International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 23s, 2025
https://www.theaspd.com/ijes.php

Comparative Clinical Assessment Of Gingival Thickness Using Different Methods And Its Relation To Various Levels Of Gingival Pigmentation – An Observational Study

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ABSTRACT:

AIM: *It's hypothesized that the probe visibility (PV) method, as recommended by current guidelines, may not effectively differentiate between thick and thin gingiva in individuals with gingival pigmentation. Hence, the aim of this study is to compare the effectiveness of the Probe Visibility (PV) method using the UNC-15 probe and Colorvue Biotype Probe (CBP) with calliper and transgingival probing measurements for assessing gingival thickness in individuals with varying degrees of gingival pigmentation.*

MATERIALS AND METHODS: *This observational study included 80 participants over a 3-month period. The buccal gingiva adjacent to the right maxillary central incisor was assessed. Gingival thickness was measured using four methods: direct measurement with a calliper (gold standard), transgingival probing with an endodontic spreader, and probe visibility using both the Colorvue Biotype Probe (CBP) and UNC-15 probe. Gingival pigmentation was assessed subjectively using the Dummett–Gupta Oral Pigmentation Index (DOPI).*

RESULTS: *Among the 80 participants, the UNC-15 probe was visible in 38 cases and not visible in 42. For the CBP, the green tip was most commonly visible (44 participants), followed by equal frequencies for white tip visible, blue tip visible, and blue tip not visible (12 each). DOPI index classifications were predominantly Class 0 and 1, with no cases in Class 3.*

Direct measurement using a calliper (mean: 0.53 mm) was significantly lower than transgingival probing (mean: 0.66 mm), with a statistically significant difference between the two ($p = 0.000$). A significant positive correlation was observed between calliper measurements and both PV methods (UNC-15 and CBP), indicating that greater gingival thickness was associated with lower probe visibility. However, correlations between gingival pigmentation (DOPI index) and gingival thickness or probe visibility were weak and not statistically significant.

Kruskal-Wallis tests revealed significant differences in gingival thickness measurements across CBP visibility categories and DOPI classes, with the "blue tip not visible" group and DOPI Class 2 showing the highest gingival thickness. Despite trends, DOPI index did not significantly predict probe transparency in regression analysis ($p > 0.05$).

CONCLUSION: *Probe visibility significantly correlates with gingival thickness measurements, while gingival pigmentation (DOPI Index) does not significantly influence probe transparency or transgingival measurements. Although DOPI affects direct calliper measurements, it is not a reliable predictor of probe visibility using UNC-15 or CBP probes.*

INTRODUCTION

In the era of personalized medicine, understanding the unique factors that can influence treatment outcomes for each patient is crucial. One such factor is gingival thickness. Historically, the term "gingival biotype" was commonly used in scientific literature. However, during the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases, this term was updated to "periodontal phenotype" to better reflect current understanding [(1)].

The concept of periodontal phenotype encompasses two key components: the gingival phenotype and the bone morphotype. Gingival phenotype refers to the three-dimensional volume of the gingiva, which includes both gingival thickness (GT) and the width of the keratinized tissue (KTW). Bone morphotype, on the other hand, focuses on the thickness of the buccal bone plate (BBPT). Together, these elements provide a comprehensive view of the periodontal structure, offering valuable insights into individual variations and their implications for treatment planning.

By adopting the term "periodontal phenotype," the dental community acknowledges the interplay between gingival tissue and underlying bone in shaping treatment outcomes, emphasizing a more holistic approach to periodontal health.

The gingiva has been classified in various ways to describe its characteristics. Healthy periodontal tissue can exhibit a range of clinical appearances. In 1969, Ochsenbein and Ross introduced one of the earliest classifications, categorizing gingival anatomy into two types: flat and pronounced scalloped biotypes. They associated flat gingiva with a square tooth form and pronounced scalloped gingiva with a tapered tooth form [(2)].

Gingival thickness (GT) plays a significant role in these classifications. Thin gingiva is defined as having a thickness of ≤1.5 mm, while thick gingiva measures ≥2 [(3)]. Seibert and Lindhe later introduced the term "periodontal biotype", categorizing them based on the periodontium's morphological features: the scalloped-thin biotype and the flat-thick biotype [(4)].

Gingival thickness significantly influences treatment outcomes, including those for restorative, periodontal, implant, and orthodontic procedures [(5)]. Thick gingiva tends to heal more predictably after surgery, experiences less ridge resorption following tooth extraction, and has a lower risk of gingival [(6)]. Additionally, sites with thicker gingiva are less prone to attachment loss after nonsurgical periodontal therapy [(3)].

A systematic review found that a critical gingival thickness of over 1.1 mm is essential for achieving complete root coverage during connective tissue grafting or guided tissue regeneration procedures [(7)].

Intra- and interindividual variations in the width and thickness of facial gingiva suggest the existence of different gingival phenotypes within populations. Joshi et al. (2016) identified two gingival biotypes: thick and thin. Thick biotypes are resilient, resist trauma and recession, support tissue manipulation, promote creeping attachment, enhance implant esthetics, and exhibit less inflammation, making surgical outcomes more predictable. In contrast, thin biotypes are delicate, often translucent, and friable, with a minimal zone of attachment. These characteristics make them more susceptible to inflammatory, traumatic, or surgical insults, frequently resulting in gingival recession and osseous defects such as fenestrations and dehiscences [(8)].

Gingival biotype is influenced by several factors, including gender, age, growth patterns, tooth shape and size, tooth position, and genetic predisposition. Generally, the thicker biotype is more common in males, while females tend to have a thin, scalloped gingival biotype. Age also plays a role, with younger individuals more likely to exhibit a thick, flat biotype, whereas older adults often present with a thin, scalloped biotype.

Accurately diagnosing the gingival tissue biotype is crucial for developing an effective treatment plan and achieving reliable, esthetically pleasing outcomes.

Various methods have been developed to measure gingival thickness (GT), each with its own advantages and limitations. Traditional techniques include transgingival probing, ultrasonic devices, the probe visibility method, and cone-beam computed tomography (CBCT).

Historically, GT was also measured directly using sterile needles or callipers during or after tooth extraction. However, due to its invasive nature, this method is now rarely used [(9)].

Transgingival probing, introduced by Greenberg et al. (1976), involves measuring GT by inserting a periodontal probe or a stainless-steel acupuncture needle through the gingiva to assess thickness [(10,11)]. While effective, this method is invasive and can cause patient discomfort, limiting its widespread use.

Hence, non-invasive techniques, such as ultrasonic devices and the probe visibility method, have become more widely accepted for their simplicity and accuracy.

Ultrasonic devices have been used as a non-invasive alternative to measure GT. This technique works on the pulse echo principle which employs ultrasonic pulses that travel through the permeable gingival mucosa and reflect back upon contacting hard tissues, such as the tooth or alveolar bone. The time delay between pulse transmission and echo return is used to estimate gingival thickness with high accuracy, down to 0.1 displayed [(12,13,14,15)]. Although these devices offer reliable and reproducible results [(15,16,17)], they are not currently commercially available, limiting their practical application.

The probe visibility method offers a simpler, non-invasive approach for assessing gingival biotype and is widely accepted. Kan et al. proposed this method, where the visibility of a periodontal probe, such as the CPU 15 UNC (by Hu-Friedy) or SE Probe SD12 Yellow (by American Eagle Instruments), through the gingival margin is observed [(18)]. If the probe is visible through the tissue, the biotype is categorized as thin; if not, it is considered thick. Despite being subjective, this method has shown high

Cone-beam computed tomography (CBCT) offers a novel, non-invasive way to measure gingival thickness and other soft tissue dimensions, such as the dentogingival unit. This method provides detailed imaging, making it a valuable tool for both research and clinical settings [20].

A more recent advancement in assessing gingival biotype is the introduction of the **Colorvue Biotype Probe (CBP)** by Hu-Friedy (Chicago, IL). This innovative tool offers reliable predictive values and demonstrates a strong correlation with actual tissue thickness (Rasperini et al. 2015; Aslan et al. 2021; Fischer et al. 2021) [21,22,23]. It works by using a series of color-coded tips, which are sequentially inserted into the gingiva. The assessment involves identifying the first tip that becomes visible through the tissue. Based on this visibility, the gingival phenotype is classified into four categories: thin, medium, thick, or very thick [21]. This is a straightforward and non-invasive approach which provides a practical way to evaluate gingival biotypes.

Understanding and accurately assessing gingival thickness is essential for developing personalized treatment plans, optimizing esthetic outcomes, and predicting treatment success.

The latest consensus report on the periodontium's developmental and acquired conditions recommends using the probe visibility test to assess gingival thickness [1]. However, it notes that the accuracy of this method has primarily been tested on individuals with unknown gingival pigmentation and has not been validated for patients with physiological gingival pigmentation.

Normal gingival color is typically pink, described as salmon or coral pink. However, the color varies depending on melanin pigmentation intensity, which is more prominent in Black and Asian individuals compared to Caucasians. Oral pigmentation, which can be either physiological or pathological, is seen across all races and nationalities. The color of gingiva is influenced by various pigments, including melanin, carotene, reduced hemoglobin, soft keratin, and oxyhemoglobin. Among these, melanin is the most common cause of gingival color variation [24]. Melanin pigmentation is most noticeable in the gingiva, affecting approximately 60% of gingival tissues, 61% of the hard palate, 22% of the mucous membrane, and 15% of the tongue.

