Müller HP, Heinecke A. Ultrasonic determination of gingival thickness. Subject variation and influence of tooth type and clinical features. J Clin Periodontol 1996;23:839-45.
12. Hwang D, Wang H-L. Flap thickness as a predictor of root coverage: A systematic review. J Periodontol 2006;77:1625-34.
13. Kim DM, Neiva R. Periodontal soft tissue non-root coverage procedures: A systematic review from the AAP Regeneration Workshop. J Periodontol 2015;86(2 Suppl):S56-72.
14. Kao RT, Fagan MC, Conte GJ. Thick vs. thin gingival biotypes: A key determinant in treatment planning for dental implants. J Calif Dent Assoc 2008;36:193-8.
15. Mallikarjuna DM, Shetty MS, Fernandes AK, Mallikarjuna R, Iyer K. Gingival biotype and its importance in restorative dentistry: A pilot study. J Interdiscip Dent 2016;6:116-20.
16. Wennström JL, Lindhe J, Sinclair F, Thilander B. Some periodontal tissue reactions to orthodontic tooth movement in monkeys. J Clin Periodontol 1987;14:121-9.
17. Claffey N, Shanley D. Relationship of gingival thickness and bleeding to loss of probing attachment in shallow sites following nonsurgical periodontal therapy. J Clin Periodontol 1986;13:654-7.
18. Savitha B, Vandana KL. Comparative assesment of gingival thickness using transgingival probing and ultrasonographic method. Indian J Dent Res 2005;16:135-9.
19. Gonçalves Motta SH, Ferreira Camacho MP, Quintela DC, Santana RB. Relationship between clinical and histologic periodontal biotypes in humans. Int J Periodontics Restorative Dent 2017;37:737-41.
20. Amid R, Mirakhori M, Safi Y, Kadkhodazadeh M, Namdari M.

Assessment of gingival biotype and facial hard/soft tissue dimensions in the maxillary anterior teeth region using cone beam computed tomography. Arch Oral Biol 2017;79:1-6.

21. Nikiforidou M, Tsalikis L, Angelopoulos C, Menexes G, Vouros I, Konstantinides A. Classification of periodontal biotypes with the use of CBCT. A cross-sectional study. Clin Oral Investig 2016;20:2061-71.
22. Kan JYK, Morimoto T, Rungcharassaeng K, Roe P, Smith DH. Gingival biotype assessment in the esthetic zone: Visual versus direct measurement. Int J Periodontics Restorative Dent 2010;30:237-43.
23. Malhotra R, Grover V, Bhardwaj A, Mohindra K. Analysis of the gingival biotype based on the measurement of the dentopapillary complex. J Indian Soc Periodontol 2014;18:43-7.
24. 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 JCDR 2017;11:ZC40-5.
25. Esfahrood ZR, Kadkhodazadeh M, Talebi Ardakani MR. Gingival biotype: A review. Gen Dent 2013;61:14-7.
26. Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol 1999;26:153-7.
27. Lee WZ, Ong MMA, Yeo AB-K. Gingival profiles in a select Asian cohort: A pilot study. J Investig Clin Dent 2018;9.
28. Lee S-P, Kim T-I, Kim H-K, Shon W-J, Park Y-S. Discriminant analysis for the thin periodontal biotype based on the data acquired from three-dimensional virtual models of Korean young adults. J Periodontol 2013;84:1638-45.
29. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. Acta Odontol Scand 1963;21:533-51.
30. Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condtion. Acta Odontol Scand 1964;22:121-35.
31. Frost NA, Mealey BL, Jones AA, Huynh-Ba G. Periodontal biotype: Gingival thickness as it relates to probe visibility and buccal plate thickness. J Periodontol 2015;86:1141-9.
32. Zweers J, Thomas RZ, Slot DE, Weisgold AS, Van der Weijden FG. Characteristics of periodontal biotype, its dimensions, associations and prevalence: A systematic review. J Clin Periodontol 2014;41:958-71.
33. Eghbali A, Rouck TD, Bruyn HD, Cosyn J. The gingival biotype assessed by experienced and inexperienced clinicians. J Clin Periodontol 2009;36:958-63.
34. Alves PHM, Alves TCLP, Pegoraro TA, Costa YM, Bonfante EA, de Almeida ALPF. Measurement properties of gingival biotype evaluation methods. Clin Implant Dent Relat Res 2018;20:280-4.
35. Lee SP, Kim TI, Kim HK, Shon WJ, Park YS. Discriminant analysis for the thin periodontal biotype based on the data acquired from three-dimensional virtual models of Korean young adults. J Periodontol 2013; 84:1638-45.
36. Mandaloy A, Sridhar R, Singh A, Shirahatti R. Papilla height as an objective parameter to measure gingival biotype (TJD v4n2a4). Savvy Publ [Internet]. Available from: http://savvysciencepublisher.com/downloads/tjdv4n2a4/. [Last accessed on 2018 Jun 27].
37. 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;36:428-33.
38. Anand V, Govila V, Gulati M. Correlation of gingival tissue biotypes with gender and tooth morphology: A randomized clinical study. Indian J Dent 2012;3:190-5.
39. Handelman CS, Eltink AP, BeGole E. Quantitative measures of gingival recession and the influence of gender, race, and attrition. Prog Orthod [Internet] 2018;19. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5787531/. [Last accessed on 2018 Jun 21].