# Evaluation of the Attached Gingival Width and Sulcus Depth in an Adult Nigerian Population - A Pilot Study

**Umeizudike Kehinde Adesola[1], Ameh Priscilla Okhiabigie[2], Adekunle Adeola[3], Ayanbadejo Patricia Omowunmi[1] and Temiye Olakunle Ayodeji[4]**

**[1]Department of Preventive Dentistry, Faculty of Dental Sciences, College of Medicine, University of Lagos; [2]Departments of Preventive Dentistry and [3]Oral and Maxillofacial Surgery, Lagos University Teaching Hospital, Idi-Araba, Lagos State, Nigeria; [4]Dental Department, State Specialist Hospital, Ikere-Ekiti, Ekiti State, Nigeria.**

**Abstract**

**Background**: The attached gingiva is an important anatomical component of the periodontium with clinical implications. Variations exist in the width of the attached gingiva reported in the literature. Concerns had been previously raised over the width that was considered adequate for a healthy periodontium. This study set out to assess baseline values of the attached gingival width and gingival sulcus depth in a healthy Nigerian population.

**Materials and methods**: Attached gingival width and sulcus depth were determined by a visual method, using a Williams periodontal probe. There were 73 subjects (females representing 74% (n = 54) and males 26% (n = 19) who represented a healthy population of dental clinic attendees seen at the periodontology clinic in a teaching hospital. Subjects with moderate to severe gingival inflammation were excluded from the study. Mean values were reported using descriptive statistics.

**Results:** Mean attached gingival width was 3.26 (SD 0.96) mm and had a wide variation in different regions of the mouth. It was greatest in the maxillary central incisors and least in mandibular first premolars. No significant associations were observed between the attached gingival width and age or gender. The mean gingival sulcus depth was 1.33 (SD 0.36) mm. There was a weak but negative correlation between the attached gingival width and gingival sulcus depth.

**Conclusion**: This study has defined baseline values for the attached gingival width and sulcus depth among Nigerians. This would help to determine deviation from the norm for this population and may help to identify individuals at risk for periodontal disease.

*Key words: Attached gingival width, gingival sulcus, Nigeria*

## Introduction

The attached gingiva is an anatomic structure of the periodontium with important functions. These include the provision of increased resistance to external injury, its contribution to the stabilization of the gingival margin, and its involvement in dissipating physiological forces exerted by the muscular fibers of the alveolar mucosa on the gingival tissue (Malathi *et al.*, 2014). The attached gingiva is continuous with the free gingiva and lies between the free gingival groove (appears as an indentation on the external surface of the facial gingiva) and the mucogingival junction, which sharply demarcates it from the loose alveolar mucosa (Fiorellini *et al.,* 2012*)*. It is tightly bound to the underlying periosteum of the alveolar bone and in the palate blends imperceptibly with the firm and dense palatal mucosa (Fiorellini *et al.,*

Correspondence to: Dr. Umeizudike K. A., College of Medicine, University of Lagos, P.M.B. 12003, Idi-Araba, Surulere, Lagos, Nigeria. Telephone: +234 8055451018; Email: kumeiz09@gmail.com

2012). Histologically, the attached gingival epithelium has keratin as well as thin, prominent epithelial ridges and a thick lamina propria (Oh, 2009). The connective tissue contains no elastic fibers (Oh, 2009). It is better suited than the non-keratinized mucosa against the effect of mechanical irritation (Lozdan and Squier, 1969). This is perhaps the reason why it is sometimes referred to as a functional mucosa. All these features highlight the importance and contribution of the attached gingiva to the health and stability of the periodontium.