Gingival hyperpigmentation occurs due to excessive melanin deposition by melanocytes, primarily located in the basal and suprabasal layers of the epithelium [25]. While pigmentation can result from localized anomalies of little significance, it may also signify systemic illnesses or malignant conditions [26]. The degree of pigmentation varies widely, influenced by factors such as melanoblastic activity and individual differences [27].

In the Indian population, gingival color ranges from fair to dark, reflecting a wide spectrum of skin tones [28]. A study by Ponnaiyan et al. on South Indians found that pigmentation was most prominent in the attached gingiva and interdental papilla, with a positive correlation to skin color.

Gingival pigmentation encompasses a variety of clinical conditions, from physiological changes to manifestations of systemic diseases or neoplasms. Its prevalence varies significantly across populations and depends on factors like vasculature size, epithelial thickness, pigmentation levels, and gingival keratinization [29]. Physiological pigmentation often appears as symmetrical, localized hyperpigmentation, particularly in African, Asian, and Mediterranean populations due to heightened melanocyte activity in the gingiva [30].

This study hypothesized that the probe visibility (PV) method, as recommended by current guidelines, may not effectively differentiate between thick and thin gingiva in individuals with gingival pigmentation. Existing literature lacks a definitive consensus on the most accurate and suitable method for measuring gingival thickness. Therefore, this study also sought to evaluate GT using various measurement techniques in the maxillary anterior region. Consequently, the study aimed to compare the PV method, using the UNC 15 probe and the Colorvue Biotype Probe (CBP), with clinical measurements obtained via a calliper to assess gingival tissue thickness in individuals with varying degrees of gingival pigmentation. Additionally, it sought to compare transgingival probing with calliper measurements in the same population.

MATERIALS AND METHODS

STUDY DESIGN

This was an observational study that involved 80 participants recruited among students, staff, and patients from the Department of Periodontology and Oral Implantology, D Y Patil deemed to be university, School of Dentistry, Nerul, Navi Mumbai. The recruitment period was 3 months from September 2024 until November 2024. The study was approved by the Institutional Ethical Committee.

SAMPLE SELECTION CRITERIA:

Inclusion criteria

1. Patients who are partially or fully dentate with the presence of upper central incisors
2. Patients more than 18 yrs old
3. Patients who are systematically healthy
4. Patients with no signs and symptoms of periodontal disease

Exclusion criteria

1. Pregnant and Lactating females.
2. Smokers.
3. Patients with severe crowding, gingival recession, caries, endodontic restorations or fixed prosthesis on the examined teeth/ ant maxilla.
4. Patients with clinical signs of gingival inflammation or history of surgery in the region of interest
5. Patients with periodontal disease.
6. Patients under orthodontic treatment or presence of previous orthodontic treatment

Written consent was obtained from all participants before data collection.

The sample size for this study was calculated based on the primary outcome of measuring the agreement between the probe visibility method with clinical measurements. The sample size was based on double-sided specification using the formula k=T/s (where k= sample size, s=sample standard deviation, T=total tolerance). The calculated kappa value is 2.326 having 95% confidence (0.05α) and 95% reliability (0.05β).

ARMAMENTARIUM (FIG 1)

- Mouth Mirror
- Cheek retractor
- Tweezers
- Topical LA
- Sterile Cotton
- Hu Friedy UNC-15 Periodontal Probe
- Endodontic spreader
- Ophthalmic calliper
- Colorvue biotype probes (Hu Friedy)
- Digital calliper

METHODOLGY

- After taking a detailed case history, patients who meet the selection criteria will be enrolled for the study.
- Patients will be informed about the study, and informed consent will be obtained.
- A clinical examination of gingiva was performed by a single trained examiner to identify the different anatomic distribution patterns of gingival pigmentation, severity of gingival pigmentation, and gingival phenotype.
- The gingival health of all participants was evaluated before collection of the clinical parameters. Participants received professional mechanical plaque removal and oral hygiene instructions depending on the status of their oral health and hygiene.

- The following clinical parameters will be recorded: -

1. Gingival thickness/biotype
2. Gingival pigmentation

1. Assessment of gingival pigmentation (FIG 11)

Subjective visual assessment of the gingival pigmentation was assessed blindly by two examiners using the Dummett–Gupta oral pigmentation index (DOPI) (Dummett & Gupta, 1964). The DOPI assessment was carried out using a standardized frontal-retracted lips photograph of the participant. The criteria of DOPI were based on the Scale of 0–3. Briefly,
Scale 0 - pink tissue with no clinical pigmentation,
Scale 1 - mild clinical pigmentation (light brown tissue),
Scale 2 - moderate pigmentation (medium brown or mixed pink and brown coloration),
Scale 3 - heavy clinical pigmentation (deep brown or blue–black tissue)

2. Assessment of gingival thickness

- To find out which methods were most suitable for measuring gingival thickness in pigmented gingiva, four methods were used to evaluate the thickness of the gingiva. These were direct measurement using a calliper, transgingival probing method using endodontic spreader, probe visibility method using the CBP, and probe visibility method using the UNC-15 probe. Direct measurement using calliper was considered as the gold standard (Kan et al., 2010).
- Buccal gingiva adjacent to the right maxillary central incisor was assessed in this study.
- Topical anaesthesia gel was applied 2 min before the procedure to reduce pain. Local anaesthesia was not given to reduce the possibility of volume changes in the gingiva.
- Three repeated measurements were taken, and the average was calculated and recorded.
- The gingival phenotype was considered thick if the measurement was >1.0 mm and thin if it measured ≤1.0 mm (Jepsen et al., 2018).
- The order of measurements was probe visibility methods using the UNC-15, followed by the CBP, the direct measurement using the calliper, and finally transgingival probing using an endodontic probe. This was to allow for the local anaesthesia to fully work before the more invasive techniques were applied. It also minimizes any trauma or bleeding from the transgingival probing from interfering with the probe visibility technique.

Direct measurement using a calliper (FIG 8,10)

The gingival thickness was measured clinically at the mid-buccal site using an ophthalmic calliper. The calliper has 0– 20 mm markings and a screw lock that locks the instrument in position when the measurement is obtained. The calliper was inserted in the buccal sulcus of the upper maxillary central incisor to a depth of 1–2 mm until resistance was felt, indicating the full depth of the sulcus. The resultant distance was transferred to a digital calliper with a sensitivity of 0.01 mm, and before each measurement, the digital calliper was reset to 0.00 mm.

Transgingival probing (FIG 9,10)

Measurements were performed by inserting an endodontic spreader perpendicular to the long axis of the axial plane of the tooth (Kloukos et al., 2018), 1 mm apical to the zenith of the mid-facial gingival margin of the upper central incisor. The tip of the spreader was inserted through a rubber stopper at a point peripheral to the premade hole at the centre of the rubber stopper to prevent undesirable movement of the stopper and to minimize the assessment error. The probe was inserted perpendicularly until tactile resistance was felt, indicating full thickness penetration and the distance between the stopper and the probe tip was then measured using a digital calliper with a sensitivity of 0.01 mm.

Probe translucency using Colorvue Biotype Probes (CBP) (FIG 4-7)

This method classifies gingival thickness based on the visibility of a probe with a colored tip by sulcus probing of the mid-facial aspect of the selected tooth. This system consists of three types of CBP (HuFriedy Mfg. Co., LLC), which are white, green, and blue. If the white tip is visible, the phenotype is classified as thin; if only the green tip is visible, the phenotype is classified as medium; and if only the blue tip is visible, then the phenotype is classified as thick; finally, if not even the blue tip is visible, then the tissue is classified as very thick (Rasperini et al., 2015; Aslan et al., 2021; Fischer et al., 2021).

Probe translucency using University of North Carolina -15 (UNC-15) probe (FIG 2,3)

Visibility of the UNC-15 probe (Hu-Friedy Mfg. Co., LLC) was performed using the same steps as in CBP by inserting the probe into the gingival sulcus at the mid-facial aspect of the tooth and the visibility of the

probe is observed. The gingiva is considered thin (≤1 mm) when the outline of the probe can be seen and thick (>1 mm) if it cannot be seen (Jepsen et al., 2018)

