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Gingival Pigmentation and Its Association with Skin Complexion and Periodontal Status Among Patients Attending a Tertiary Hospital in Nigeria: A Cross-Sectional Study

Alade GO[1], Ogundana AC[2]
[1] Department of Preventive and Social Dentistry, Faculty of Dentistry, University of Port Harcourt, Nigeria
[2] Department of Preventive Dentistry, Faculty of Dental Sciences, University of Lagos, Nigeria
Correspondence: Alade GO
Email: grace.alade@uniport.edu.ng

ABSTRACT
Introduction: Gingival color varies among different races and can be affected by a number of factors including pigmentation. Gingival pigmentation is of aesthetic concern in some individuals and has been linked to skin complexion. However, there is paucity in the literature regarding the association between gingival pigmentation and periodontal disease.
Methods: This was a cross-sectional study conducted among participants who attended the Periodontology Clinic, University of Port Harcourt Teaching Hospital (UPTH). A convenient, non-probability sampling technique was used to recruit participants who gave consent. Data collection was done using a semi-structured questionnaire, which had three sections. Section A included information on sociodemographics, Section B included intraoral examination to assess periodontal health status, and Section C included assessment of gingival pigmentation and skin pigmentation. The modified Community Periodontal Index (CPI) was used to assess periodontal health status. Gingival pigmentation was assessed using the Dummett-Gupta Oral Pigmentation Index (DOPI) and the index by Ponnaiyan et al., while the Fitzpatrick scale was used to assess skin complexion.
Results: There were 114 participants, with age range 17–84 years, M:F = 1:1.38. The prevalence of gingival pigmentation among the participants was 80.7%, with more females presenting with gingival pigmentation than males. More participants from other ethnic groups had heavy pigmentation compared to those from the three common ethnic groups; this finding was not statistically significant ($p = 0.746$). Skin pigmentation was significantly associated with gingival pigmentation ($p < 0.001$). There was a statistically significant association between gingival pigmentation and periodontal disease, as more participants with heavy pigmentation had healthy periodontium (CPI 0) compared with participants with pink tissue ($p = 0.003$).
Conclusion: The prevalence of gingival pigmentation in this study was 80.7%. It was higher among participants from the other ethnic groups. Gingival pigmentation was significantly associated with skin complexion and periodontal disease.
KEYWORDS: Gingival pigmentation, skin complexion, periodontal status

INTRODUCTION
The gingiva is a fibrous mucosa that surrounds the teeth and covers the coronal portion of the alveolar process; its color varies in the papillary, marginal, and attached gingiva.[1] It also varies among different races, from pale pink and coral pink in Caucasians[2] to brown and blue-black in Africans or Asians.[3] The gingival color is influenced by the number and size of vasculature, epithelial thickness, degree of keratinization, and pigments within the gingival epithelium. Melanin, carotene, reduced hemoglobin, and oxy-hemoglobin are the key pigments contributing to the color of gingiva, of which melanin is the most common.[4]
Melanin is the basic pigment which gives color to the skin, gingiva, and remaining mucous membrane, and it appears as early as three hours after birth in the oral tissues.[5] It is a non-hemoglobin-derived pigment formed by melanocytes, which are dendritic cells of neuroectodermal origin located in the basal and spinous layers of the gingival epithelium. It is generally accepted that pigmented areas are present only when melanin granules produced by melanocytes are transported to keratinocytes.[6] There are three basic types of melanin: eumelanin, pheomelanin, and neuromelanin. The most common type is eumelanin, and it is produced in 'black' and 'brown' subtypes, which is more photoprotective.[7]
Gingival pigmentation is a discoloration of the gingiva due to a variety of lesions and conditions.8 It may range from physiologic reasons (e.g., racial pigmentation) to manifestations of systemic illness (e.g., Addison's disease) to malignant neoplasms (e.g., melanoma and Kaposi's sarcoma).[5] It is classified into physiologic or pathologic pigmentation. Physiologic pigmentation develops during the first two decades of life but may be noticed later in life. It is asymptomatic and no treatment is required. Moreover, color variation may be uniform, unilateral, bilateral, mottled, macular, or blotched and may involve the gingival papillae alone or extend throughout the gingiva and into other oral tissues. Physiologic pigmentation clinically manifests as multifocal or diffuse melanin pigmentation with variable prevalence in different ethnic groups. It is common in African, Asian, and Mediterranean populations, and it is due to greater melanocyte activity rather than a greater number of melanocytes; the attached gingiva is the most common site of such pigmentation.[8]
The process of pigmentation consists of three phases: Phase 1 (Activation of melanocytes) occurs when the melanocytes are stimulated by factors like stress hormones, sunlight, etc., leading to production of chemical messengers like melanocyte-stimulating hormone. In Phase II (Synthesis of melanin), melanocytes make granules called melanosomes, which occurs when the enzyme tyrosinase converts the amino acid tyrosine into a molecule called dehydroxyphenylalanine (DOPA). Tyrosinase then converts DOPA into a secondary chemical, dopaquinone. After a series of reactions, dopaquinone is converted into either dark melanin (eumelanin) or light melanin (pheomelanin). Phase III (Expression of melanin) involves the transfer of melanosomes from the melanocytes to the keratinocytes, which are the skin cells located above melanocytes in the epidermis. After this,