It was advocated more than a decade ago that an "adequate" width of attached gingiva was necessary for the maintenance of gingival health and prevention of gingival recession. This was based on the findings of (Lang and Löe, 1972) in which plaque-free areas on tooth surfaces with less than 2 mm of keratinized gingiva remained inflamed despite effective oral hygiene, leading the authors to conclude that at least 1 mm of attached gingiva was necessary for gingival health. Based on this, different periodontal surgical techniques were developed to widen areas of the attached gingiva considered to be too narrow irrespective of the presence or absence of gingival inflammation. These notions were, however, challenged several years later by Wennstrom (1987) following a longitudinal study that found a lack of association between an "inadequate" zone of attached gingiva and an increased incidence of soft tissue recessions in patients who maintained good plaque control. These findings revolutionized the rationale for surgical procedures aimed at increasing the width of the attached gingiva. Furthermore, Freedman *et al.* (1999), in an 18-year longitudinal study conducted periodontal assessment on 61 keratinized gingival sites in 17 subjects (initially freshmen dental students now practicing dentists in the United States). The mean width of keratinized gingiva increased from $1.74 \pm 0.55$ at the beginning of the study to $2.02 \pm 0.89$ mm after the study period while the plaque index significantly decreased from $0.77 \pm 0.44$ to $0.36 \pm 0.34$ (Freedman *et al.,* 1999). The researchers concluded that with good oral hygiene and gingival health, keratinized gingiva ultimately remained stable.

In a more recent review article by Mehta and Lim (2010), the earlier assumption of an association between the lack of attached gingiva and gingival recession was highlighted. Their review article further emphasized other findings which concluded that it was gingival recession that presented as a narrow width of attached gingiva and not vice versa. To further elucidate the pathogenesis of gingival recession, Baker and Seymour (1976) attributed recession to a thin gingival biotype rather than to a narrow width of the attached gingiva. This began to draw more attention to the importance of gingival biotypes rather than the width of attached gingiva in relation to periodontal health.

On the other hand, Stetler and Bissada (1987) found an association between increased gingival inflammation and narrow attached gingiva in subgingivally placed dental restorations. They proposed that tooth brushing was more challenging in those areas, resulting in greater plaque retention. The implication is that attached gingival width should be a strong consideration in subgingivally placed restorations. The effect of orthodontic tooth movement on the width of the attached gingiva was also assessed in the study by Wennstrom *et al.* (1987). Following the surgical excision of the keratinized gingiva adjacent to some teeth in five adult monkeys, orthodontic appliances were applied 6 months later to bodily move some of the teeth out of the bony plate. They observed the reformation of a narrow area of keratinized gingiva around the affected teeth after 4-5 months. Their conclusion was that the attached gingival width was not affected by orthodontic movement provided the teeth were moved within the bony alveolus and the patient maintained good plaque control. On the other hand, the relevance of the thickness of the gingiva in periodontal health during orthodontic treatment began to gain ground following findings from studies by Ericsson and Lindhe (1984), Wennstrom *et al.* (1987), and Goldberg *et al.* (2001). These researchers placed greater emphasis on the effect of orthodontic appliances on attached gingiva thickness rather than attached gingival width.

As the placement of dental implants became popular, the importance of the width of the attached gingiva on treatment outcomes was revisited and outlined in the review by Mehta and Lim (2010). In the study by Bouri *et al.* (2008) among 76 subjects with 200 dental implants in Cleveland in the United States, increased width of keratinized gingiva around implants was associated with less alveolar bone loss and improved indices of the soft tissue health. It has also been suggested that areas with narrow width of keratinized gingiva around implants may be susceptible to recession. Other factors that may predispose to gingival recession include smoking and the surface texture of implants (Schrott *et al.*, 2009, Mehta and Lim, 2010). On the contrary, Zigdon and Machtei, 2008) found gingival biotypes rather than the attached gingival width to be associated with gingival recession in implant patients that affected soft tissue aesthetics. In the literature analysis by Cairo *et al.* (2008), it was highlighted that the width of keratinized gingival tissue did not influence the survival rate of dental implants, nor was there any evidence to recommend specific techniques to augment the keratinized tissue. They concluded that there was weak scientific evidence of an association between keratinized gingiva and peri-implant soft tissue health. Despite their findings, however, they still opined that soft tissue augmentation at implant sites was to be considered in some clinical situations. These may include patients with challenging plaque control and aesthetic concerns that would benefit from implant placement within an adequate keratinized gingiva.

