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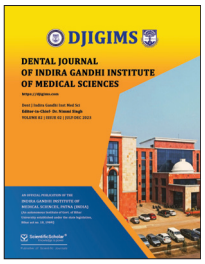

Original Article

Using a Conventional Steel Probe and a Plastic Colour-Coded Probe to Distinguish between Thin and Thick Gingival Phenotypes, Compare the Diagnostic Accuracy of the Two Transparency Methods: A Cross-Sectional Study

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Received: 06 July 2024

Accepted: 29 July 2024

EPub Ahead of Print:
04 September 2024

Published: 23 September 2024

DOI
10.25259/DJIGIMS_15_2024

Quick Response Code

ABSTRACT

Objectives: The cross-sectional study to evaluate the ability to categorize gingival phenotype according to gingival thickness (GT) using colored periodontal probes (CPP) and a traditional steel probe (SP).

Material and Methods: A total of 150 patients (n = 900) had three anterior teeth examined; the buccal GT in those teeth was assessed by transgingival sounds and categorized using two distinct methods. Specifically, it assessed diagnostic reasons for how well a standard periodontal probe (SPP) could differentiate between thin and thick gingiva, and a CPP could distinguish between medium, thick, and extremely thick gingiva. GT was assessed using transgingival evaluation at a distance of 2 mm from the gingival edge. Based on corresponding GT, thin and thick phenotypes were identified as being ≤1 mm and >1 mm, respectively. Using the transparency approach, the gingival phenotype was ascertained using SPP and a color-coded probe (CCP). Furthermore, keratinized tissue width (KTW) was assessed. Thin and thick gingival phenotypes were identified using experimental periodontal probes, and their diagnostic accuracy was compared.

Results: Nine hundred gingival sites were analyzed, transgingival technique classified 40% (n = 360) thin phenotypes (GT: 0.78 ± 0.12 mm, 3.52 ± 1.11 mm) and 60% (n = 540) thick phenotypes (GT: 1.22 ± 0.28 mm, 4.61 ± 1.1 mm). Similar diagnostic accuracy values of 0.69 and 0.70 were recorded for the SPP and CCP, respectively.

Conclusion: Identification of gingival phenotype maxillary anterior tooth achieved with comparable efficacy both color-coded plastic probe and SP.

Keywords: Diagnosis, Gingiva, Phenotype, Biotype, Sensitivity, Specificity

INTRODUCTION

Most patients want prosthetic restorations that are functional and aesthetically pleasing, and the peri-implant and periodontal phenotypes are crucial parameters. [1,2] Gingival phenotype, which is composed of keratinized tissue width (KTW) and gingival thickness (GT). A peri-implant phenotype is made up of supracrestal tissue height, keratinized mucosa width, and peri-implant bone thickness. Results of several clinical procedures, including surgical ones involving natural teeth and dental implants, are influenced by GT and mucosal thickness, respectively. For example, following mucogingival surgery, a lower rate of full root coverage is linked to thinner gingiva as opposed to thicker gingiva.[3–5] Therefore, it is critical to measure GT, the thickness of

the mucosa surrounding dental implants and natural teeth, to accurately analyze research findings and plan therapy in clinical settings.[1,2,4]

Much literature describes several GT assessment and classification techniques. A standard periodontal probe (SPP) is typically inserted into the gingival sulcus of the tooth in the midfacial aspect. [3] Gingiva is classified as 'thin' if SPP is visible or shining through tissue and 'thick' if the probe is not visible through gingival tissue.[2,6] The Probe transparency approach does, however, have a subjective component. In a prior study, three evaluators were able to reach perfect agreement in 80% of cases for classifying GT, thin or thick with SPP.[4] Other techniques include visual judgment or transgingival sound, either significantly more difficult to use or extremely inaccurate[3] or intrusive.[4]

Transparency technique, which evaluates gingival morphology using steel and color-coded probes (CCPs), has not yet been the subject of a clinical trial aimed at determining its diagnostic accuracy in India; that is, neglecting thin and thick GT values as outlined in the 2017 World Workshop Classification.[1,7] Moreover, few research assess GT and KTW for incorporating them in classifications. This study evaluated the diagnostic accuracy of two transparency techniques using steel and plastic CCP to differentiate between thin and thick gingival phenotypes. The study evaluated the null hypothesis (H0), which states steel periodontal and CCPs have comparable diagnostic accuracy when it comes to identifying gingival phenotype.

