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CLINICAL RESEARCH

Comparison of different methods used in the classification of maxillary gingival phenotype: A diagnostic accuracy study

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Abstract

Aims: This study aimed to evaluate the reliability and applicability of novel methods for determining gingival phenotypes and compare them with currently recommended methods.

Methods: Six maxillary anterior teeth from 50 systemically and periodontally healthy patients were evaluated using two conventional methods (periodontal probe translucency method [PP] and transgingival measurement with an endodontic file [EF]), and two novel methods (colored biotype probe translucency method [CBP] and transgingival measurement with a Florida probe [FP]). All data were statistically analyzed. Intra-examiner reproducibility and inter-examiner reproducibility for all methods were analyzed using 10 randomly selected patients who were re-evaluated for each analysis.

Results: Moderate agreement was found between EF and PP, with statistically significant differences between median gingival thickness (GT) values for thick 0.8 mm (0.5–1.1 mm) and thin 1 mm (0.6–1.7 mm) phenotypes, and a threshold GT value of ≤0.92 mm ($p < .001$). FP and PP also showed moderate agreement, with statistically significant differences between median GT values for thick and thin phenotypes (0.80 mm [0.40–1.60 mm] and 0.89 mm [0.40–1.60 mm], respectively), and a threshold GT value of ≤0.8 mm ($p < .001$). PP and CBP values showed a substantial agreement ($p < .001$). A statistically significant difference was found between median EF values and CBP categories ($p < .001$); however, paired comparisons showed that the distinction was applicable only between thin and other phenotypes.

Conclusion: Although CBP was found to be successful in detecting the thin phenotype, it was not successful in distinguishing between medium, thick, and very thick phenotypes; moreover, it did not appear to offer any advantages over PP. Although FP may be preferable to EF in measuring gingival thickness, the cost of FP is a disadvantage.

KEYWORDS
gingiva, gingival thickness, methods, phenotype, transgingival probing, transparency of probe

1 | INTRODUCTION

Gingival phenotype refers to a three-dimensional classification of buccolingual gingival thickness (GT) and keratinized tissue width.[1,2] GT is one of the important aspects in determining the long-term success of periodontal and implant treatment in terms of aesthetics and function. The need for connective tissue grafts in flap procedures for root coverage may vary depending on the initial thickness of the soft tissue.[3] Additionally, the success of implants in aesthetically sensitive areas is significantly influenced by the management and thickness of the soft tissue.[4,5] Thus, quick, objective identification of GT is crucial in clinical practice.[1,6]

Various invasive and non-invasive techniques have been used to evaluate the GT, including cone-beam computed tomography (CBCT),[7] transgingival probing,[8] transparency,[9] and ultrasonographic devices.[10] Transgingival probing is a commonly used and relatively easy method for measuring thickness by penetrating a dental instrument, that is, an endodontic file perpendicular to the buccal gingiva.[8] While studies have noted that improper use of probing instruments can lead to measurement failure[11] as well as necessitating anesthesia for the procedure is another limitation of the method. Keskiner et al.[12] reported that the failures of conventional methods can be minimized using a Florida probe. However, the calculations of the thickness and thresholds for classification remain unclear.[13]

The periodontal probe translucency method (PP), which classifies gingival phenotype as "thin" or "thick" according to the visibility of the probe from the buccal gingival sulcus,[9] is considered both highly reproducible and highly reliable.[14] However, recent studies have reported that the probe is only visible in thin phenotypes of <1 mm, but not in thick phenotypes of ≥1 mm.[9] While the recommendation from the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions for using transparency to evaluate gingival phenotype remains valid, reports indicate that the method is vulnerable to examiner bias.[1] A more sophisticated non-invasive technique that has been suggested for its ability to distinguish between thin, medium, thick, and very thick gingival phenotype based on the probe's transparency through soft tissue is the colored biotype probe translucency method (CBP), which is carried out with Colorvue biotype probe.[15]

Although various recommendations have been made over the years as to which method is most advantageous for identifying gingival phenotype according to GT measurements, only a small number of studies have compared methods and/or devices.[6] Given the lack of clear methodological guidelines for the clinical assessment of GT, the primary aim of this study was to evaluate the agreement and applicability of novel gingival phenotype assessment methods, that is, CBP and transgingival measurement with Florida probe (FP), and compare them with conventional methods, that is, PP and transgingival measurement with endodontic file (EF). The study hypotheses were that (1) transgingival measurement with a Florida probe and transgingival measurement with an endodontic file would yield similarly acceptable values for classifying gingival phenotypes according to GT and that (2) values obtained using the transparency method with a CBP would correlate with those obtained using a standard probe. This study further aimed to establish threshold values for defining GT.

CLINICAL RELEVANCE

Background

Gingival thickness, a key component of the gingival phenotype, significantly influences treatment outcomes. Accurate and easy determination of gingival thickness is essential for enhancing the quality and success of clinical dental treatments.