The width of the attached gingiva varies from 1-9 mm, being widest in the incisor region (3-5 mm), especially around the lateral incisor, and narrowest in the region of the mandibular canines and first premolar region (Lang and Löe, 1972). Furthermore, it has been reported to increase with age, resulting from a compensatory eruption of the teeth (Ainamo and Talari, 1976; Ainamo *et al.,* 1981). This may explain its reported increase in supra-erupted teeth (Ainamo and Ainamo, 1978).

Another important characteristic feature of the attached gingiva is the stippling texture of its surface, which resembles an orange peel. Stippling varies with age, being absent in infancy, increasing until adulthood, and often disappearing in the elderly (Fiorellini *et al.,* 2012). Stippling is prominent on the labial surfaces, appears to be a form of adaptive specialization for function, and seems to be produced by alternate rounded elevations and depressions in the gingival epithelium (Fiorellini *et al.,* 2012). The stippled texture appears to coincide with the intersection of the epithelial ridges with the underlying connective tissue. In addition, a healthy periodontium is characterized by a gingival sulcus depth of 2-3 mm (Fiorellini *et al.,* 2012). Most reported baseline values of a healthy periodontium in the literature are from Caucasian and Asian populations. These values may not be truly representative of the African or particularly the Nigerian population. Establishing the reference value for a population will help to readily observe the deviation from the norm in that specific population and identify individuals at risk for periodontal disease. To the best of our knowledge, no study has reported the width of the attached gingiva and gingival sulcus depth among the Nigerian population. The present study was therefore aimed at evaluating the width of the attached gingiva and the gingival sulcus depth in a healthy adult population at the periodontology clinic in Lagos.

## Materials and methods

The study was approved by the Health Research and Ethics Committee of the Lagos University Teaching Hospital before it was commenced and was conducted in line with the Declaration of Helsinki. This was a descriptive cross sectional study carried out at the Periodontology Clinic of the Lagos University Teaching Hospital, Lagos, Nigeria. One hundred systemically healthy volunteers above the age of 18 years who gave their written consent were initially recruited after the purpose of the study was explained to them. Only 73 subjects (54 females and 19 males) met the inclusion criteria that included at least 20 teeth and gingival index score of 0 or 1. The subjects consisted of undergraduate dental students, nurses, and otherwise healthy subjects presenting for routine check-up. The exclusion criteria were patients with systemic illnesses, pregnant or lactating women, patients on medications that could modify the gingiva such as calcium channel blockers, moderate to severe gingival inflammation, presence of gingival recession, and presence of clinical attachment loss. In order to confirm that volunteers were free from periodontitis, subjects with periodontal probing depths (PD) $\geq$ 4 mm (World Health Organization, 1997) and clinical attachment loss (CAL) of $\geq$ 1 mm were excluded from the study (Armitage, 1999).

A form consisting of two sections was used for data collection. The first section was used to document information on participants' socio-demographic characteristics while the second section was used to record the findings from the periodontal examination. The periodontal examination was performed using a Williams periodontal probe on selected surfaces of the index teeth in all quadrants of the mouth. These teeth were the incisors, canines, premolars and first molars. The selected areas were the mid-labial and mid-buccal zones of the teeth. The lingual zone of the attached gingivae was not used in the measurement because of its undefined demarcation and thus continuity with the alveolar mucosa. The status of the gingiva was assessed clinically to ensure its health using the gingival index (GI; Löe and Silness, 1963).

The GI of the individual was obtained by adding the total values for each index tooth and dividing by the number of teeth examined. Only subjects with GI of 0 or 1 were included in the study. Likewise, only subjects with PD < 4 mm and CAL of 0 were included in the study.