melanin color eventually becomes visible on the surface of the skin.[5] The development of gingival pigmentation is regulated by the genetic makeup of an individual[9] and its intensity is influenced by physical, chemical, and hormonal factors.[10,11] Gingival pigmentation was reported to be 54% among Blacks.[12]

The defensive role of melanin-pigmented gingiva in the presence of plaque-induced inflammation is not fully understood. It has been hypothesized that oral mucosal melanin can act as a defense barrier by scavenging antioxidants and preventing oxidative stress.[13]This is achieved by binding toxins such as free radicals associated with superoxide anion, which are generated as a result of the 'respiratory burst' of phagocytosis, and polycyclic compounds to melanin. These free radicals play a potential role in matrix destruction in the inflamed periodontium by depolarizing proteoglycans and hyaluronan, and activating neutrophil collagenase, which in turn initiates matrix degradation.[14]

It is reported that there is a correlation between gingival pigmentation and skin complexion among White, Negro, Asiatic, and Indian populations;[15] the color of gingiva and skin are two indispensable parameters for an aesthetic smile and a pleasant facial appearance. Gingival pigmentation has also been associated with periodontal disease; it was reported to be inversely related to periodontitis, as there was a decrease in the markers of gingival inflammation in pigmented gingival subjects compared to non-pigmented gingival subjects.[16]

There is paucity in the literature regarding the association between gingival pigmentation, skin pigmentation, and periodontal disease among Nigerians. A previous study was conducted among Nigerians which assessed the association between gingival color and skin complexion;[15] however, the prevalence of gingival pigmentation and its relationship with periodontal status was not assessed, representing a gap in knowledge. Hence, this study aims to assess the prevalence of gingival pigmentation among the participants, its distribution among the ethnic groups in Nigeria, and its association with skin complexion. Additionally, the study aims to assess the association between gingival pigmentation and periodontal disease among participants attending the University of Port Harcourt Teaching Hospital.

METHODS

Study Design and Setting: This was a cross-sectional study conducted among participants who attended the Periodontology Clinic, University of Port Harcourt Teaching Hospital (UPTH), Port Harcourt, Rivers State, Nigeria, between November 2024 and May 2025. UPTH is a tertiary health facility serving as a major referral center for the South-South region of Nigeria.

Participants: A convenient, non-probability sampling technique was used to recruit participants who presented at the clinic during the study period and met the eligibility criteria.

Eligibility criteria: Inclusion criteria: Patients who gave consent, aged ≥ 17 years, with at least 20 teeth with uniformly pigmented and non-mottled labial gingivae between the maxillary central and lateral incisors, and whose skin color was distinctly dark or light.

Exclusion criteria: Patients who smoked or had any systemic diseases/conditions such as diabetes mellitus, pregnancy, leukemia, recent periodontal treatment, on medications that could affect or modify the periodontium or oral pathology (such as Addison's disease, Peutz-Jeghers syndrome) which might induce color changes, drug or chemical pigmentation, mottling, chemical skin peeling, albinism, and mixed racial skin were excluded from the study.