MATERIAL AND METHODS

Study population

The cross-sectional study was conducted in the Department of Periodontology at KVG Dental College & Hospital and evaluated the diagnostic accuracy of 150 patients undergoing dental therapy. The Institutional Ethics Committee approved this study, and it followed the guidelines provided by the Helsinki Declaration. Sample size calculation was conducted using software,* taking into account the space beneath the receiver operating characteristic curve (ROC) value (AUC), previously reported by Frost *et al.*,[5] for the steel probe (SP), using a threshold of 1 mm to differentiate thin and thick phenotypes (AUC = 0.60). Study subjects were at least 18 years old and possessed all three types of maxillary anterior teeth (canines, lateral incisors, and central incisors). Patients who exhibited periodontitis,[6] gingival enlargement, gingival recession, severe gingival melanin pigmentation, restorations involving the cervical third of tooth crown, pregnancy, use of medications that may cause gingival overgrowth, previous periodontal surgical treatment, including clinical crown lengthening, root coverage and any other soft tissue procedure at the study sites[8] were excluded from this study. All eligible participants were asked to sign a written informed consent form after being made aware of the study's goals, risks, and advantages. Additionally, demographic data on age and gender were gathered.

Gingival phenotype assessment

Central, lateral, and canine anterior teeth of the maxillary jaw were all clinically assessed for gingival phenotype at the mid-buccal aspect. The gingival phenotype was determined by probe transparency using SPP and CCP, GT as determined by the transgingival technique, and KTW (it was measured in the distance in millimeters from the gingival margin to the mucogingival junction) were the clinical parameters examined.

GT by transgingival method

GT was assessed via transgingival sounding at each included tooth. Following local anesthetic gel, an endodontic file (ISO 20) mounted with a silicon stop was inserted perpendicularly into the buccal aspect of the gingiva 1 mm below the gingival margin, touching the tooth surface; insertion depth was ensured by placing the silicon stopper in contact with the gingiva and using flowable composite to secure it in place. After the endodontic file was removed, insertion depth was measured, and a ruler image was captured.

Gingival phenotype by transparency method

Using the following probes, the gingival phenotype was clinically determined using the transparency method:

1. *Steel probe*: A black-marked SSP will be placed in the gingival sulcus, and the gingival margin will be used to gauge the probe's transparency. Depending on SP, if visible or not through gingiva, the site will be classified as thin or thick.
2. *Colour-coded probe*: Gingival sulcus will be used to insert the probe with plastic tips that are white, green, and blue. The gingival margin will be utilized to measure the transparency of the probe. Depending on whether tips were visible or not through the gingiva, the site will be categorized as thin, medium, thick, or very thick. Thin–white tip will be easily noticeable. Medium white will not be recognized, but the green tip will be apparent. The thick–blue tip will be seen through the gingiva, but white and green are not made clear through the gingiva. Very thick – you won't be able to see any of the tips through the gingiva. The following sequence will be followed for all clinical evaluations: first, SP will be used to evaluate all maxillary anterior teeth, and then CCP (white, green,

and blue tips) will be used. Following the evaluation of the gingival phenotype, GT will be evaluated while under topical anesthetic.

Statistical analysis

For each variable, mean, standard deviation (SD), median, and interquartile (IQ) range were determined. All variables, except for KTW and AG (Kolmogorov-Smirnov test), were regularly distributed. Using the transparency approaches, the interval of GT, KTW, and AG that matched the phenotype detected by the two probes was found.

One-way analysis of variance (ANOVA) and Tukey post hoc test were used to assess the differences in GT between the tooth groups that were discovered by the transgingival technique. A 95% confidence interval (95% CI) was obtained using Spearman correlation to evaluate the strength of the connection between KTW and GT. Corresponding phenotypes found by the SP and CCP transparency methods and the GT intervals found by the transgingival approach were compared using one-way ANOVA and the Tukey post hoc test.