There were two measurements recorded: depth of the gingival sulcus in the mid-facial regions, and the width of the attached gingiva. The width of the attached gingiva was derived by measuring the distance from the crest of the gingival margin to the mucogingival junction and then subtracting the probing depth of the gingival sulcus from this distance on the selected teeth surfaces (Kolte *et al.,* 2014). The mucogingival junction was determined using a visual method, assessed as a scalloped line separating the attached gingiva from the loose alveolar mucosa under good illumination.

The measurements were performed by two examiners who were dentists trained for the purpose of the study. To minimize inter-examiner error, the percentage agreement between the two examiners within 0.5 mm error margin was determined on non-study subjects to be 82.8%.

The data were analyzed using Statistical Package for Social Sciences software (Version 22). The mean width of the attached gingiva was compared with age, gender, ethnicity, and orange peel appearance using one-way analysis of variance (ANOVA). The Pearson correlation coefficient was used to assess the strength of the correlations among attached gingival width, age, and gingival sulcus depth. $p$ values < 0.05 were considered as statistically significant.

## Results

### *Socio-demography of the study population*

*Table 1* reveals the demographic and clinical characteristics of the study population. A total of 73 healthy subjects participated in the study having a mean age of 24.1 (SD 3.6) years and range 18 - 34 years. Females represented 74%, while Yoruba ethnicity was predominant in 74% of the subjects. The majority (98.6%) had tertiary level education with undergraduate students comprising 58.9%. The majority (97.3%) of the subjects used soft to medium tooth brushes to clean their teeth.

**Table 1.** Demographic, oral hygiene habits and clinical variables of the subjects

| Variable | n (%) |
|---|---|
| ***Age (years)*** | |
| 18 - 24 | 43 (58.9) |
| 25 - 34 | 30 (41.1) |
| ***Gender*** | |
| Male | 19 (26.0) |
| Female | 54 (74.0) |
| ***Ethnicity*** | |
| Yoruba | 54 (74.0) |
| Non-Yoruba | 19 (26.0) |
| ***Level of education*** | |
| Tertiary | 72 (98.6) |
| Secondary | 1 (1.4) |
| ***Occupation*** | |
| Students | 43 (58.9) |
| Professionals | 30 (41.1) |
| ***Tooth brush type*** | |
| Soft | 10 (13.7) |
| Medium | 61 (83.6) |
| Hard | 2 (2.7) |
| ***Tooth brushing frequency*** | |
| At least morning and bedtime | 35 (48.0) |
| Morning only | 38 (52.0) |
| ***Orange peel appearance*** | |
| Present | 57 (78.1) |
| Absent | 16 (21.9) |
| ***Melanin pigmentation*** | |
| Present | 45 (61.6) |
| Absent | 28 (38.4) |

### *Clinical variables*

A significant proportion (61.6%) had melanin pigmentation on their gingivae, while the orange peel appearance was present in 78.1% of the subjects. The mean attached gingival width of the subjects was 3.26 ± 0.96 mm with a range of 0-10 mm.

Among the maxillary teeth, the right central incisor had the highest average attached gingival width (4.86 mm), while the left first premolar had the least (3.21 mm). In the mandible, the right and left lateral incisors had the greatest mean attached gingival width (3.35 mm), while the left first premolar had the least (2.18 mm). The attached gingival width was generally greater in the anterior than the posterior teeth segment (*Table 2*).

Regarding the attached gingival width for individual teeth, the maxillary right central incisor had the greatest attached gingival width (4.86 mm), while the mandibular left first premolar had the least (2.18 mm; *Table 2*).