Added Value of this Study

This study evaluates both conventional and novel methods for identifying gingival phenotype and gingival thickness. Our findings aim to aid clinicians in selecting the most suitable method for assessing gingival thickness, thereby contributing to improved clinical practices and future research in this field.

Clinical Implications

The results of this study can guide clinicians in the accurate assessment of gingival thickness, leading to better-informed decisions during aesthetic and implant treatments. By adopting the most effective measurement techniques, dental practitioners can enhance treatment outcomes and patient satisfaction.

2 | METHODS

2.1 | Study Design & Participants

This cross-sectional study included 50 patients who underwent periodontal treatment at the Periodontology Department of the Faculty of Dentistry at Ondokuz Mayıs University between June 2021 and March 2022. This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (OMUKAEK-29.01.2021/protocol no:2021/44, Clinical Trial Number: NCT05478148). All patients provided written informed consent prior to enrollment. This study adhered to (Standards for Reporting of Diagnostic Accuracy Studies) STARD guidelines.

Based on the comparison of kappa tests using similar Kloukos et al.[16] study as a reference, a power analysis was conducted using PASS 11 program with a power of 80% and a type 1 error rate of 0.05. The minimum sample size was calculated to be 40. Patients meeting the criteria of "clinical health" according to the 2017 consensus on an

intact periodontium were included in the study.[17] Study groups was established based on the clinical evaluation of patient periodontal status, which was assessed according to the Loe & Silness Plaque index (PI),[18] Silness & Loe gingival index (GI),[19] bleeding on probing index (BOP)[20] and probing pocket depth in six regions of each tooth of the mouth. The exclusion criteria were as follows: (i) smoking/history of smoking, (ii) current/previous orthodontic treatment, (iii) use of medication that may cause gingival hyperplasia, (iv) pregnancy/lactation, (v) structural defects, crowns, or large restorations in the maxillary anterior teeth, (vi) missing or supernumerary teeth in the maxillary anterior region, (vii) skeletal/dental anomalies, and (viii) presence of melanin pigmentation.

2.2 | Gingival phenotype Classification

Measurements were obtained from the buccogingival aspect of the six maxillary anterior teeth. Gingival phenotype was classified using four different methods, including the currently recommended conventional and novel methods of assessment based on transparency and transgingival measurements, as follows:

PP (conventional transparency/noninvasive): A periodontal probe (UNC 15 probe, Hu-Friedy, Chicago, IL.) was used to classify the gingival phenotype as thin or thick, based on visibility from the buccal gingival sulcus (Figure 1).

All transgingival measurements (EF and FP) were taken from the base of the gingival sulcus, which is in line with methods of Olsson et al.[21] Xylocaine spray (10% lidocaine) was applied topically to alleviate pain prior to performing transgingival measurements.

EF (conventional transgingival/invasive): A plastic stopper was attached to an endodontic file (EF) (20 K-files, Kerr, Brea, CA.) that was used to perform transgingival probing perpendicular into the buccal soft tissue until resistance was encountered (i.e., hitting the root surface or the buccal bone). The GT was measured as the distance between the tip of the file and the stopper using a digital caliper. Prior to the measurement, the EF was modified by extending its tips with a composite filler for greater accuracy (Figure 2).

CBP (novel transparency/non-invasive): A colored biotype periodontal probe (Colorvue Biotype Probes, Hu-Friedy) was used to classify gingival phenotype as either thin (white tip visible) (Figure 3), medium (white tip invisible [Figure 4A], green tip visible [Figure 4B]), thick (green tip invisible [Figure 5B], blue tip visible [Figure 5C]), or very thick (blue tip invisible) (Figure 6C). FP (novel transgingival/invasive): Transgingival probing was performed using an FP. The FP stored data electronically and had an accuracy of around 0.2 mm. FP was used to perform transgingival probing perpendicular into the buccal soft tissue until resistance was encountered (i.e., hitting the root surface or the buccal bone). Prior to the measurement, the FP was modified by replacing the blunt tip of the probe with a dental injector needle (Figure 7).

All the measurements were performed by the same pre-calibrated investigator (RG). The measurements were performed sequentially as follows: CBP, PP, FP, and EF. Noninvasive methods (CBP and PP) were used first to avoid bleeding and/or tissue discoloration. To achieve standardization, all direct transgingival measurements were performed by inserting the tool perpendicular into the buccal soft tissue until contact was made with the alveolar bone or root surface. A threshold value of 1 mm was used to distinguish between "thin" and "thick" phenotypes.

2.3 | Intra-examiner repeatability and Inter-examiner reproducibility

The intra-examiner repeatability for all methods was analyzed by having the clinician who performed the clinical examinations (RG) re-examine 10 randomly selected patients 21 days after the initial measurements were obtained. Inter-examiner reproducibility was evaluated by another investigator who performed measurements on 10 randomly selected patients immediately after the initial measurements made by the RG.