Furthermore, for KTW and AG intervals, the Kruskal-Wallis and Dunn post hoc tests were used to compare the transgingival SP and CCP transparency approaches. Using the transgingival approach as a standard (thin ≤1 mm/thick >1 mm), the transparency methods' diagnostic accuracy was determined. AUC and 95% CIs were computed for the following: positive and negative predictive values; accuracy (ability to identify the correct phenotype); specificity (ability to classify GT >1 mm, i.e., results for green and blue tips of the CCP were included for analysis); and sensitivity accuracy (i.e., ability to identify correct thin phenotype, i.e., GT ≤1 mm). A significant threshold of $p < 0.05$ was established. Two pieces of software were used for all statistical analyses [Table 1].

RESULTS

Out of the 150 people assessed, 150 patients – 55 females and 95 males – with a mean age of 28 years (SD was 11.5), who met the study's eligibility requirements) were added to the examination. Of the participants, 100% were classified as Asian. Nine hundred teeth were analyzed, including 300 teeth from each of the three anterior tooth regions – canines (C), lateral incisors (LI), and central incisors (CI) [Table 2].

GT by transgingival method

Mean values for GT using the transgingival method are described in Table 1. The mean GT was 1.02 mm (SD was 0.2). Nine hundred gingival sites were evaluated; 40% (number = 360) were thin (GT: 0.78 ± 0.12 mm), and 60% (number = 540) had thick phenotypes (GT: 1.22 ± 0.28 mm). Gingiva is significantly thicker in the central incisor region than in the lateral incisor and canine regions ($p < 0.05$).

Keratinized tissue width

The mean values of KTW are shown in Table 1. Overall mean KTW was 4.09 mm (SD was 1.26). The thick gingival phenotype exhibited significantly wider KTW (4.61 ± 1.1 mm)

Table 1: GT assessed by the transgingival method, KTW, and absolute frequency of thin or thick gingival phenotypes according to teeth groups

Clinical parameters	Central incisor (n = 300)	Lateral incisor (n = 300)	Canine (n = 300)	Overall (n = 900)
Gingival thickness (mm, SD)	1.22 ± 0.28	0.95 ± 0.19	0.90 ± 0.19	1.02 ± 0.22
Thin/thick phenotype (%)	132/168	186/114	198/102	172/128
KTW (mm,SD)	4.61 ± 1.1	4.16 ± 1.3	3.52 ± 1.12	4.09 ± 1.17

Different symbols show statistically significant differences between tooth groups. GT: gingival thickness, KTW: keratinized tissue width, SD: standard deviation, Thick: >1 mm; Thin: ≤1 mm.

Table 2: GT, KTW, and AG for the transgingival method as well as for the transparency methods using steel and color-coded probes

Clinical parameters	Transgingival	Transgingival	Steel probe	Steel probe	Colour-coded probe	Colour-coded probe	Colour-coded probe
	Thin (n = 172) Mean ± SD	Thick (n = 128) Mean ± SD	Thin (n = 172) Mean ± SD	Thick (n = 54) Mean ± SD	Thin (n = 172) Mean ± SD	Medium (n =54) Mean ± SD	Thick (n = 54) Mean ± SD
GT (mm)	0.78 ± 0.12	1.16 ± 0.12	0.90 ± 0.18	1.15 ± 0.16	0.92 ± 0.15	1.1 ± 0.14	1.3 ± 0.16
KTW (mm)	4 ± 1.1	4.2 ± 1.3	4 ± 1.3	4.6 ± 1.1	4 ± 1.2	4.4 ± 1	5.0 ± 1.1
AG (mm^2)	3.12 ± 1.2	4.8 ± 1.4	3.6 ± 1.3	5.2 ± 1.4	3.6 ± 1.2	4.84 ± 1.6	6.5 ± 1.5

Mean (SD) and median [IQ range]; AG: area of the gingiva; GT: gingival thickness; KTW: keratinized tissue width; SD: standard deviation.