**Table 2.** Average attached gingival width (mm) on mid-facial surface per specific tooth.

| Maxillary right teeth | (mean ± SD) | Maxillary left teeth | (mean ± SD) |
|---|---|---|---|
| 11 | 4.86 ± 1.81 | 21 | 4.70 ± 1.64 |
| 12 | 4.39 ± 1.80 | 22 | 4.39 ± 1.90 |
| 13 | 3.92 ± 1.55 | 23 | 3.53 ± 1.46 |
| 14 | 3.28 ± 1.49 | 24 | 3.21 ± 1.43 |
| 15 | 3.40 ± 1.60 | 25 | 3.23 ± 1.54 |
| 16 | 3.36 ± 1.71 | 26 | 3.52 ± 1.67 |
| **Mandibular right teeth** | | **Mandibular left teeth** | |
| 41 | 3.19 ± 1.15 | 31 | 3.18 ± 1.07 |
| 42 | 3.35 ± 1.23 | 32 | 3.35 ± 1.23 |
| 43 | 2.51 ± 1.17 | 33 | 2.51 ± 1.17 |
| 44 | 2.27 ± 1.17 | 34 | 2.18 ± 1.01 |
| 45 | 2.78 ± 1.09 | 35 | 2.49 ± 0.93 |
| 46 | 3.15 ± 1.11 | 36 | 3.16 ± 0.94 |

Regarding specific tooth types, the average attached gingival width for maxillary central incisors was 4.79 mm, while for mandibular central incisors it was 3.20 mm (*Figure 1*). The average attached gingival width for maxillary and mandibular lateral incisors was 4.37 mm and 3.31 mm, respectively. The maxillary first molars had an average attached gingival width of 3.42 mm, while that of the lower first molars was 3.11 mm. The attached gingival width was generally greater in the maxillary than the mandibular region. The maxillary central incisors had the greatest average attached gingival width of 4.79 mm, while the mandibular first premolars had the least, with 2.21 mm. The average attached gingival width was greater in males (3.35 mm) than females (3.22 mm), 18 - 24-year-olds (3.27 mm) than 25 - 34-year-old subjects (3.24 mm), non-Yoruba (3.32 mm) than those of Yoruba ethnicity (3.06 mm), and in the absence of orange peel appearance (3.57 mm) than the presence of orange peel gingiva (3.17 mm). These differences were not statistically significant (*Table 3*).

The average gingival sulcus depth was 1.33 ± 0.36 mm (*Table 4*). It was not significantly associated with the age, gender, ethnicity, or the presence of the orange peel gingival surface texture (*Table 5*). A weak negative correlation was found among the average attached gingival width and the age of the subjects and the average gingival sulcus depth. The correlation between the attached gingival width and the gingival sulcus depth was significant ($p = 0.003$; *Table 6*).