COLOR PLATES

Figure 1: Armamentarium

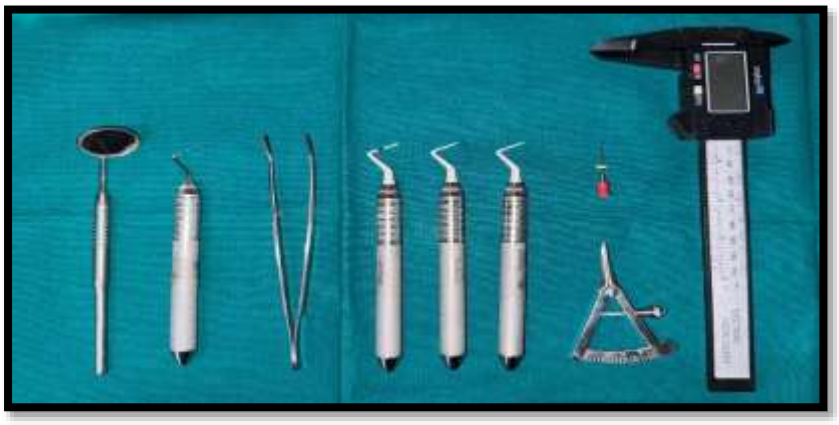


Figure 2: Probe visibility using UNC-15 probes – visible

Figure 3: Probe visibility using UNC-15 probes – not visible

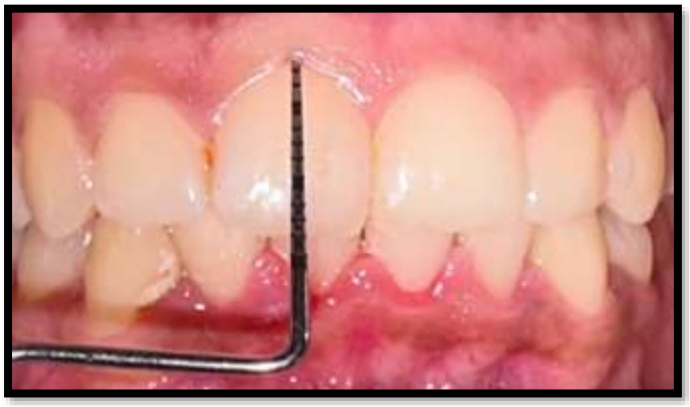


Figure 4: Probe visibility using CBP probes – white tip visible

Figure 5: Probe visibility using CBP probes – green tip visible

Figure 6: Probe visibility using CBP probes – blue tip visible

Figure 7: Probe visibility using CBP probes – blue tip not visible

Figure 8: Direct measurement using calliper

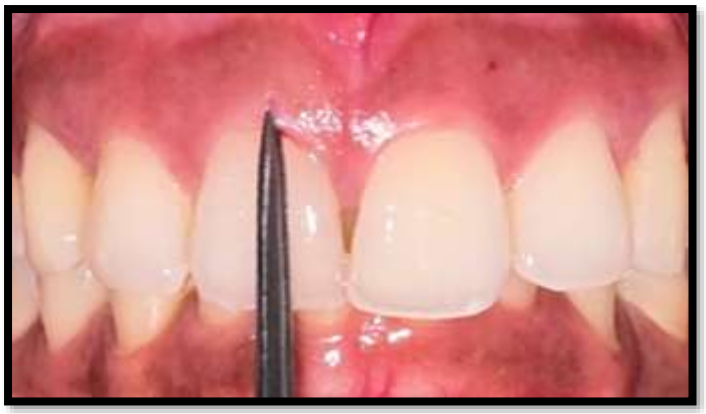


Figure 9: Transgingival probing using endodontic spreader

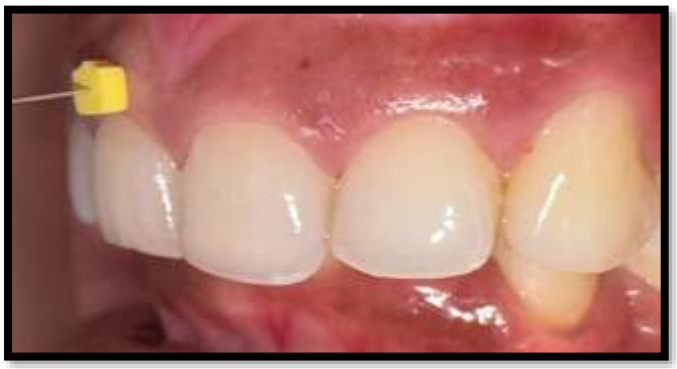


Figure 10: Transfer of measurements on Digital Vernier Calliper

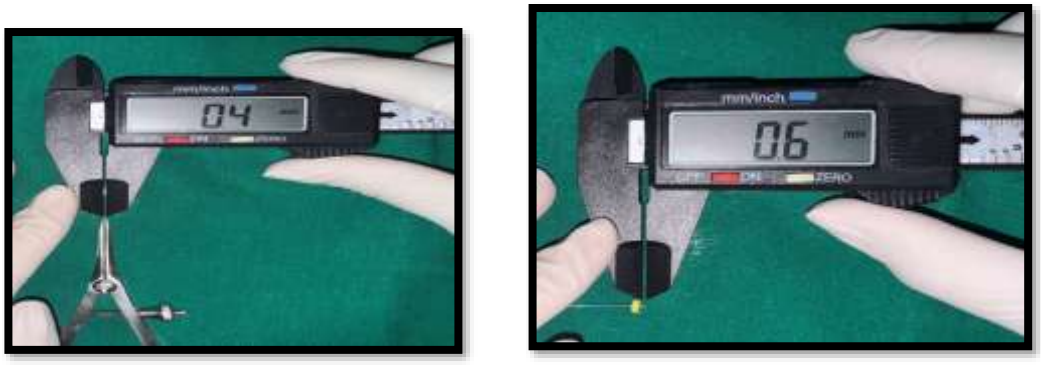
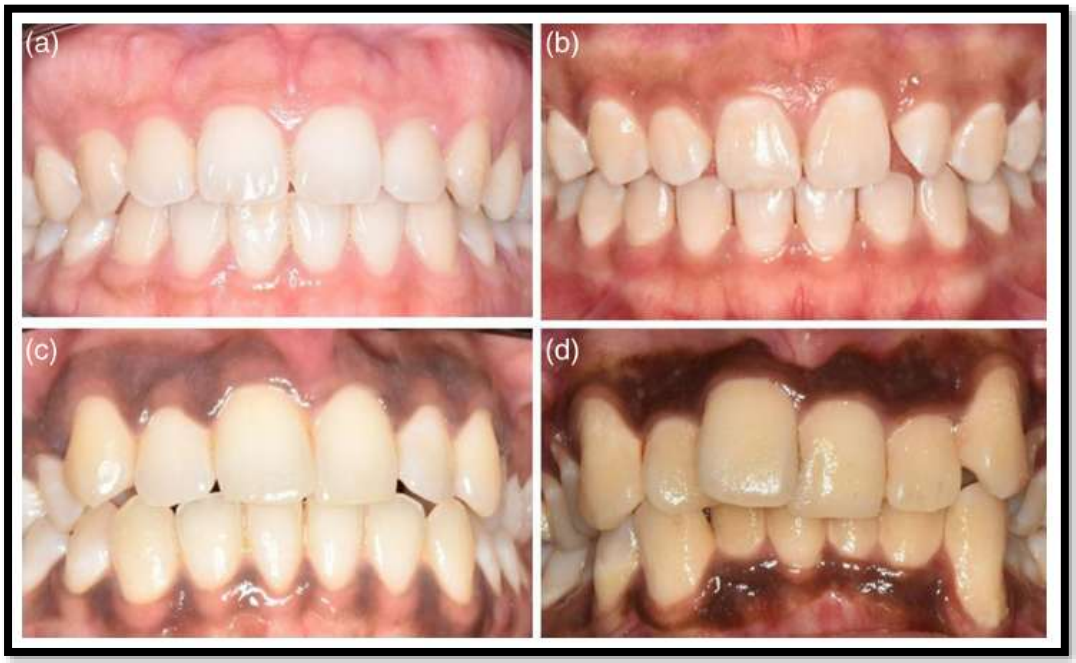


Figure 11: DOPI Index

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 23s, 2025
https://www.theaspd.com/ijes.php



a) Class 0 b) Class 1 c) Class 2 d) Class 3

STATISTICAL ANALYSIS

All the data were analysed using the Statistical Package for the Social Science (SPSS) version 26.0 software.

The relationship between gingival thickness and gingival pigmentation was analysed using Spearman's correlation. Logistic regression was used to analyse the associations between CBP and UNC-15 probe with gingival pigmentation.

Significance was considered at $p \leq 0.05$.

Descriptive statistics of the data were also conducted.

RESULTS

1. DISTRIBUTION OF THE DATA

TABLE 1: Frequency table for Probe Transparency using UNC-15 Probes

	Frequency	Percent	Valid Percent	Cumulative Percent
Visible	38	47.5	47.5	47.5
Not Visible	42	52.5	52.5	100.0
Total	80	100.0	100.0	

GRAPH 1: Frequency table for Probe Transparency using UNC-15 Probes

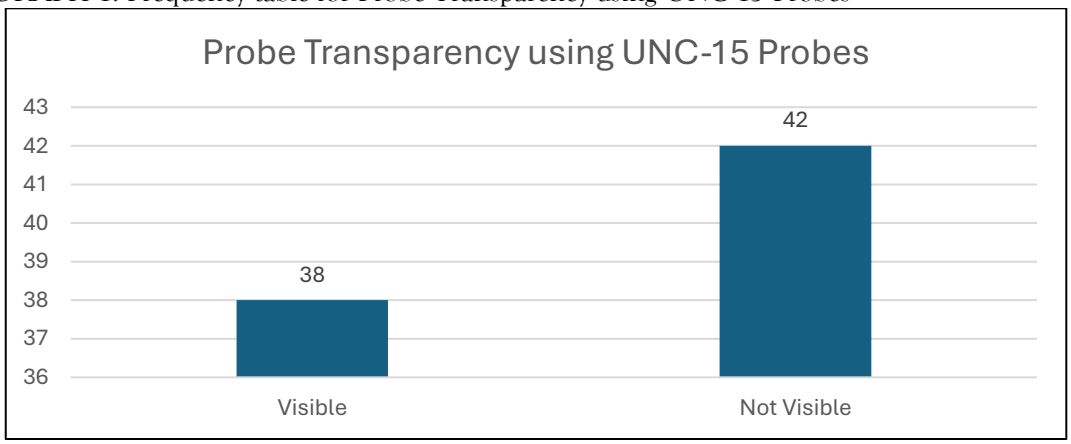


Table 1 and Graph 1 represent the transparency of the UNC-15 probe through the gingiva in the patients. In 38 patients the UNC-15 probe was visible whereas in 42 patients it was not visible.