2.4 | Data Analysis

Data analysis was performed using IBM SPPS V23. Normality of distribution was evaluated using the Shapiro–Wilk and Kolmogorov–Smirnov

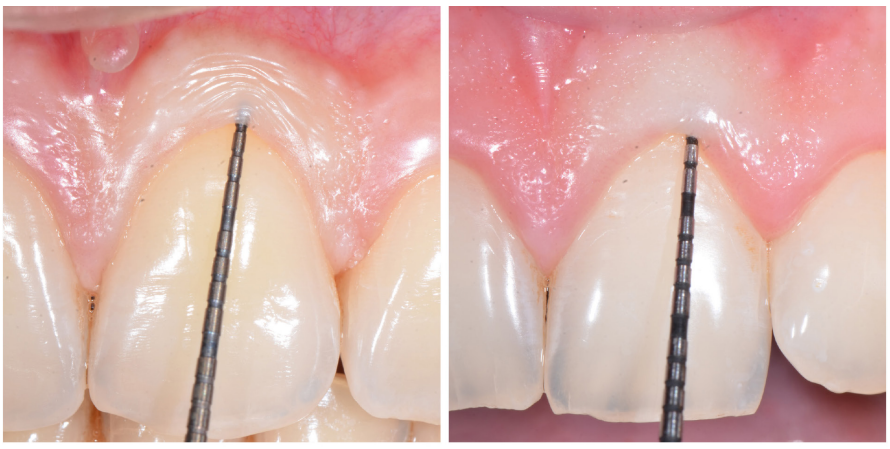

FIGURE 1 Transparency technique with periodontal probe.

tests. The independent samples *t*-test was used to compare normally distributed data between groups, and the Mann–Whitney *U*-test was used for non-normally distributed data. For groups of three or more, one-way analysis of variance and a post-hoc Tamhane test were used to compare normally distributed data, and the Kruskal–Wallis test and a post-hoc Dunn test were used to compare non-normally distributed data. Normally distributed data in dependent groups were compared using repeated-measures ANOVA with Bonferroni correction, and non-normally distributed data in dependent groups were compared using the Friedman test, followed by Dunn's test. Receiver operating characteristic (ROC) analysis was performed to determine threshold values for the variables. To assess intra-examiner repeatability, intra-examiner reliability, and agreement between various methods, the Kappa Test was used for categorical variables and intraclass correlation coefficient (ICC) analysis was performed for quantitative variables. Bland–Altman analysis was used to evaluate the agreement between the FP and EF measurements. Results are presented as frequency (percentage) for categorical variables and mean ± standard deviation and median (minimum–maximum) for quantitative variables, with a significance level of $p < .05$.

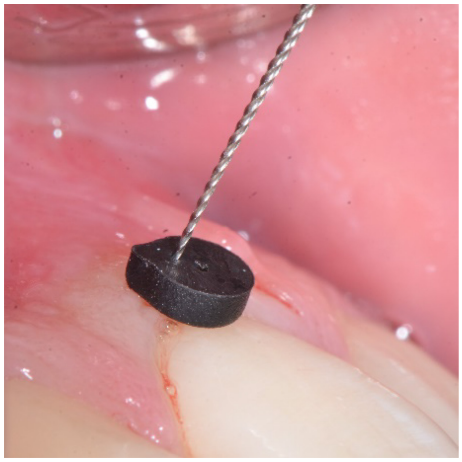

FIGURE 2 Transgingival probing with endodontic file.

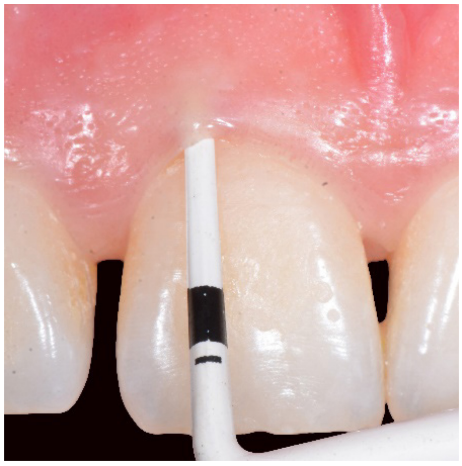

FIGURE 3 First, the white probe is used. If it is visible, the phenotype is classified as thin.

The Kappa test was used to examine agreement between categorical variables (gingival phenotype classification) using a 6-level ranking system (1-poor agreement, <0.00; 2-slight agreement, 0.0–0.2; 3-fair agreement, >0.2–0.4; 4-moderate agreement, >0.4–0.6; 5-substantial agreement, >0.6–0.8; 6-almost perfect agreement, >0.8–1.0).[22] ICC analysis was used to examine the agreement between quantitative variables (GT measurements). ICC values range between 0 and 1, and are designated as follows: <0.5 = poor reliability; 0.5–0.75 = moderate reliability, 0.75–0.9 = good reliability, >0.9 = excellent reliability.[23]

3 | RESULTS

This study was conducted with 50 participants (men: $n = 27$, 54%; women: $n = 23$, 46%; mean age: 23.68 ± 3.6) and 300 teeth (162 in men and 138 in women). All study participants had PI, GI, and PD values indicative of a healthy periodontal status and an overall BOP <15%.