Variables: The primary outcome variables were gingival pigmentation (assessed by location and intensity) and periodontal status. The secondary outcome variable was skin complexion. Predictor variables included sociodemographic characteristics (age, sex, highest educational status, ethnicity, and marital status).

Data Sources and Measurement: Data Collection Instrument: The researchers collected data using a semi-structured questionnaire, which had three sections. Section A included information on sociodemographics (age, sex, highest educational status, ethnicity, and marital status). Section B included intraoral examination to assess periodontal health status. Section C included assessment of gingival pigmentation and skin pigmentation.

Pretesting and Validity: After face validity of the questionnaires by the first author and another dentist, the questionnaires were pre-tested among dental house officers to ensure simplicity and ease of understanding by the participants. Data were collected by two examiners, and the Cohen's kappa coefficient for inter-examiner variation was 0.84.

Periodontal Assessment: The modified Community Periodontal Index (CPI) was used to assess periodontal health status[18]. The examination of signs of periodontal disease was performed with the aid of a standardized CPITN-C probe and mouth mirror. The

CPITN-C probe has a ball tip of 0.5 mm diameter, and black band markers between 3.5 mm to 5.5 mm from the tip and at 8.5 mm and 11.5 mm from the tip.

CPI scores:

- 0 = Healthy
- 1 = Bleeding on probing
- 2 = Presence of supragingival and subgingival calculus
- 3 = Pocket depth 4–5 mm
- 4 = Pocket depth ≥ 6 mm

Measurement of Community Periodontal Index was carried out by dividing the mouth into six sextants: 18–14, 13–23, 24–28, 34–38, 33–43, and 43–48. It was recorded only for index teeth. The indexed teeth in each sextant were examined by running the CPI probe around the whole circumference of the tooth, and pocket depths were measured at six sites per tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual/palatal, mid-lingual/palatal, and disto-lingual/palatal).

For analysis, CPI codes were categorized as follows: Code 0 (Healthy) was categorized as healthy periodontium; Code 1 (Bleeding on probing) and Code 2 (Calculus detected during probing) were categorized as gingivitis; while Code 3 (pocket depth of 4–5 mm) and Code 4 (pocket depth of 6 mm or more) were categorized as periodontitis.

Assessment of Gingival Pigmentation: Gingival pigmentation was assessed using the Dummett-Gupta Oral Pigmentation Index (DOPI)[19] and the index by Ponnaiyan et al.[7]

According to the classification by Ponnaiyan et al., gingival pigmentation was classified based on location, as follows:

- Pink tissue - no pigmentation
- Class I – Pigmentation in the attached gingiva only
- Class II – Pigmentation in attached gingiva and interdental papilla
- Class III – Diffuse pigmentation involving all parts of the gingiva
- Class IV – Pigmentation in marginal gingiva only
- Class V – Pigmentation in interdental papilla only
- Class VI – Pigmentation in marginal gingiva and interdental papilla

The Dummett Oral Pigmentation Index (DOPI) represents the assignment of a composite numerical value to the total melanin pigmentation manifested on clinical examination of various parts of the gingiva. The criteria are as follows:

- 0 - Pink tissue (no clinical pigmentation)
- 1 - Mild, light brown tissue (mild clinical pigmentation)
- 2 - Medium brown or mixed pink or brown tissue (moderate clinical pigmentation)
- 3 - Deep brown or blue/black tissue (heavy clinical pigmentation)

Assessment of Skin Complexion: Skin complexion was assessed according to the Fitzpatrick scale[20]. The areas not exposed to the sun, such as the region of the zygoma of the face, or under the arm or behind the ear, were used in natural daylight to assess the color of skin.

- I - Pale white skin
- II - White skin
- III - Light brown skin
- IV - Moderate brown skin
- V - Dark brown skin
- VI - Deeply pigmented dark brown to black skin

Bias: To minimize measurement bias, standardized indices (CPI, DOPI, and Fitzpatrick scale) were used. Data were collected by two examiners, and inter-examiner reliability was assessed (Cohen's kappa coefficient = 0.84), indicating excellent agreement. Pre-testing of the questionnaire was conducted to ensure clarity and reduce information bias. Selection bias was minimized by applying consistent eligibility criteria to all participants attending the clinic during the study period.