Table 3: Diagnostic accuracy tests of the transparency methods (steel and color-coded probes) compared to the transgingival method (reference-standard) to diagnose gingival phenotypes

Probe	Thin phenotype ≤1 mm	Thin phenotype >1 mm	Not thin phenotype ≤1 mm	Not thin phenotype >1 mm	Sensitivity	Specificity	Accuracy	PPV	NPV	AUC (95%CI)
Steel probe	285	352	196	67	0.948	0.352	0.693	0.663	0.833	0.650 (0.593–0.704)
Color-coded	280	350	193	77	0.942	0.391	0.707	0.675	0.833	0.666 (0.610–0.719)
	TP	FP	TN	FN						

95% CI: confidence interval, AUC: area under the ROC curve, FN: false negative, FP: false positive, NPV: negative predictive value, PPV: positive predictive value, TN: true negative, TP: true positive, *Green/blue (n)-45/5, *color of the probe.

than the thin phenotype (3.52 ± 1.11mm). Among tooth groups, it was found that KTW is significantly wider at the central incisor, followed by the lateral incisor and canine. There is a weak correlation between KTW and GT (r = 0.196; p <0.001).

Gingival phenotype by transparency methods

Table 2 describes the mean GT and KTW of each transparency method. The transparency method using SP identified 78.9% of sites as thick and 21.05% as thin phenotypes, whereas CCP identified 78.1% as thick, 18.18 % as medium, and 11.3% as thin phenotypes. A very thick phenotype was not observed in any patient.

Transgingival versus transparency probe methods

Table 2 shows the mean (SD) GT, KTW, and AG for each evaluation method for the identification of gingival phenotype. Thick phenotype sites diagnosed by both transparency methods showed equal GT mean values (SP: 1.22 ± 0.28 and CCP: 1.22 ± 0.28) greater than the mean value found for the transgingival method (0.78 ± 0.12).

Steel or colour-coded probe diagnostic accuracy

Table 3 illustrates the diagnostic accuracy of color-coded SPs in comparison to the transgingival approach. The predictive value, specificity and sensitivity of both transparency methods to identify different phenotypes were similar. Diagnostic accuracy and ROC curve values of SP and CCP methods were also similar. Values showed that both transparency methods (SP and white-colored probe) were highly sensitive (≥0.94) to identifying thin phenotype; however, it was poorly specific (0.352–0.391) to diagnosing thick phenotype [Table 2].

Post hoc power analyses

This investigation involved 900 teeth, of which 360 were considered as thin phenotype and 540 using transgingival technique as a thick phenotype. Original power analysis was calculated anticipating an AUC of 0.6 for SP in relation to transgingival assessment; however, the observed AUC was 0.65. Based on the findings, a post hoc power analysis was performed, and a 99.6% power was observed for study objectives [Table 3].

DISCUSSION

Researchers and medical professionals have used a variety of techniques to gauge gingiva thickness, which is crucial given their application in several treatment approaches for the resolution of mucogingival issues.

A bulk of the very few clinical trials conducted in this field, according to the literature search, have examined the thickness of masticatory mucosa on the palatal aspect, with a consideration that few of the therapeutic modalities utilize donor palatal tissue to address mucogingival issues. The accuracy of two distinct transparency approaches, which used steel and CCPs, respectively, to discern between thick and thin gingival characteristics, was examined in this study. Similar diagnostic accuracy was demonstrated by the transparency methods, which were quite sensitive in identifying thin phenotype but not very specific in identifying thick phenotype.

There isn't much research evaluating the transparency method's accuracy. Doctors most often employ this technique to diagnose gingival phenotype.

Non-invasive techniques include cone beam computed tomography and the use of ultrasonic devices to measure these characteristics. Patients can feel more at ease using a previous approach, but authors encountered difficulties consistently getting trustworthy findings.[5,6] With this approach, which uses CBCT, where measurements of the sizes and connections between these structures are possible, a high-quality image of both soft and hard tissue is revealed. However, CBCT pictures of normal and inflammatory gingiva are identical and cannot distinguish between the two.