3.1 | Conventional Transparency (PP) versus Conventional Transgingival (EF) Methods

Groupings of "thin" and "thick" gingival phenotype based on PP and EF showed a moderate level of agreement ($K = .538$; $p < .001$) (Table 1). The

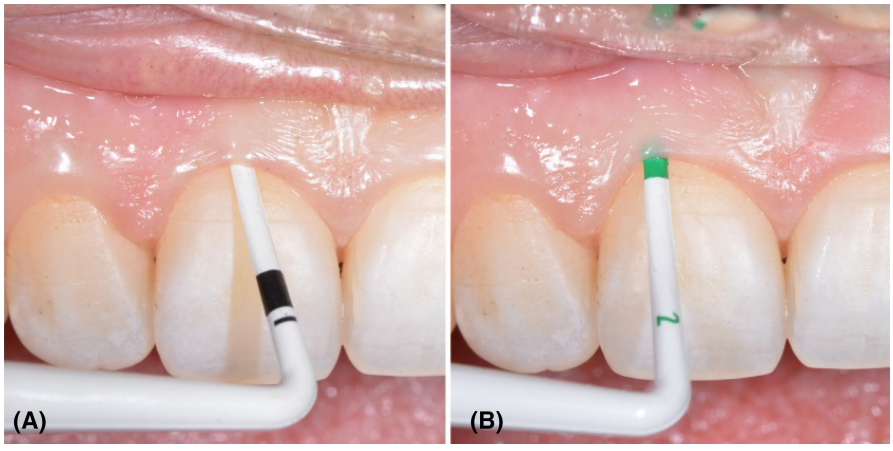

FIGURE 4 Secondly, if the white probe is not visible (A), the green probe is used. If it is visible (B), the phenotype is classified as medium.

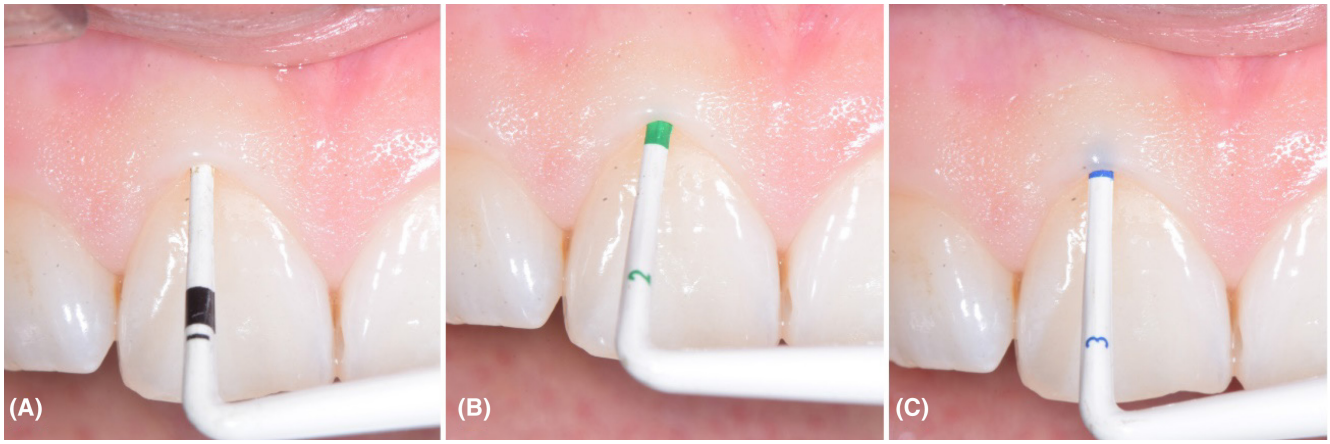

FIGURE 5 Thirdly, if the white (A) and green (B) probe is not visible, the blue probe is the final option. If it is visible (C), the phenotype is classified as thick.