Study Size: The sample size was scientifically determined based on reported proportions[17] to be 125. One hundred and thirty questionnaires were distributed; however, 114 questionnaires were accurately answered and included in the analysis, yielding a response rate of 87.7%.

Quantitative Variables: Continuous variables (age) were expressed as means and standard deviations.

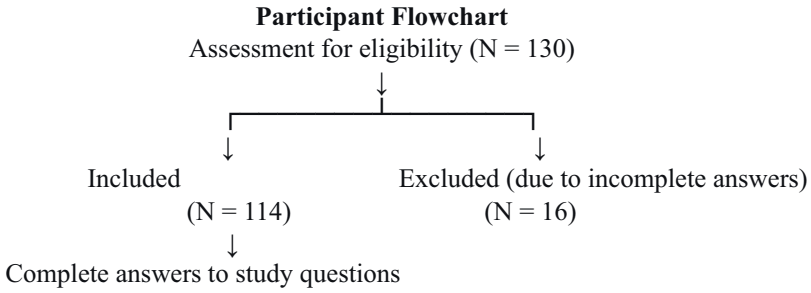
Categorical variables: (sex, educational status, marital status, ethnicity, gingival pigmentation location and intensity, skin

complexion, periodontal status) were presented as frequencies and percentages. For analysis, gingival pigmentation intensity was categorized into four levels (none, mild, moderate, heavy), skin complexion into six types (I–VI), and periodontal status into three categories (healthy, gingivitis, periodontitis).

Statistical Methods: Statistical analysis was performed using the Statistical Product and Service Solution (SPSS) version 25.0 (IBM SPSS Inc., Chicago, Illinois).
Descriptive statistics: Continuous variables were expressed as means and standard deviations. Categorical variables were presented as frequencies and percentages.
Inferential statistics: Differences between groups were compared using the chi-square test for categorical variables and the independent t-test for continuous variables. Binary logistic regression was used to estimate the odds ratio (OR) and 95% confidence interval (CI) for the association between exposure variables (skin complexion, gingival pigmentation) and outcome variables (gingival pigmentation, periodontal status). The level of statistical significance was set at P-values < 0.05.

Missing data: There were no missing data for any variable, as incomplete questionnaires (n=16) were excluded from the analysis, and all included questionnaires (n=114) were fully completed.

Ethical Considerations: Ethical approval (UPTH/ADM/90/S.II/VOL.XI/1620) for the study was obtained from the Health Research and Ethics Committee of the University of Port Harcourt Teaching Hospital prior to commencement of the study. Written informed consent was obtained from all participants. Participation was voluntary, and confidentiality of all data was assured.



RESULTS

Sociodemographic Characteristics of Participants: Table 1 shows the sociodemographic characteristics of the 114 participants. The age range of the population was 17–84 years, with a mean age of 40.94 ± 16.93 years. There were 48 males and 66 females, with a male-to-female ratio of 1:1.38. Most participants (64.0%) had tertiary education, and 56.1% were married.

Table 1: Sociodemographic Characteristics of Participants (N = 114)

Variable		Frequency	Percentage
Age group (years)	< 20	6	5.3
	20–29	33	28.9
	30–39	18	15.8
	40–49	19	16.7
	50–59	21	18.4
	60–69	11	9.6
	70–79	4	3.5
	80–89	2	1.8
Sex	Female	66	57.9
	Male	48	42.1
Educational status	Primary	1	0.9
	Secondary	30	26.3
	Tertiary	73	64.0
	Postgraduate	10	8.8
Marital status	Single	47	41.2
	Married	64	56.1
	Widowed	3	2.6
Ethnicity	Igbo	45	39.5
	Hausa	1	0.9
	Yoruba	8	7.0
	Others	60	52.6

Distribution of Gingival Pigmentation, Skin Complexion, and Periodontal Status: Table 2 shows that the prevalence of gingival pigmentation among the participants was 80.7%. Based on the location of gingival pigmentation, most participants (48, 42.1%) had Class II (pigmentation on attached gingiva and interdental gingiva). Based on the intensity of gingival pigmentation, 19 (16.7%) had mild pigmentation, 30 (26.3%) had moderate pigmentation, and 43 (37.7%) had heavy pigmentation.
Regarding skin complexion, 44 (38.6%) of the participants had skin color V (dark brown skin). Concerning periodontal status, most participants (54, 47.4%) had CPI code 2 (calculus), 26 (22.8%) had CPI code 0 (healthy), and 3 (2.6%) had CPI code 4 (pocket depth ≥ 6 mm).