TABLE 2: Frequency table for Probe Transparency using CBP Probes

	Frequency	Percent	Valid Percent	Cumulative Percent
White tip visible	12	15.0	15.0	15.0
Green tip visible	44	55.0	55.0	70.0
Blue tip visible	12	15.0	15.0	85.0
Blue tip not visible	12	15.0	15.0	100.0
Total	80	100.0	100.0	

GRAPH 2: Frequency table for Probe Transparency using CBP Probes

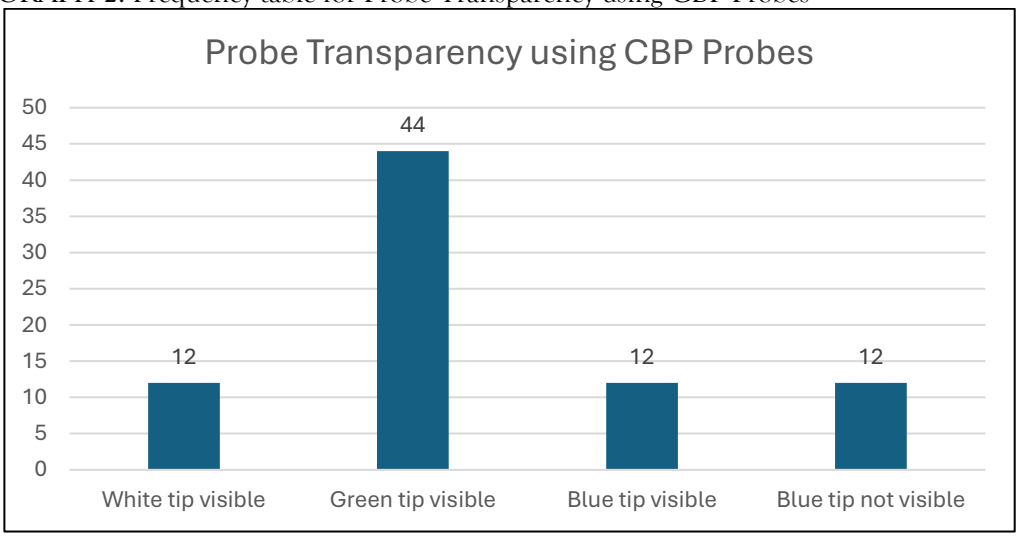


Table 2 and Graph 2 represent the transparency of the CBP probe through the gingiva in the patients. White tip was visible in 12 patients, green tip was visible in 44 patients, blue tip was visible in 12 patients and blue tip was not visible in 12 patients.

TABLE 3: Frequency table for DOPI Index

	Frequency	Percent	Valid Percent	Cumulative Percent
Class 0	28	35.0	35.0	35.0
Class 1	38	47.5	47.5	82.5
Class 2	14	17.5	17.5	100.0
Total	80	100.0	100.0	

GRAPH 3: Frequency table for DOPI Index

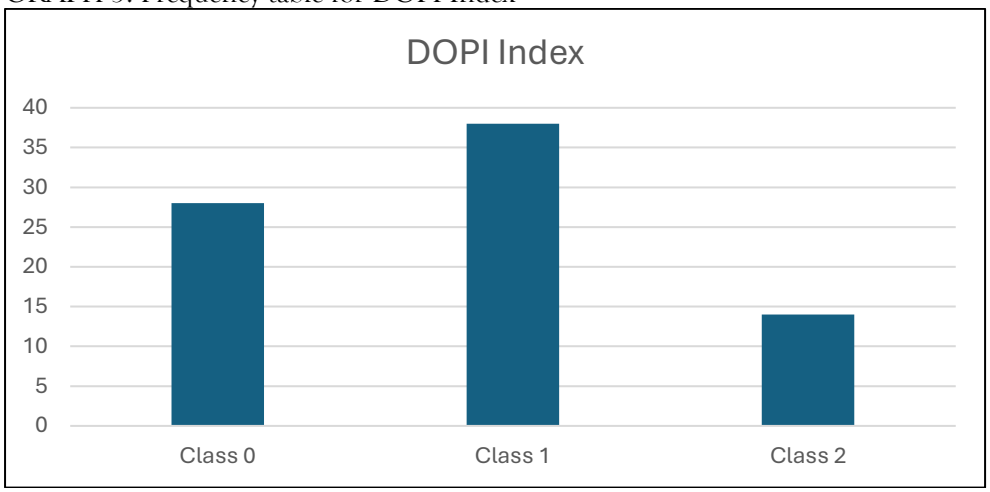


Table 3 and Graph 3 represents the frequency of different pigmentation levels in different patients according to the DOPI index. It was Class 0 in 28 patients, Class 1 in 38 patients, Class 2 in 14 patients and there were no patients having Class 3 index in our study.

TABLE 4: Descriptive Statistics for Direct Measurement using Calliper and Transgingival Probing

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Direct Measurement using Calliper	80	0.83	0.17	1.00	0.5329	0.23042
Transgingival Probing	80	1.13	0.20	1.33	0.6558	0.28585
Valid N (listwise)	80					

GRAPH 4: Descriptive Statistics for Direct Measurement using Calliper and Transgingival Probing

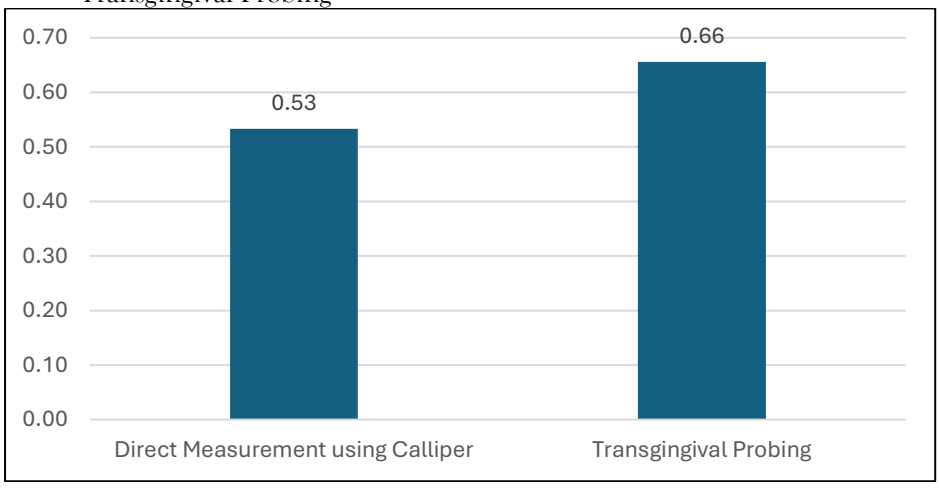


Table 4 and Graph 4 represents the mean values of the Direct Measurement using Calliper and Transgingival Probing. For Direct Measurement using Calliper it was 0.53 having minimum values of 0.7 to maximum values of 1.00. For Transgingival probing it was 0.66 having minimum values of 0.20 to maximum values of 1.33.

TABLE 5: Independent Samples Test for Direct Measurement using Calliper and Transgingival Probing

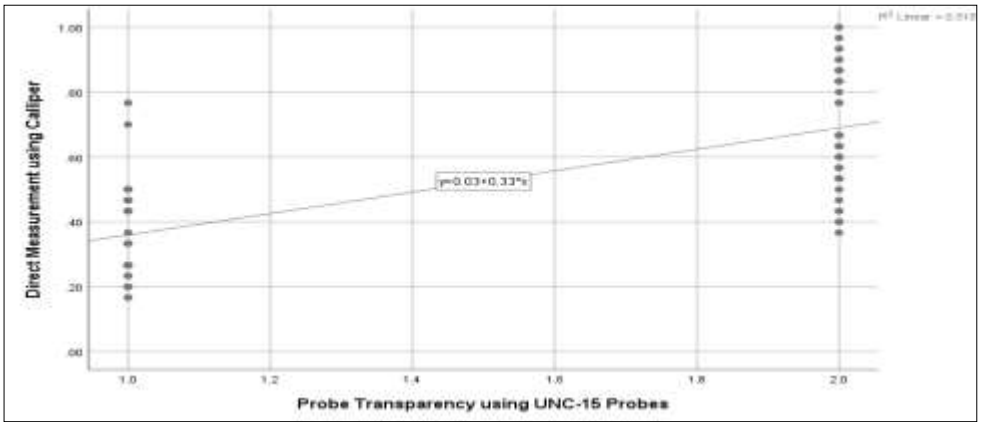
		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Probing	Equal variances assumed	6.070	0.015	-2.994	158	0.003
	Equal variances not assumed			-2.994	151.187	0.003

In Table 5, as the t value is negative, the mean of transgingival probing is higher than direct measurement using calliper therefore there is a statistically significant difference between both the groups.

TABLE 6: Spearman's correlation between Direct Measurement using Calliper and UNC-15 probe

			Direct Measurement using Calliper	Probe Transparency using UNC 15 Probes
Spearman's rho	Direct Measurement using Calliper	Correlation Coefficient	1.000	.733**
		Sig. (2-tailed)		0.000
		N	80	80
	Probe Transparency using UNC-15 Probes	Correlation Coefficient	.733**	1.000
		Sig. (2-tailed)	0.000	
		N	80	80
**. Correlation is significant at the 0.01 level (2-tailed).				