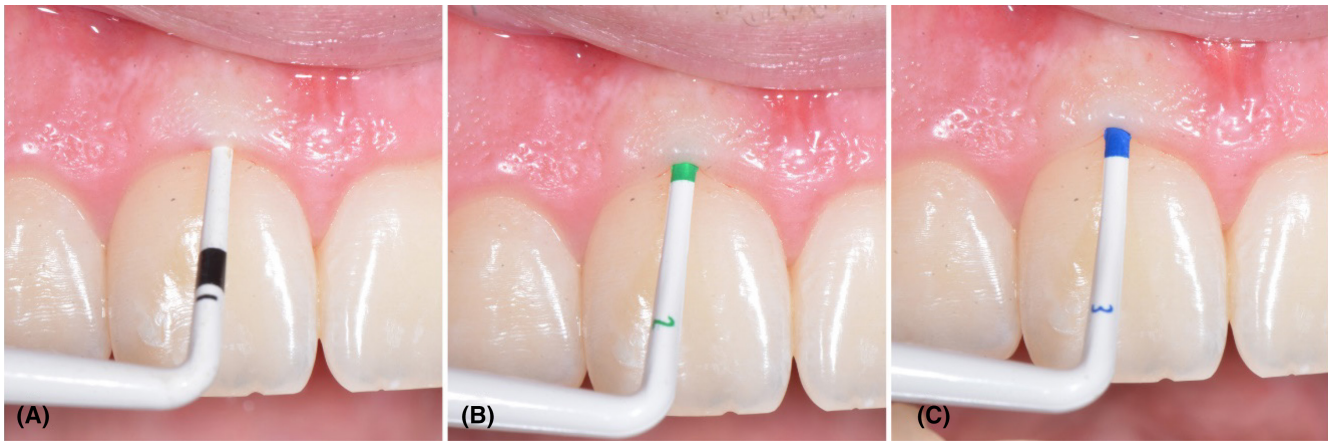

FIGURE 6 If the white (A), green (B) and blue (C) probe is also not visible, the phenotype is then classified as very thick.

"thin" and "thick" gingival phenotype groups created based on PP transparency evaluation had median GT values, as measured by EF, of 0.80 mm (range: 0.5–1.1 mm) and 1 mm (range: 0.6–1.7 mm), respectively, and the difference between these values was statistically significant ($p < .001$) (Table 2). The threshold GT value for phenotype classification as determined by EF measurement was ≤0.92 mm (Table 3).

3.2 | Conventional Transparency (PP) versus Novel Transgingival (FP) Methods

Groupings of "thin" and "thick" gingival phenotype based on PP and FP showed a moderate level of agreement ($K = .404$; $p < .001$) (Table 1). The "thin" and "thick" gingival phenotype groups created based on PP transparency evaluation had median GT values, as measured by FP, of 0.80 mm (range: 0.40–1.60 mm) and 0.89 mm (range: 0.40–1.60 mm), respectively, and the difference between these values was statistically significant ($p < .001$). The threshold GT value for phenotype classification as determined by FP measurement was ≤0.80 mm (Table 3).

3.3 | Conventional Transparency (PP) versus Novel Transparency (CBP) Methods

A substantial level of agreement was found between the PP and CBP values ($K = .726$; $p < .001$) (Table 1). The frequency distributions between the phenotype measurement values obtained with PP and CBP are shown in Table 4

3.4 | Conventional Transgingival (EF) versus Novel Transgingival (FP) & Novel Transparency (CBP) Methods

The EF and FP values showed good agreement (ICC = 0.792; $p < .001$), with a Bland–Altman mean difference of −0.008 (Figure 8). Discounting outliers, the lower limit of agreement was −0.385, and the upper limit of agreement was 0.369 (Figure 1) There were no instances in which gingival phenotype classified as "thin" by PP was classified as "thick" or "very thick" by CBP (Table 5).

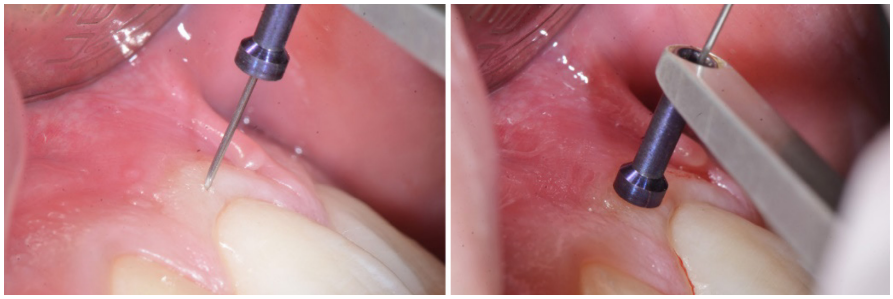

FIGURE 7 Transgingival probing with Florida Probe.

	Sens.	Spec.	PPV	NPV	Accur.	Kappa	p
PP vs EF	994.76%	53.52%	86.80%	76.00%	85.00%	.538	<.001*
PP vs FP	776.42%	70.42%	89.29%	48.08%	75.00%	.404	<.001*
PP vs CBP	996.51%	71.83%	91.70%	86.44%	90.67%	.726	<.001*

Abbreviations: Accur, Accuracy; NPV, Negative predictive value; PPV: Positive predictive value; Spec, Specificity; Sens, Sensitivity.

*Kappa analysis, $p < .05$ significancy level.

TABLE 1 The agreement of gingival phenotype determinations made with PP versus EF, FP and CBP.