Table 2: Distribution of Gingival Pigmentation, Skin Complexion, and Periodontal Status (N = 114)

Variable		Frequency	Percentage
Location of gingival pigmentation	Pink tissue with no pigmentation	22	19.3
	Class I	29	25.4
	Class II	48	42.1
	Class III	12	10.5
	Class IV	0	0.0
	Class V	0	0.0
	Class VI	3	2.6
Intensity of gingival pigmentation	Pink tissue (no pigmentation)	22	19.3
	Mild clinical pigmentation	19	16.7
	Moderate clinical pigmentation	30	26.3
	Heavy clinical pigmentation	43	37.7
Skin complexion	Pale white skin (I)	1	0.9
	White skin (II)	1	0.9
	Light brown skin (III)	26	22.8
	Moderate brown skin (IV)	34	29.8
	Dark brown skin (V)	44	38.6
	Dark brown to black skin (VI)	8	7.0
Periodontal status (CPI)	Healthy (0)	26	22.8
	Bleeding on probing (1)	12	10.5
	Calculus (2)	54	47.4
	Pocket depth 4–5 mm (3)	19	16.7
	Pocket depth ≥ 6 mm (4)	3	2.6

Sex Distribution of Skin Complexion: Figure 1 shows that 17 females (14.91%) and 9 males (7.89%) had type III skin color (light brown skin); 21 females (18.42%) and 13 males (11.40%) had type IV skin color (moderate brown skin).

Figure 1: Sex Distribution of Skin Complexion

Skin Complexion	Female (n=66)	Male (n=48)
I - Pale white skin	0 (0.0%)	1 (0.88%)
II - White skin	1 (0.88%)	0 (0.0%)
III - Light brown skin	17 (14.91%)	9 (7.89%)
IV - Moderate brown skin	21 (18.42%)	13 (11.40%)
V - Dark brown skin	22 (19.30%)	22 (19.30%)
VI - Dark brown to black skin	5 (4.39%)	3 (2.63%)

Distribution of Skin Complexion Among Ethnic Groups: Table 3 shows that among Igbo participants, 10 (22.2%) had light brown skin, 15 (33.3%) had moderate brown skin, 17 (37.8%) had dark brown skin, and 3 (6.7%) had deeply pigmented dark brown to black skin. Among participants from other ethnic groups, 14 (23.3%) had light brown skin, 18 (30.0%) had moderate brown skin, 21 (35.0%) had dark brown skin, and 5 (8.3%) had deeply pigmented dark brown to black skin. This finding was not statistically significant (p = 0.968).

Table 3: Distribution of Skin Complexion Among Ethnic Groups

Ethnicity	I n (%)	II n (%)	III n (%)	IV n (%)	V n (%)	VI n (%)	P-value
Hausa	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0.968#
Igbo	0 (0.0)	0 (0.0)	10 (22.2)	15 (33.3)	17 (37.8)	3 (6.7)	
Yoruba	0 (0.0)	0 (0.0)	2 (25.0)	1 (12.5)	5 (62.5)	0 (0.0)	
Others	1 (1.7)	1 (1.7)	14 (23.3)	18 (30.0)	21 (35.0)	5 (8.3)	
# Fisher's exact test							

I - Pale white skin; II - White skin; III - Light brown skin; IV - Moderate brown skin; V - Dark brown skin; VI - Deeply pigmented dark brown to black skin

Sex Distribution of Gingival Pigmentation: Figure 2 shows that 11 females (9.65%) and 11 males (9.65%) presented with pink tissue (no clinical pigmentation); 10 females (8.77%) and 9 males (7.89%) had mild clinical pigmentation; 22 females (19.30%) and 8 males (7.02%) had moderate clinical pigmentation; and 23 females (20.18%) and 20 males (17.54%) had heavy clinical pigmentation.