Graph 5: Correlation graph between Direct Measurement using Calliper and UNC-15 probe

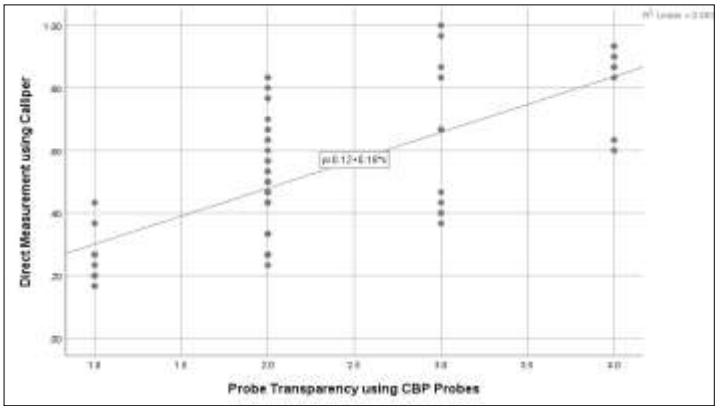


In Table 6 and Graph 5 there is a significant positive correlation between Direct Measurement using Calliper and UNC-15 probe which means that higher the value of direct measurement using calliper, higher the chance of the probe not being visible.

TABLE 7: Spearman's correlation between Direct Measurement using Calliper and CBP probe

			Direct Measurement Using Calliper	Probe Transparency Using CBP Probes
Spearman's rho	Direct Measurement using Calliper	Correlation Coefficient	1.000	.698**
		Sig. (2-tailed)		0.000
		N	80	80
	Probe Transparency using CBP Probes	Correlation Coefficient	.698**	1.000
		Sig. (2-tailed)	0.000	
		N	80	80
**. Correlation is significant at the 0.01 level (2-tailed).				

GRAPH 6: Correlation graph between Direct Measurement using Calliper and CBP probe.



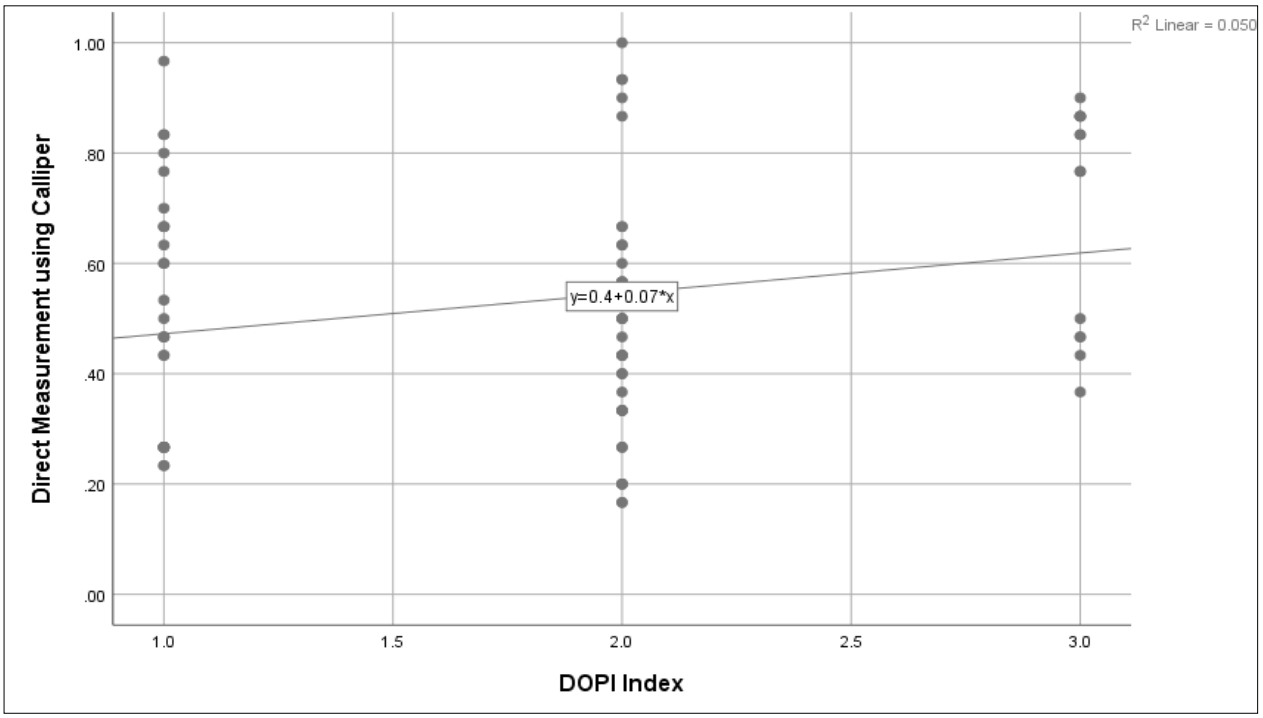
In Table 7 and Graph 6 there is a significant positive correlation between Direct Measurement using Calliper and CBP probe which means that higher the value of direct measurement using calliper, higher the chance of the probe not being visible.

TABLE 8: Spearman's correlation between Direct Measurement using Calliper and DOPI index

			Direct Measurement using Calliper	DOPI Index
Spearman's rho	Direct Measurement using Calliper	Correlation Coefficient	1.000	0.184
		Sig. (2-tailed)		0.102
		N	80	80
	DOPI Index	Correlation Coefficient	0.184	1.000

		Sig. (2-tailed)	0.102	
		N	80	80

GRAPH 7: Correlation graph between Direct Measurement using Calliper and DOPI index

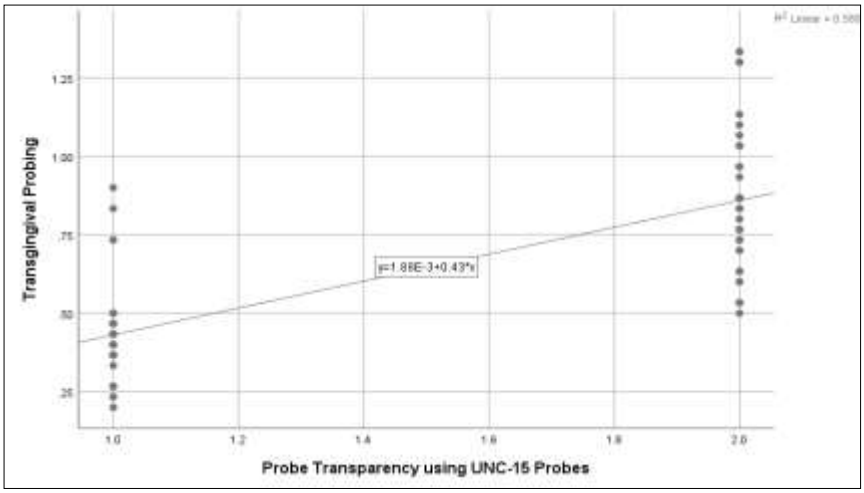


In Table 8 and Graph 7 there is a non-significant positive correlation between Direct Measurement using Calliper and DOPI index, means that there is a slight, positive relationship between the two variables, but this relationship is not strong enough or statistically significant to confidently say that one variable causes or is reliably associated with the other.

TABLE 9: Spearman's correlations between Transgingival probing and UNC-15 probe

			Transgingival Probing	Probe Transparency using UNC-15 Probes
Spearman's rho	Transgingival Probing	Correlation Coefficient	1.000	.789**
		Sig. (2-tailed)		0.000
		N	80	80
	Probe Transparency using UNC-15 Probes	Correlation Coefficient	.789**	1.000
		Sig. (2-tailed)	0.000	
		N	80	80
**. Correlation is significant at the 0.01 level (2-tailed).				

GRAPH 8: Correlation graph between Transgingival probing and UNC-15 probe

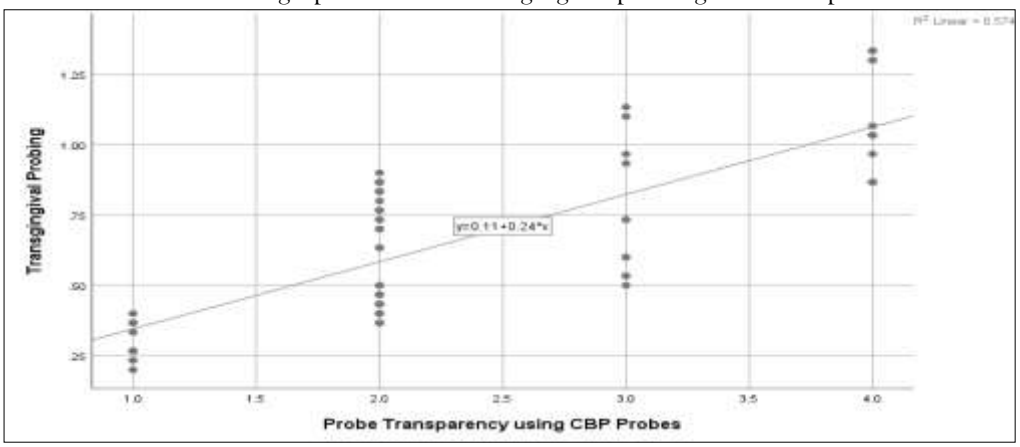


In Table 9 and Graph 8 there is a positive correlation between Transgingival probing and UNC-15 probe which means that higher the value of direct measurement using calliper, higher the chance of the probe not being visible.