	PP			FP	
	Thin	Thick	p Value	ICC (%95 CI)	p Value
EF	0.8 (0.5–1.1)	1 (0.6–1.7)	<.001*	0.792 (0.738–0.834)	<.001**

*Mann Whitney *U* Test; Mean ± standard deviation; Median (min-max). **ICC analysis, ICC: Intraclass Correlation Coefficient.

$p < .05$ significancy level.

TABLE 2 Difference between EF measurements according to thin and thick gingival phenotype determined with PP and the agreement of these values with FP measurements.

TABLE 3 Threshold values of EF and FP measurements.

	Threshold value	AUC (%95 CI)	p	Sens.	Spec.	PPV	NPV	Accur.
EF	≤0.92	0.873 (0.823–0.922)	<.001*	89.96%	71.83%	91.15%	68.92%	85.67%
FP	≤0.80	0.805 (0.748–0.862)	<.001*	76.42%	70.42%	89.29%	48.08%	75.00%

Abbreviations: Accur, Accuracy; NPV, Negative predictive value; PPV: Positive predictive value; Spec, Specificity; Sens, Sensitivity.

*ROC Analysis, $p < .05$ significancy level.

3.5 | Inter-examiner reproducibility and intra-examiner repeatability

Inter-examiner agreement varied among the methods as follows: EF, moderate agreement (ICC = 0.713; $p < .001$); FP, excellent agreement (ICC = 0.947; $p < .001$); fair agreement ($K = .277$; $p < .001$); and PP, moderate agreement ($K = .487$; $p < .001$).

Intra-examiner repeatability also varied among the methods as follows: EF, excellent agreement (ICC = 0.974; $p < .001$); FP, excellent agreement (ICC = 0.947; $p = .002$); good agreement ($K = .871$; $p < .01$); and PP, moderate agreement ($K = .475$; $p < .001$).

TABLE 4 Frequency distributions of PP versus CBP.

	PP	
CBP	Thin (%)	Thick (%)
Thin	221 (96.5)	20 (28.2)
Medium	8 (3.5)	28 (39.4)
Thick	0 (0)	14 (19.7)
Very thick	0 (0)	9 (12.7)

4 | DISCUSSION

The current study undertook a comparative evaluation of both conventional and novel methods, namely, non-invasive classification according to translucency using a standard periodontal probe versus a CBP, as well as direct transgingival measurement using an endodontic probe versus a Florida probe. Based on the study findings, a threshold value for identifying "thin" and "thick" gingival tissue was proposed.

According to the data, both transgingival methods provided comparably precise measurements. Moreover, CBP, which was designed

TABLE 5 Comparison of EF measurements according to phenotype categories made with CBP.

CBP	EF (total)	
	Median (min-max)	%95 CI
Thin	0.8 (0.5–1.1)[b]	(0.74–0.78)
Medium	1 (0.6–1.2)[a]	(0.93–1.01)
Thick	1.1 (1–1.4)[a]	(1.06–1.17)
Very Thick	1.6 (1.2–1.7)[a]	(1.37–1.64)
p	<.001*	

*Kruskal-Wallis test followed by Mann–Whitney test with Bonferroni correction; a, b: There is no difference between colored biotype probe categories with the same letter.

$p < .05$ significancy level.

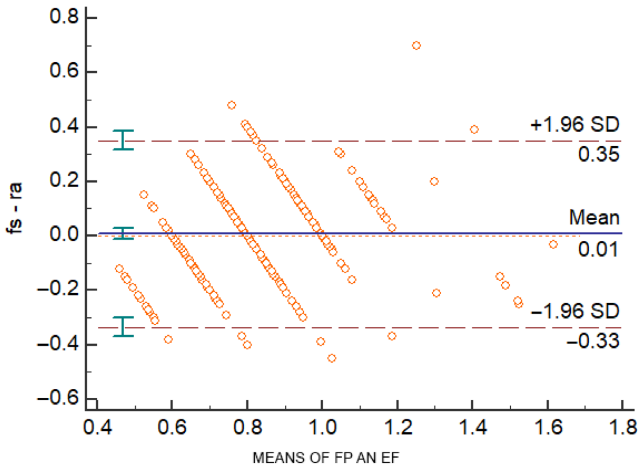

FIGURE 8 Repeatability comparisons of FP and EF with Bland–Altman Plot.

specifically to improve the accuracy of clinical identification of very thin and very thick gingival phenotypes, was found to be capable of successfully identifying the thin gingival phenotype but was incapable of differentiating between medium, thick, and very thick gingival phenotypes.

Most studies rely mainly on direct measurement of gingiva for determining phenotype due to the strong association between GT and gingival phenotype;[14,24] however, because this method requires inserting sharp instruments into the gingival tissue, its clinical applicability has sometimes been questioned.[24] Transgingival probing may be performed with a variety of instruments.[3,16,25–27] Several recent studies have reported transgingival probing to be an easy-to-use, highly reproducible and reliable technique that offers the best performance in measuring GT,[25,28,29] and while Studer et al.[30] caution that values obtained by transgingival measurement should not be regarded as absolute, they still give the clinician important knowledge about GT.