An additional technique that has been employed is transgingival sounding using a periodontal probe; however, because it is intrusive and requires infiltration of local anesthetic, this approach appears to be uncomfortable for the patient.[8,9]

This study showed similar diagnostic accuracy for both SP and CCP (0.69 and 0.7, respectively) in diagnosing thin phenotypes. Frost *et al.*,[5] in contrast, assessed the accuracy of SP using various GT thresholds and found that when GT was 0.8 mm, SP had a greater accuracy (0.67), but when GT was 1 mm, SP had a lower accuracy (0.43). According to the authors, there isn't a particular GT for probe invisibility. The disparities noted in the research mentioned above could be attributed to an inconsistent approach and the absence of standardization of the separation between gingival margin and measurement.[10–17] While the transparency approach was examined using standardized pictures by Bossuyt PM *et al.*[6] which might not accurately reflect day-to-day clinical practice, assessment in the current investigation was carried out by seeing probes clinically. Transgingival technique classified 40% (n = 360) as thin phenotypes (GT: 0.78 ± 0.12 mm, 3.52 ± 1.11mm) and 60% (n = 540) as phenotypes that are thick (GT: 1.22 ± 0.28 mm, 4.61 ± 1.1 mm). Similar diagnostic accuracy values of 0.69 and 0.70 were recorded for SP and CCP, respectively. The transparency of the probe approach appears to be a successful and non-invasive technique for the evaluation of the thickness of soft tissue and diagnosis of phenotype, as shown by the high sensitivity of SP and CCP. It is crucial to remember that since KTW is not evaluated by any technique used to evaluate GT, it is unable to categorize gingival phenotype. It might also be argued that because of the amount of collagen in connective tissue, KTW might potentially have impacted how the probe is visualized through transparency. Among tooth groups, it was found that KTW was significantly wider at the central incisor, followed by the lateral incisor and canine. There is a weak correlation between KTW and GT ($r = 0.196$; $p < 0.001$). Recently, Barootchi *et al.*[18] suggested that KTW and GT may similarly influence the position of the gingival margin; they could be independent of each other. Further studies are needed to assess the importance of the relationship between GT and KTW or the superiority of one over another. Medium gingival phenotype with heterogeneous GT values documented in literature has been proposed by a few investigations[15] conducted in previous years. Fischer *et al.*[16] found GT values for medium phenotype ranging from 0.58 to 0.81 mm, identified by transgingival method, while Aslan *et al.*[15] suggested 0.83–1.07 mm using CBCT assessment. However, Kloukos *et al.*[9] found significantly lower values ranging from 0.54 to 0.62 mm for medium phenotype at mandibular central incisor sites, whereas a different study[8,9] found a cutoff value of 0.85 mm. However, no significant differences were found between medium, thick, or very thick phenotypes in terms of complete root coverage, suggesting similar treatment results. Data obtained from this study demonstrated that there was no significant difference in GT of sites diagnosed as medium compared to thick phenotypes. Several limitations were taken into account when interpreting this study's findings. The transparency approach considered gingival sulcus thickness, whereas the transgingival approach measured gingival margin thickness 2 mm apically. Angle changes may interfere with GT even if the needle is put perpendicular to the tooth surface during transgingival evaluation. Another potential limitation was that measurement was performed by a single examiner. Similar to the visual method, the assessment of gingival phenotype by the transparency method can be considered subjective. The order in which evaluations were conducted and intervals between probes can have an impact on outcomes.

CONCLUSION

It's imperative to comprehend the function of gingival and periodontal phenotypes, since periodontists collaborate closely with orthodontists and restorative dentists to supply a solid foundation for orthodontics, dental implant and restorative procedures. For identification of gingival phenotypic near the front teeth region of the maxilla, colour-coded and steel periodontal probes work equally well.

Ethical approval

The research/study was approved by the Institutional Ethics Committee, number IECKVGDCH/PG08/2023-24, dated: 23.05.23.

Conflicts of interest

There are no conflicts of interest.

Declaration patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of AI-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: MM D, H P, G PPP, H S. Using a Conventional Steel Probe and a Plastic Colour-Coded Probe to Distinguish between Thin and Thick Gingival Phenotypes, Compare the Diagnostic Accuracy of the Two Transparency Methods: A Cross-Sectional Study. Dent J Indira Gandhi Int Med Sci. 2024;3:72-7. doi: 10.25259/DJIGIMS_15_2024