TABLE 10: Spearman's correlations between Transgingival probing and CBP probe

			Transgingival Probing	Probe Transparency using CBP Probes
Spearman's rho	Transgingival Probing	Correlation Coefficient	1.000	.761**
		Sig. (2-tailed)		0.000
		N	80	80
	Probe Transparency using CBP Probes	Correlation Coefficient	.761**	1.000
		Sig. (2-tailed)	0.000	
		N	80	80
**. Correlation is significant at the 0.01 level (2-tailed).				

GRAPH 9: Correlation graph between Transgingival probing and CBP probe

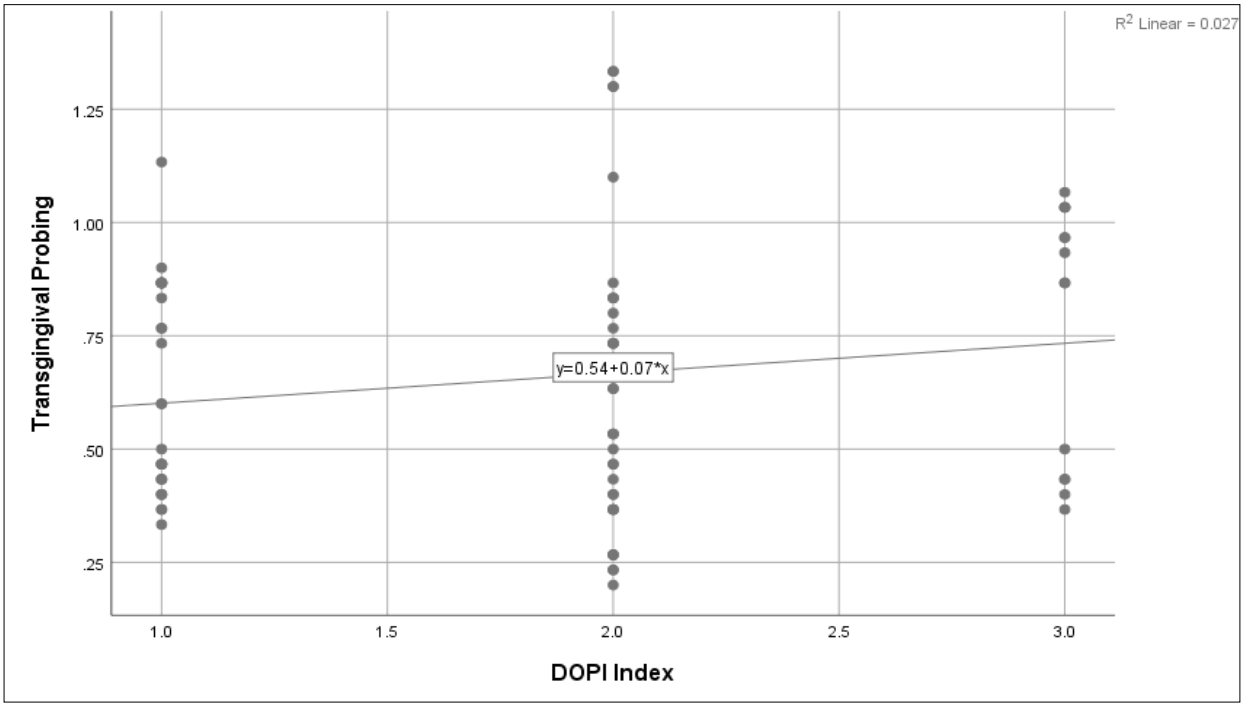


In Table 10 and Graph 9 there is a positive correlation between Transgingival probing and CBP probe which means that higher the value of direct measurement using calliper, higher the chance of the probe not being visible.

TABLE 11: Spearman's correlations between Transgingival probing and DOPI index

			Transgingival Probing	DOPI Index
Spearman's rho	Transgingival Probing	Correlation Coefficient	1.000	0.135
		Sig. (2-tailed)		0.232
		N	80	80
	DOPI Index	Correlation Coefficient	0.135	1.000
		Sig. (2-tailed)	0.232	
		N	80	80

GRAPH 10: Correlation graph between Transgingival probing and DOPI index



In Table 11 and Graph 10 there is a non-significant positive correlation between Transgingival probing and DOPI index, which means that there is a slight, positive relationship between the two variables, but this relationship is not strong enough or statistically significant to confidently say that one variable causes or is reliably associated with the other.

TABLE 12: Comparison between probe visibility and DOPI score

		DOPI Index			Total
		Class 0	Class 1	Class 2	
Probe Transparency using CBP Probes	White tip visible	2	8	2	12
	Green tip visible	20	19	5	44
	Blue tip visible	3	7	2	12
	Blue tip not visible	3	4	5	12
Probe Transparency using UNC-15 Probes	Visible	16	17	5	38
	Not Visible	12	21	9	42
Total		28	38	14	80

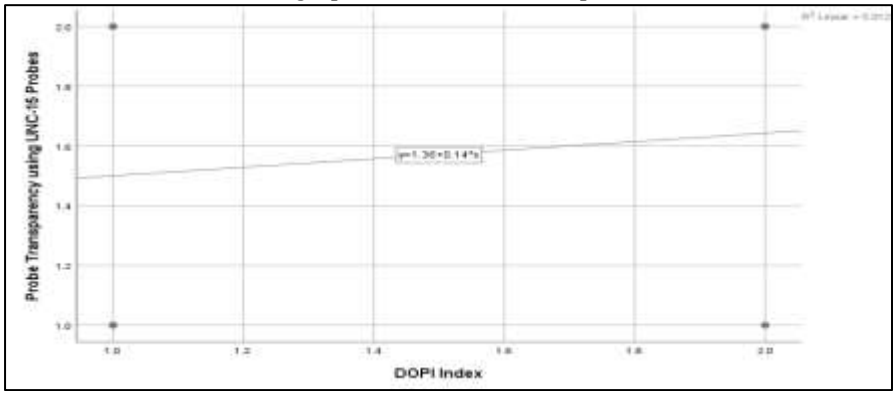
DOPI: Dummett Oral Gupta Index

In Table 12, it indicates that there were no subjects that had class 3 DOPI score. DOPI Classes 0 and 1 were combined to Class A and Class 2 assigned to Class B and Spearman's correlation test was carried out.

TABLE 13: Spearman's correlations between UNC-15 probe and DOPI index

			DOPI Index	Probe Transparency Using UNC-15 Probes
Spearman's rho	DOPI Index	Correlation Coefficient	1.000	0.109
		Sig. (2-tailed)		0.337
		N	80	80
	Probe Transparency Using UNC-15 Probes	Correlation Coefficient	0.109	1.000
		Sig. (2-tailed)	0.337	
		N	80	80

GRAPH 11: Correlation graph between UNC-15 probe and DOPI index

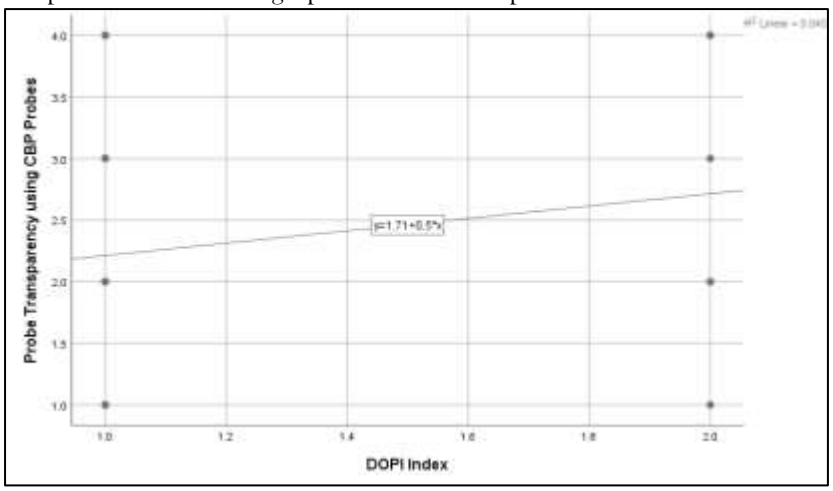


In Table 13 and Graph 11, A Spearman's rank-order correlation was run to determine the relationship between DOPI Index and Probe Transparency using UNC-15 Probes. There was a negligible, positive correlation between DOPI Index and DOPI Index and Probe Transparency using UNC-15 Probes, which was NOT statistically significant (rs(8) = .109, p = .337).

TABLE 14: Spearman's correlations between CBP probe and DOPI index

			DOPI Index	Probe Transparency using CBP Probes
Spearman's rho	DOPI Index	Correlation Coefficient	1.000	0.182
		Sig. (2-tailed)		0.106
		N	80	80
	Probe Transparency Using CBP Probes	Correlation Coefficient	0.182	1.000
		Sig. (2-tailed)	0.106	
		N	80	80

Graph 12: Correlation graph between CBP probe and DOPI index



A Spearman's rank-order correlation was run to determine the relationship between DOPI Index and Probe Transparency using CBP Probes. There was a negligible, positive correlation between DOPI Index and Probe Transparency using CBP Probes, which was NOT statistically significant (rs(8) = .182, p = .106).

Hence, from table 13 and 14 it can be concluded that there was no significant difference between UNC-15 probe visibility and CBP probe visibility between participants with class A and B levels of pigmentation.