Different findings have been reported regarding the usefulness of the translucency method for determining the GT, with the method described by Kan et al.[31] reported to have the highest level of predictability. Kan et al.[9] found no statistically significant differences in the classification of "thin" and "thick" gingiva according to translucency and according to direct measurement by transgingival probing, with 100% correspondence observed between ≤0.6 mm GT and the thin phenotype, as well as between >1.2 mm GT and the thick phenotype;[9] however, the authors reported difficulties in correctly classifying phenotype when GT measurements ranged between 0.6 and 1.2 mm. Similarly, Alves et al.[28] stated that classifying the gingival biotype according to translucency is only appropriate when the GT is less than 0.6 mm or greater than 1.2 mm. Fischer et al.[32] stated that the use of a dichotomous classification made it difficult to categorize thicknesses with mid-range values. Alkan et al.[33] reported agreement between transgingival measurement and assessment by translucency, whereas Fu et al.[2] concluded that translucency was an inadequate method for identifying the gingival phenotype because of weak correlations between the two. Our study of 300 maxillary anterior teeth showed a moderate agreement between PP and EF ($K = .538$; $p < .001$).

Our study also showed a substantial level of agreement between the PP and CBP assessments of translucency, with sensitivity and specificity values of 96.51% and 71.83%, respectively. All teeth classified as "thick" using a PP were classified as either "thick" or "very thick" using a CBP, with good intra-examiner repeatability. However, in line with Bertl et al.,[34] we found that CBP had low inter-examiner reproducibility ($K = .277$). This result indicates the method's susceptibility to examiner-dependent variability to a considerable extent.

CBP, which was first described by Rasperini et al.,[15] has been recommended as a unique, reliable, simple, and non-invasive method for classifying the gingival phenotype.[35] In a subsequent study by Kloukos et al.,[16] CBP was used to identify the gingival phenotype of the central mandibular teeth of 200 patients, and the classifications were compared to direct GT measurement. Although the measured GT values overlapped for the "thick" and "very thick" phenotypes identified by the CBP, indicating a lack of reproducibility, regression analysis showed a balanced progression of GT values from "thin" to "thick" phenotype, leading the authors to endorse both the feasibility and validity of CBP for determining gingival phenotype.[16] GT values reported in that study ranged between 0.46–0.88 mm; however, no threshold values were established for differentiating among phenotypes.

In another preliminary study conducted with 105 teeth from 10 patients, Aslan et al.[36] attempted to establish threshold values for each phenotype by examining the correlations between the CBP phenotype classification and CBCT measurements of the buccal GT. The authors reported a strong correlation between the direct measurements and CBP translucency values when only the anterior teeth were considered. Bertl et al.,[34] who compared phenotype classification according to PP and CBP translucency visually evaluated from intraoral photographs by six observers with direct transgingival measurement of the buccal gingiva in three anterior teeth in each of 50 patients using an EF, noted difficulties in distinguishing between phenotypes using CBP. In that study, visual assessment resulted in >85% of cases being classified as "medium." Measured thresholds

for "thin," "medium," "thick," and "very thick" phenotypes were reported to be <1 mm, ≥1–1.25 mm, ≥1.25–1.5 mm, and ≥1.5 mm, respectively.[34]

In our study, mean GT values obtained with an EF for the phenotypes identified as "thin," "medium," "thick," and "very thick" with a CBP were 0.78 mm ± 0.15, 1.01 mm ± 0.08, 1.1 mm ± 0.06, and 1.56 mm ± 0.11, respectively. These ranges are similar to those reported by Bertl et al.,[34] but differ from those reported by Kloukos et al.[16] and Aslan et al.[36] The differences may be due to differences in the study methodologies. While our study measured only the maxillary anterior teeth, Kloukos et al.[16] measured the anterior region of both the upper and lower jaws, Aslan et al.[36] used CBCT to obtain GT measurements, and our study utilized EF.

One crucial finding of the present study is that despite the overall statistically significant difference observed between CBP assessment and transgingival measurements made with an EF, paired comparisons indicated that the difference was only significant for the "thin" phenotype. In other words, CBP successfully identified "thin" gingival phenotype, but was unable to distinguish between "medium," "thick," and "very thick" gingival phenotype. This is in line with Kloukos et al.[16] as well as Bertl et al.,[34] both of whom showed that the CBP failed to accurately discriminate between "thick" and "very thick" phenotypes. Fa da Costa et al.[37] further highlighted the need for caution to prevent overtreatment of thick sites that are mistakenly identified as having a thin phenotype, as shown by low specificity.