Figure 2: Sex Distribution of Gingival Pigmentation

Gingival Pigmentation	Female (n=66)	Male (n=48)
0 - Pink tissue (no pigmentation)	11 (9.65%)	11 (9.65%)
1 - Mild clinical pigmentation	10 (8.77%)	9 (7.89%)
2 - Moderate clinical pigmentation	22 (19.30%)	8 (7.02%)
3 - Heavy clinical pigmentation	23 (20.18%)	20 (17.54%)

Distribution of Gingival Pigmentation Among Ethnic Groups: Table 4 shows that among Igbo participants, 9 (20.0%) had pink tissue, 6 (13.3%) had mild pigmentation, and 16 (35.6%) had heavy pigmentation. Five Yoruba participants (62.5%) had heavy pigmentation. Among participants from other ethnic groups, 11 (18.3%) had pink tissue, 12 (20.0%) had mild pigmentation, 15 (25.0%) had moderate pigmentation, and 22 (36.7%) had heavy pigmentation. This finding was not statistically significant (Fisher's exact = 6.461, p = 0.746).

Table 4: Distribution of Gingival Pigmentation Among Ethnic Groups

Ethnicity	Pink Tissue n (%)	Mild Pigmentation n (%)	Moderate Pigmentation n (%)	Heavy Pigmentation n (%)	P-value
Hausa	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.746#
Igbo	9 (20.0)	6 (13.3)	14 (31.1)	16 (35.6)	
Yoruba	1 (12.5)	1 (12.5)	1 (12.5)	5 (62.5)	
Others	11 (18.3)	12 (20.0)	15 (25.0)	22 (36.7)	
# Fisher's exact test					

Association Between Skin Complexion and Gingival Pigmentation: Table 5 shows that one participant (100%) with pale white skin had mild clinical pigmentation. One participant (100%) with white skin had mild clinical pigmentation. Among participants with dark brown skin, 8 (18.2%) had pink tissue, 2 (4.5%) had moderate clinical pigmentation, and 34 (77.3%) had heavy clinical pigmentation. Among participants with deeply pigmented dark brown to black skin, all 8 (100.0%) had heavy clinical pigmentation. The odds of gingival pigmentation occurring were higher in participants with darker skin complexion (OR = 256.2, 95% CI [31.6, 2077.4]). This finding was statistically significant (Fisher's exact = 6.272, p < 0.001).

Table 5: Association Between Skin Complexion and Gingival Pigmentation

Skin Complexion	Pink Tissue n (%)	Mild Pigmentation n (%)	Moderate Pigmentation n (%)	Heavy Pigmentation n (%)	Odds Ratio [95% CI]	P-value
Pale white skin (I)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	256.2 [31.6–2077.4]	<0.001*#
White skin (II)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)		
Light brown skin (III)	7 (26.9)	16 (61.5)	3 (11.5)	0 (0.0)		
Moderate brown skin (IV)	7 (20.6)	1 (2.9)	25 (73.5)	1 (2.9)		
Dark brown skin (V)	8 (18.2)	0 (0.0)	2 (4.5)	34 (77.3)		
Dark brown to black skin (VI)	0 (0.0)	0 (0.0)	0 (0.0)	8 (100.0)		
*Statistically significant; # Fisher's exact test; CI = Confidence interval						

Association Between Gingival Pigmentation and Periodontal Status

Table 6 shows that among participants with pink tissue, 1 (4.5%) had healthy periodontium, 10 (45.5%) had supra- and subgingival calculus, 4 (18.2%) had pocket depth of 4–5 mm, and 1 (4.5%) had pocket depth ≥ 6 mm. Among participants with moderate clinical pigmentation, 11 (36.7%) had healthy periodontium, 8 (26.7%) had calculus, and 2 (6.7%) had pocket depth ≥ 6 mm. Among participants with heavy clinical pigmentation, 9 (20.9%) had healthy periodontium, and 4 (9.3%) had pocket depth 4–5 mm. The odds of having a healthy periodontium were higher in participants with gingival pigmentation (OR = 5.56, 95% CI [0.66, 46.67]). This finding was statistically significant (Fisher's exact = 26.449, p = 0.003).