TABLE 15: Mann Whitney Test between Direct Measurement using Calliper and transgingival probing with UNC-15 probe

Ranks				
Probe Transparency using UNC-15 Probes		N	Mean Rank	Sum of Ranks
Direct Measurement	Visible	38	22.74	864.00
	Not Visible	42	56.57	2376.00

using Calliper	Total	80		
Transgingival Probing	Visible	38	21.38	812.50
	Not Visible	42	57.80	2427.50
	Total	80		

Test Statistics[a]		
	Direct Measurement using Calliper	Transgingival Probing
Mann-Whitney U	123.000	71.500
Wilcoxon W	864.000	812.500
Z	-6.516	-7.013
Asymp. Sig. (2-tailed)	0.000	0.000
a. Grouping Variable: Probe Transparency using UNC-15 Probes		

The results from Table 15 indicate that the *Not Visible* group had the highest concentrations overall in both Direct Measurement using Calliper and Transgingival Probing. In terms of Direct Measurement using Calliper, this group had the highest mean rank, suggesting it exhibited the highest concentrations. Similarly, for Transgingival Probing, the *Not Visible* group also had the highest mean rank, indicating it surpassed the other groups in terms of concentration levels for this measurement as well.
From this data, it can be concluded that the *Not Visible* group had statistically significantly higher values than the *Visible* group in both Direct Measurement using Calliper and Transgingival Probing. Specifically, Direct Measurement using Calliper in the *Not Visible* group was significantly higher than in the *Visible* group (U = 123, p = 0.000). Similarly, Transgingival Probing in the *Not Visible* group was also significantly higher than in the *Visible* group (U = 71.50, p = 0.000).

TABLE 16: Kruskal Wallis Test between Direct Measurement using Calliper and transgingival probing with CBP probe

Ranks			
Probe Transparency using CBP Probes		N	Mean Rank
Direct Measurement using Calliper	White tip visible	12	9.92
	Green tip visible	44	38.52
	Blue tip visible	12	50.71
	Blue tip not visible	12	68.13
	Total	80	
Transgingival Probing	White tip visible	12	7.46
	Green tip visible	44	38.28
	Blue tip visible	12	50.54
	Blue tip not visible	12	71.63
	Total	80	
Test Statistics[a,b]			

	Direct Measurement using Calliper	Transgingival Probing
Kruskal-Wallis H	40.534	48.623
df	3	3
Asymp. Sig.	0.000	0.000
a. Kruskal Wallis Test		
b. Grouping Variable: Probe Transparency using CBP Probes		

In Table 16, Kruskal-Wallis H test showed that there was a statistically significant difference in Direct Measurement using Calliper between the different Probe Transparency using CBP Probes, $\chi 2 = 40.534$, $p = 0.000$, with a mean rank Direct Measurement using Calliper of 9.92 for White tip visible, 38.52 for Green tip visible 50.71 for Blue tip visible and 68.13 for Blue tip not visible.
In Table 16, Kruskal-Wallis H test showed that there was a statistically significant difference in Transgingival Probing between the different Probe Transparency using CBP Probes, $\chi 2 = 48.623$, $p = 0.000$, with a mean rank Direct Measurement using Calliper of 7.46 for White tip visible, 38.28 for green tip visible 50.54 for Blue tip visible and 71.63 for Blue tip not visible.
For both **Direct Measurement using Calliper** and **Transgingival Probing**, the **Blue tip not visible** group shows the highest mean rank, indicating it has the highest measurements overall. On the other hand, the **White tip visible** group has the lowest mean rank, showing the lowest measurements in both tests. The **Green tip visible** and **Blue tip visible** groups show intermediate ranks, with **Blue tip visible** outperforming **Green tip visible** in both measurements.
These results suggest that the transparency of the probe (particularly the **Blue tip not visible** probe) plays a significant role in the measurements obtained, and there is a clear statistical difference between the probe transparencies for both types of measurement.

TABLE 17: Kruskal Wallis Test between Direct Measurement using Calliper and transgingival probing with DOPI index.

Ranks			
DOPI Index		N	Mean Rank
Direct Measurement using Calliper	Class 0	28	38.91
	Class 1	38	35.86
	Class 2	14	56.29
	Total	80	
Transgingival Probing	Class 0	28	39.38
	Class 1	38	37.03
	Class 2	14	52.18
	Total	80	

Test Statistics[a,b]		
	Direct Measurement using Calliper	Transgingival Probing
Kruskal-Wallis H	8.141	4.468

df	2	2
Asymp. Sig.	0.017	0.107
a. Kruskal Wallis Test		
b. Grouping Variable: DOPI Index		

In Table 17, Kruskal-Wallis H test showed that there was a statistically significant difference in Direct Measurement using Calliper between the different DOPI Index, $\chi 2 = 8.141$, $p = 0.017$, with a mean rank Direct Measurement using Calliper of 38.91 for Class 0, 35.86 for Class 1 and 56.29 for Class 2.
The significant result suggests that the DOPI Index classification influences the measurements taken using the Calliper, with Class 2 showing higher values than Class 0 and Class 1. This could indicate that individuals in **Class 2** tend to have higher concentrations in Direct Measurement using Calliper compared to those in the other classes.
In Table 17, Kruskal-Wallis H test showed that there was NO statistically significant difference in Transgingival Probing between the different DOPI Index, $\chi 2 = 4.468$, $p = 0.107$, with a mean rank Direct Measurement using Calliper of 39.38 for Class 0, 37.03 for Class 1 and 52.18 for Class 2.
Although **Class 2** has the highest mean rank for Transgingival Probing, the p-value of 0.107 suggests that this difference is not statistically significant. Therefore, while there is a trend showing **Class 2** having the highest mean rank, this is not strong enough to conclude a true difference between the groups hence the DOPI Index classification does not influence this measurement.

TABLE 18: Regression analysis to analyse the associations between the visibility of the UNC-15 probe with gingival pigmentation.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.324	0.155		8.523	0.000
	DOPI Index	0.110	0.079	0.155	1.384	0.170
a. Dependent Variable: Probe Transparency using UNC-15 Probes						

Table 18 provides us with the necessary information to predict Probe Transparency using UNC-15 Probes from DOPI Index, as well as determine whether DOPI Index contributes statistically significantly to the model.
Since the **p-value is greater than 0.05 (0.170)**, we conclude that the **DOPI Index** does **not contribute statistically significantly** to predicting **Probe Transparency using UNC-15 Probes** in the regression model. Therefore, the **DOPI Index** is not a significant predictor of probe transparency based on this analysis.

TABLE 19: Regression analysis to analyse the associations between the visibility of the CBP probe with gingival pigmentation.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.968	0.281		7.013	0.000
	DOPI Index	0.182	0.143	0.142	1.269	0.208
a. Dependent Variable: Probe Transparency using CBP Probes						

The Coefficients table provides us with the necessary information to predict Probe Transparency using CBP Probes from DOPI Index, as well as determine whether DOPI Index contributes statistically significantly to the model.
Since the **p-value is greater than 0.05 (0.208)**, we conclude that the **DOPI Index** does **not contribute statistically significantly** to predicting **Probe Transparency using CBP Probes** in the regression model. Therefore, the **DOPI Index** is not a significant predictor of probe transparency based on this analysis.

DISCUSSION

The clinical assessment of gingival thickness (GT) involves various methods, each with its own advantages and limitations. Transgingival probing is an invasive technique that offers direct measurements but may cause discomfort. The probe transparency method uses periodontal probes to evaluate GT based on visibility, providing simplicity yet limited precision. Cone-Beam Computed Tomography (CBCT) delivers accurate, non-invasive measurements but requires advanced equipment. Ultrasound imaging and digital superimposition are reliable, non-invasive options, with the latter offering high accuracy through specialized software. Visual assessment relies on clinician experience but is subjective. Colorvue biotype probes (CBP) simplify GT classification into categories, though they may fail to capture subtle differences. Histological analysis is the gold standard for precision but is invasive and unsuitable for routine use. Overall, the selection of an appropriate method depends on clinical requirements, resources, and the desired accuracy. Discussing these methods emphasizes their applicability and relevance in various contexts.The present study used four methods to evaluate the thickness of the gingiva. These were direct measurement using a calliper, transgingival probing method using endodontic spreader, probe visibility method using the CBP, and probe visibility method using the UNC-15 probe. Direct measurement using calliper was considered as the gold standard [18].
Descriptive Statistics for Direct Measurement using Calliper and Transgingival Probing (Table 4) showed that the range value for Direct Measurement using Calliper was 0.83 having minimum values of 0.17 to maximum values of 1.00 with mean (SD) of 0.53(0.23) For Transgingival probing it was 1.13 having minimum values of 0.20 to maximum values of 1.33 and mean (SD) value of 0.66(0.29). The range tells us the extent variation in measurements. A smaller mean value of 0.53 for the Calliper indicates less variation, while a larger mean value of 0.66 for Transgingival Probing indicates more variation in measurements highlighting that the calliper might deliver more consistent readings due to its narrower range, while transgingival probing captured a broader variation in data. B. Table 5 presents Levene's Test for Equality of Variances, revealing a significant difference between the groups, with a p-value of 0.003, which is less than the set significance level of $p>0.05$. Table 6 highlights a Spearman's correlation between Direct Measurement using Calliper and UNC-15 probe, indicating a positive correlation for both methods. However, Direct Measurement using Calliper shows a stronger and more precise positive relationship compared to Probe Transparency using UNC-15 Probes and CBP probes (Table 7). The study aligns with findings by Nik-Azis NM [32], where Transgingival and calliper methods display good agreement and significant correlation ($r = 0.229$; $p = 0.003$). Transgingival needle probing constitutes an accurate method for measuring GT at various levels.similar findings were seen in study done by Frost NA [35]. Contrarily, the study contradicts findings by Sala L [36], which state that the tension-free calliper is not an effective tool for predicting thick gingival biotypes. The results align with D. Kloukos' [11] research, which concludes good agreement for the color-coded periodontal probe (intraclass correlation coefficient = 0.624). Transgingival measurements with a standard periodontal probe are found to be more accurate than those other methods [37] .
The Dummett Oral Pigmentation Index (DOPI) is a prominent tool for evaluating gingival pigmentation, based on visual inspection to classify pigmentation levels. A study by Nejad AE et al. demonstrated high internal and external reproducibility for DOPI, with Fleiss kappa values exceeding 0.8 across all time points (0, 7, and 14 days), reflecting strong examiner agreement. Spearman's correlation coefficient is positive and significant ($P < 0.001$), affirming DOPI's reliability in classifying gingival pigmentation and marking it as an effective and reproducible tool for this study. Table 8 provides Spearman's correlation between Direct Measurement using Calliper and the DOPI index, with a coefficient value of 0.184, indicating a very weak correlation and suggesting little to no association. The p-value of 0.102 reflects