A study by Keskiner et al.,[12] which measured GT to identify changes in tissue thickness following a free gingival graft in the palatal region, reported that the Florida probe offers a simple, direct way of determining tissue thickness. In the present study, ICC analysis indicated a good level of agreement between EF and FP measurements, whereas kappa analysis showed moderate agreement between FP measurements and GT evaluation using PP. The ICC analysis also demonstrated excellent intra-examiner agreement for both EF and FP, good inter-examiner agreement for EF, and excellent inter-examiner agreement for FP. While these results suggest that GT measurements obtained using an FP may be useful as a supplementary means of assessing periodontal tissue loss, the cost of the device and additional software requirements represent disadvantages in routine clinical applications. The main advantage of an FP over an EF is the ease with which data can be transferred to a digital format without the need for a second measuring tool, such as a caliper. The 15 g spring of the FP also provided controlled stability and more reliable measurements than the plastic stopper used with the EF. While the FP's 0.2 mm range of inaccuracy represents a disadvantage, it should be noted that measurement inaccuracies are also associated with EF.

Previous studies have reported gingival thickness to range between 0.7 and 1.5 mm, with a gingival phenotype of <1 mm generally accepted as "thin" and a gingival phenotype of ≥1 mm as "thick."[1,14,28] Unsurprisingly, studies using different measurement methodologies have produced different threshold values for identifying "thin" and "thick" gingival phenotype.[6] According to Bertl et al.,[34] considering that phenotype is known to vary not only among individuals, but also in different regions of the mouth of the same individual,[38] the failure to standardize the apicocoronal level at which transgingival measurements are performed has resulted in reported GT threshold values that are arbitrary and essentially meaningless.

Despite the lack of standardization in measurement, several studies have attempted to identify threshold values for "thin" and "thick" gingiva in order to determine the effects of phenotype on restorative and periodontal treatment outcomes.[3,9,34,38–40]

In their comprehensive study of measurements made from 6 different points on the gingiva, Stein et al.[39] reported that measurements made between 0.5 mm and 1 mm from the gingival margin resulted in the best agreement between translucency assessment and direct GT measurement. In our study, transgingival measurements were obtained using the base of the gingival sulcus as the measurement point. Thus, for example, the lower GT threshold value obtained in our study compared to Kan et al.[9] may be due to the fact that while all transgingival measurements in that study were made 2 mm apical from the gingival margin, in our study, which used the gingival sulcus as a reference point, 264 of the 300 teeth were measured at 1 mm apical from the gingival margin, and only 36 teeth were measured 2 mm apical to the gingival margin. The median value for GT measurements obtained using EF ranged from 0.5–1.7 mm. Moreover, a statistically significant difference was observed between the median values of the "thin" and "thick" phenotypes identified using EF. Our study found consistency between a GT of <0.6 mm and "thin" gingival phenotype, and between a GT of >1.1 mm and "thick" gingival phenotype. This is in line with the results of both Kan et al.[9] and Alves et al.[28]

In a study by Frost et al.[41] that identified >0.8 mm as the GT threshold based on evaluations of gingival phenotype and GT in the upper anterior teeth of 36 individuals, the researchers reported an AUC of 0.666 (95% GA = 0.594, 0.737); however, relatively low sensitivity (67.7%) and specificity (65.4%) were reported for the 0.8 mm threshold value. In contrast, our study, which set the GT threshold value at 0.92 mm, yielded a statistically significant AUC value of 0.873 ($p < .001$), with a sensitivity of 90% and a specificity of 71.8%.

There are no studies on gingival phenotype variability in the Turkish population regarding racial characteristics, so it is not accurate to confirm these factors' influence. Moreover GT is thicker in individuals with high pigmentation, which hinders transparency.[16] Thus, for standardization, we excluded patients with melanin pigmentation and conducted our study solely on individuals from the Turkish population.

In terms of the number of researchers, involving more examiners could have resulted in a more robust inter-examiner assessment. However, this may not be feasible from an economic perspective and considering the increased patient exposure to procedures.

A number of limitations should be taken into consideration when interpreting the results of this study, namely, its investigation of only the maxillary anterior teeth, which were selected for evaluation because of their aesthetic value. To further refine the methods, future studies could be conducted with a larger sample size. Furthermore, a clearer evaluation of the measurement instruments and techniques

would have been possible if the measurements were followed by clinical interventions and evaluation of treatment outcomes.

5 | CONCLUSIONS

In summary, while the CBP successfully identified the "thin" phenotype, it struggled to differentiate between the "medium," "thick," and "very thick" phenotypes, with fair inter-examiner agreement. Therefore, in view of its relatively higher cost compared to a standard periodontal probe, CBP is not recommended for clinical use.

While the FP also costs more than a standard EF, it may be considered a practical alternative for use in clinical practice, given that it has demonstrated greater inter-examiner repeatability as well as direct digitization of measurements.

All things considered, the ideal method for determining GT and gingival phenotype should possess high reproducibility, applicability, and reliability. Finally, future studies are required to identify the appropriate apicocoronal level for obtaining GT measurements to provide the most precise data regarding the gingival phenotype.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest, and no external funding was obtained for this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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