Table 6: Association Between Gingival Pigmentation and Periodontal Status

Gingival Pigmentation	Healthy n (%)	Bleeding on Probing n (%)	Calculus n (%)	Pocket Depth 4–5 mm n (%)	Pocket Depth ≥ 6 mm n (%)	Odds Ratio [95% CI]	P-value
Pink tissue	1 (4.5)	6 (27.3)	10 (45.5)	4 (18.2)	1 (4.5)	5.56 [0.66–46.67]	0.003*#
Mild clinical pigmentation	5 (26.3)	3 (15.8)	8 (42.1)	3 (15.8)	0 (0.0)		
Moderate clinical pigmentation	11 (36.7)	1 (3.3)	8 (26.7)	8 (26.7)	2 (6.7)		
Heavy clinical pigmentation	9 (20.9)	2 (4.7)	28 (65.1)	4 (9.3)	0 (0.0)		
*Statistically significant; # Fisher's exact test; CI = Confidence interval							

Summary of Results

Associations with Gingival Pigmentation and Periodontal Status: The association between ethnicity and skin complexion was weak and not statistically significant (Cramer's V = 0.138; p = 0.968). Similarly, the association between ethnicity and gingival pigmentation was also weak and non-significant (Cramer's V = 0.149; p = 0.746). A strong and statistically significant association was found between skin complexion and gingival pigmentation. Participants with darker skin (Fitzpatrick types V–VI) had markedly higher odds of exhibiting heavy gingival pigmentation (DOPI score 3) compared to those with lighter complexions (types I–IV) (OR = 256.2; 95% CI [31.6–2077.4]; p < 0.001). It should be noted that due to a small sample size in one comparison cell, this estimate is numerically unstable and should be interpreted with caution, although the direction and strength of the effect are clear.

The analysis of periodontal status revealed a significant association with gingival pigmentation. Participants with heavy gingival pigmentation had higher odds of having a healthy periodontium (CPI score 0) compared to those with no pigmentation (pink tissue), with an odds ratio of 5.56 (95% CI [0.66–46.67]). The overall association between gingival pigmentation and periodontal status across all CPI categories was statistically significant (p = 0.003).
In summary, darker skin complexion was a very strong predictor of heavy gingival pigmentation. Furthermore, heavier gingival pigmentation was significantly associated with better periodontal health status in this study population.

DISCUSSION

Findings: The prevalence of gingival pigmentation in this study was 80.7%. This value is in accordance with the findings by Rosa et al.,[21] who reported that melanin pigmentation in different populations varies between 0% and 89% based on ethnic factors and smoking habits. The finding in this study is consistent with a previous study which reported a prevalence of 84.3%.[22] However, the prevalence of gingival pigmentation in the current study is higher than 9.11% from a previous study[17] and 42.3% from another study,[12] but lower than 100% from a study conducted in India.[23] These discrepancies could be due to the influence of race, ethnicity, and genetic factors. In Nigeria, people from different ethnic groups have different skin colors. The three major ethnic groups—the Hausa in the north—are a blend of extremely light to extremely dark-skinned persons, revealing adaptation to the Sahel and savannah climates. The Yoruba in the southwest are largely dark-skinned, and the Igbo in the southeast are largely light-skinned.[24] However, in this study, participants from other ethnic groups (Ijaw, Ikwerre, etc.) had more gingival pigmentation. This could be because more dark-skinned participants were from the other ethnic groups.

Regarding the location of gingival pigmentation, Class II (pigmentation on attached gingiva and interdental gingiva) had the highest prevalence among the participants. This finding is consistent with a previous study[7] but contrasts with other studies[15,25]where pigmentation was more common on the attached gingiva alone (Class I). The attached gingiva is reported as the most pigmented part of the gingiva because it is highly keratinized, and keratinocytes are required for melanin deposition.[6] Furthermore, none of the participants in this study had Class IV (pigmentation on the marginal gingiva only) or Class V (pigmentation of the interdental gingiva only), which contrasts with the finding by Ponnaiyan et al.,[7] where a few participants presented with Class IV and Class V gingival pigmentation. This finding may be because the marginal and interdental gingivae are less keratinized compared to the attached gingiva. Some studies have reported that females are more likely to present with gingival pigmentation due to the influence of hormonal changes during pregnancy, oral contraceptive use, or hormone replacement therapy.[26,27] This finding is corroborated in the present study and follows the trend observed in a previous study.[27]In contrast, males had more pigmented gingiva in the study by Mahmood et al.,16 while there was no sex difference in the study by Dosunmu et al.[15]