statistical insignificance, showing that these observed correlations are not robust enough to draw confident conclusions, as the p-value exceeds 0.05. Table 9 and 10 shows Spearman's correlations between Transgingival probing and Probe Transparency using UNC-15 and Transgingival probing and CBP probe. Transgingival Probing showed a positive correlation of 0.789 with UNC-15 probe and 0. 761 with CBP probe, these values were statistically significant at p>0.0001. Transgingival probing shows perfect consistency with a correlation value of 1, in comparison to UNC-15 probe and CBP probe. da Costa FA et al. [33] conducted a study for the identification of thin and thick gingival phenotypes by two transparency methods. This study compares the diagnostic accuracy of transparency methods using steel probes (SP) and plastic color-coded probes (CCP) for identifying gingival phenotypes based on gingival thickness (GT) and keratinized tissue width (KTW). Maxillary anterior teeth (n = 300) from 50 individuals are assessed, with thin phenotypes classified as GT ≤1 mm (57%) and thick phenotypes as GT >1 mm (43%). SP and CCP show high sensitivity (>0.94) for identifying thin phenotypes but low specificity (0.35–0.39) for diagnosing thick phenotypes. Diagnostic accuracy is similar for SP (0.69) and CCP (0.70), highlighting their comparable effectiveness in identifying thin gingival phenotypes. Table 11,13 and 14 describes Spearman's correlation between Transgingival probing , Probe Transparency using UNC-15 probes and CBP probe with DOPI index. The Spearman's correlation coefficient correlating Transgingival probing and DOPI index showed a value of 0.135 ,UNC-15 Probe and DOPI index showed a value of 0.109 and CBP probe and DOPI index showed a value of 0.106 indicating a very weak positive relationship between Transgingival probing and the DOPI index, meaning Transgingival probing and DOPI index are poorly associated, The results were statistically insignificant. Table 15 indicated that Mann Whitney test values for both Direct Measurement using Calliper and Transgingival Probing was significantly higher for *Not Visible* group . Table 16 showed that for both Direct Measurement using Calliper and Transgingival Probing,in the current study the Blue tip not visible group showed the highest mean rank, indicating it has the highest measurements overall. A study done by Bertl K [31] revealed that in their study gingival thickness ranged from 0.57 to 2.37 mm. Colored Periodontal Probe (CPP) resulted in medium judgment for 87% of cases, but had limitations in accurately identifying "thin" cases where 88% were misclassified as not thin when ≤1 mm and distinguishing "thick" and "very thick" cases. Though standard periodontal probe(SPP) outperformed Color Periodontal Probe , it still wrongly classified 64% of cases ≤1 mm as not thin. Positive predictive value was high (≥ 0.82) across methods, but all exhibited high false negative rates (≥ 0.73). Examiner agreement was highest for SPP (κ = 0.427), with visual judgment and CPP showing only fair (κ = 0.211) and slight (κ = 0.112) agreement. Overall, CPP struggled to reliably identify thin high-risk cases. Kong J [38] in his study showed that the probe method effectively differentiates between gingival phenotype (GP) categories, though further research is needed to evaluate its sensitivity in marginal cases. In contrast, the visual method lacks accuracy and consistency among assessors in identifying GP. De Rouck T [19] in their study on gingival biotypes revealed that thin gingiva is observed in about one-third of the sample, primarily in females with slender teeth, a narrow zone of keratinized tissue, and a highly scalloped margin ("thin-scalloped biotype," cluster A1). Thick gingiva is found in two-thirds of the sample, mostly in males. Half display quadratic teeth, a broad keratinized tissue zone, and a flat margin ("thick-flat biotype," cluster B), while the other half exhibit slender teeth, a narrow keratinized tissue zone, and a high scallop (cluster A2). Uysal BF [34] conducted a study that explored the agreement among dentists in classifying gingival phenotype (GP) through periodontal probe visibility (PPV) using various probe types and visual methods, as well as its relationship with gingival thickness (GT). Photographs taken with different probes showed that the visual method had poor to fair agreement in GP classification, and PPV with white-tipped CCPP had the lowest agreement. The highest agreement in singular PPV was observed with CCPP blue (κ = 0.932), followed by CCPP green (κ = 0.791), MPP black (κ = 0.783), SPP (κ = 0.730), and MPP gray (κ = 0.690). Combined PPV data demonstrated moderate to substantial agreement with MPP and fair to moderate agreement with CCPP. GT corresponding to GP classifications based on combined PPV was comparable. However, no significant GT cutoff value was found to distinguish thin and non-thin phenotypes. Overall, determining precise GT for GP classification remains challenging due to potential misclassification, despite acceptable agreement across probe types. Fischer KR [23] conducted a study on gingival phenotype (GP) assessment methods based on soft tissue transparency using PCP12, DBS12, and CBP probes, evaluated on pig

specimens with tissue thicknesses from 0.2 to 1.25 mm. Thresholds for GP differentiation were identified: <0.5 mm as thin, 0.5–0.8 mm as moderate, and >0.8 mm as thick, consistent across methods. Background color minimally influenced results for PCP12 and DBS12, and assessor experience showed no significant impact on GP classification. CBP provided detailed classifications (thin/moderate/thick/very thick) and showed a high predictive value. Overall, GP differentiation into three entities was deemed effective, and all methods were easy to perform with high potential for clinical relevance. Therefore, the DOPI Index is not a significant predictor of probe transparency based on this analysis. These findings were in line with study done by Dr. Shahna N et al [39] which said that The DOPI (Dummett Oral Pigmentation Index) is specifically designed to measure gingival pigmentation based on the visual intensity and distribution of melanin pigmentation. It assigns scores to classify pigmentation but does not address gingival transparency or thickness, which are crucial for identifying gingival phenotypes (thin or thick gingiva).
Probe transparency, a method often used to assess gingival thickness and phenotype, involves evaluating whether a periodontal probe is visible through the gingiva. This method directly relates to the gingival tissue's thickness and keratinized tissue width (KTW). Since DOPI focuses solely on pigmentation and not the structural or optical properties of the gingiva, it cannot serve as a reliable predictor for probe transparency. In other words, the extent of pigmentation measured by DOPI does not correlate with the degree of probe visibility or the classification of gingival phenotype.
Studies often rely on transgingival measurements, gingival transparency assessments with specific probes, or other indices when evaluating phenotypes. For example, methods like those using steel or color-coded probes have demonstrated their diagnostic accuracy for phenotype classification, but pigmentation-related indices such as DOPI are not relevant in this context. Therefore, while DOPI is valuable for assessing pigmentation, its utility is unrelated to diagnosing gingival thickness or phenotype through transparency methods.

LIMITATIONS

The study's small sample size and focus on maxillary central incisors limit generalizability. Absence of a definitive gold standard for gingival thickness measurement, potential variability in pigmentation across sites, and non-standardized probing force may have affected accuracy. Patient discomfort during probing could also have influenced results. Differentiating between the visibility of the white-colored probe and blanching of the gingiva due to probing might have created confusion during assessments, leading to potential misinterpretations. These factors collectively underline key areas that warrant further attention and standardization in future research.

CONCLUSION

After analysing the results of the present study, we may conclude that:

- **Positive Correlations**: There are positive correlations between measurements and probe visibility.
- **DOPI Index and Pigmentation**: Relationships involving the DOPI Index and pigmentation levels lack statistical significance. This suggests that the extent of gingival pigmentation, as assessed by DOPI, does not strongly influence probe transparency or visibility.
- **Probe Visibility Impact**: Probe visibility influences both Direct Measurement using Calliper and Transgingival Probing.
- **DOPI Index and Direct Measurement**: The DOPI Index significantly impacts Direct Measurement using Calliper.
- **DOPI Index and Transgingival Probing**: The DOPI Index has no significant effect on Transgingival Probing.
- **DOPI Index and Probe Transparency**: The DOPI Index does not significantly contribute to predicting probe transparency for either UNC-15 Probes or CBP Probes. Regression models showed p-values greater than 0.05 (0.170 for UNC-15 and 0.208 for CBP), indicating no significant relationship.

Hence, the DOPI Index is not a reliable or significant predictor of probe transparency.

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