The sex difference in gingival pigmentation may also be due to environmental or genetic variation.[28]
Regarding skin complexion, the highest prevalence was found among participants with dark brown skin (Class V), followed by moderate brown skin (Class IV), and then light brown skin (Class III). This finding is consistent with a study conducted in Eastern Nigeria, which reported that the skin color among Nigerians is predominantly brown.[29]However, this finding contrasts with a study conducted at Tagore Dental College, India, where most participants had moderate dark skin,[30] and with the study by Ponnaiyan et al.,[7] conducted among South Indians, where most participants had whitish skin. This discrepancy may be attributed to racial differences. It has been reported that skin color can be used as a predictor for mucosal and gingival pigmentation, as the appearance of pigmentation in people with dark skin complexion is more pronounced than in people with fair complexion after surgical depigmentation.[31] This could be due to increased intrinsic melanogenesis in people with dark complexions.[32] The present study corroborates this report, revealing a very strong statistically significant association between skin complexion and gingival pigmentation, which aligns with previous studies.[7,15]

Concerning periodontal health, almost half of the participants presented with calculus (CPI 2), some had healthy periodontium (CPI 0), while the fewest participants had advanced periodontitis (CPI 4). This finding follows the trends in a previous study where CPI 2 was the most prevalent among participants, followed by CPI 0.[33]Gingival pigmentation has also been linked to periodontal health due to the defensive properties of melanin against reactive oxygen species, especially the superoxide anion.[16] Oxidative stress is characterized by an imbalance between reactive oxygen species (ROS) production and antioxidant defenses, causing tissue damage and inflammation in periodontitis and other oral diseases.[34] These free radicals play a potential role in matrix destruction in the inflamed periodontium by depolarizing proteoglycans and hyaluronan, and activating neutrophil collagenase, which in turn initiates matrix degradation.[14]This finding is corroborated in the present study, as 65.1% and 20.9% of participants with heavy clinical pigmentation had calculus (CPI 2) and healthy periodontium (CPI 0), respectively, compared with participants with no pigmentation. This finding is consistent with a previous study.[31] Additionally, participants with heavy clinical pigmentation had no advanced periodontitis (CPI 4). However, this finding should be interpreted with caution, as the Community Periodontal Index (CPI) is not a comprehensive diagnostic tool for individual patients; it does not measure attachment loss and examines only specific "index teeth" in each sextant, thereby underestimating the true prevalence and severity of periodontal disease in a population compared to full-mouth examinations.[35]

Implications: The presence of gingival pigmentation may be one of the physiological factors that determines an individual's susceptibility to periodontal disease.

Trade-Offs (Limitations):
- This was a cross-sectional study, hence it prevents causal inferences.
- Convenience sampling was used, which introduced selection bias and limits generalizability.
- Some data were self-reported, which has potential for recall and social desirability bias.
- The sample size was small and limited to individuals attending a single tertiary hospital in Nigeria, which may have introduced selection bias and limited the generalizability of the findings to other populations.
- The use of self-reported ethnicity may have introduced inaccuracies in the data, as individuals may identify with different ethnic groups and cultures.
- The number of subjects among different ethnic groups varied, which could have influenced the results of the analysis.
- Some confidence intervals were extremely wide, which could be due to small cell counts.
- Unassessed factor: Loss of attachment (LOA) was not examined.

Take-Home (Conclusion): The prevalence of gingival pigmentation was 80.7%. Based on the location of gingival pigmentation, Class II gingival pigmentation was more common. Based on the intensity of gingival pigmentation, heavy pigmentation was more common. Gingival pigmentation was more common in females and participants from other ethnic groups. There was a statistically significant association between gingival pigmentation and both skin complexion and periodontal status.

Expectations for Future Research: Future studies could be conducted utilizing longitudinal designs to assess the nature of the association between skin complexion, gingival pigmentation, and periodontal disease.

Recommendations: The mechanisms linking oxidative stress to gingival pigmentation and periodontal disease should be investigated to enhance effective management of both oxidative stress-related oral conditions and gingival pigmentation issues.
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