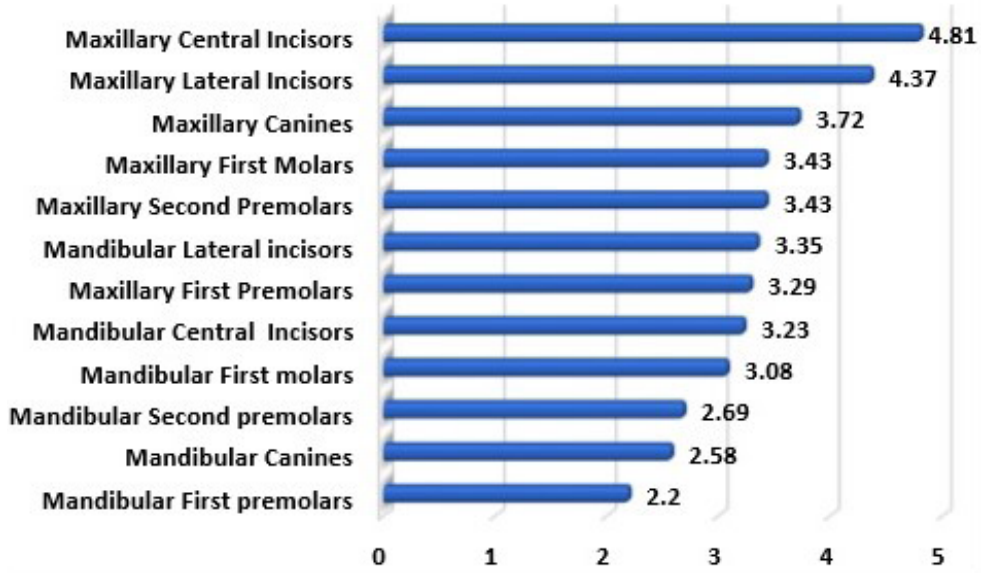


***Figure 1. The average attached gingival width (mm) for specific tooth types.***

**Table 3.** Comparison of average attached gingival width with other variables.

| Variable | n | mean | SD | *p* value |
|---|---|---|---|---|
| ***Age (years)*** | | | | |
| 18 - 24 | 42 | 3.27 | 0.96 | 0.912 |
| 25 - 34 | 29 | 3.24 | 0.96 | |
| ***Gender*** | | | | |
| Male | 19 | 3.35 | 0.92 | 0.618 |
| Female | 52 | 3.22 | 0.97 | |
| ***Ethnicity*** | | | | |
| Yoruba | 19 | 3.06 | 0.77 | 0.305 |
| Non-Yoruba | 52 | 3.32 | 1.01 | |
| ***Orange peel appearance*** | | | | |
| Present | 55 | 3.17 | 0.90 | 0.143 |
| Absent | 16 | 3.57 | 1.10 | |

**Table 4.** Average gingival sulcus depth (mm) on mid-facial surface per tooth.

| Maxillary right teeth | (mean ± SD) | Maxillary left teeth | (mean ± SD) |
|---|---|---|---|
| 11 | 1.27 ± 0.60 | 21 | 1.35 ± 0.49 |
| 12 | 1.48 ± 0.59 | 22 | 1.47 ± 0.59 |
| 13 | 1.42 ± 0.62 | 23 | 1.41 ± 0.65 |
| 14 | 1.31 ± 0.54 | 24 | 1.32 ± 0.54 |
| 15 | 1.49 ± 0.64 | 25 | 1.52 ± 0.62 |
| 16 | 1.50 ± 0.57 | 26 | 1.45 ± 0.60 |
| **Mandibular right teeth** | | **Mandibular left teeth** | |
| 41 | 1.12 ± 0.49 | 31 | 1.19 ± 0.55 |
| 42 | 1.20 ± 0.55 | 32 | 1.22 ± 0.53 |
| 43 | 1.40 ± 0.63 | 33 | 1.38 ± 0.65 |
| 44 | 1.25 ± 0.53 | 34 | 1.21 ± 0.55 |
| 45 | 1.23 ± 0.52 | 35 | 1.27 ± 0.59 |
| 46 | 1.18 ± 0.56 | 36 | 1.17 ± 0.58 |

**Table 5.** Comparison of gingival sulcus depth with other variables.

| Variable | n | mean | SD | *p* value |
|---|---|---|---|---|
| ***Age (years)*** | | | | |
| 18 - 24 | 43 | 1.28 | 0.38 | 0.218 |
| 25 -34 | 30 | 1.39 | 0.33 | |
| ***Gender*** | | | | |
| Male | 19 | 1.30 | 0.44 | 0.722 |
| Female | 52 | 1.33 | 0.34 | |
| ***Ethnicity*** | | | | |
| Yoruba | 19 | 1.31 | 0.30 | 0.870 |
| Non-Yoruba | 52 | 1.33 | 0.38 | |
| ***Orange peel appearance*** | | | | |
| Present | 57 | 1.36 | 0.36 | 0.124 |
| Absent | 16 | 1.20 | 0.36 | |

**Table 6.** Correlation between mean attached gingival width (AGW) and age and mean gingival sulcus depth (GSD).

| | | Mean AGW | Age (years) | Mean GSD |
|---|---|---|---|---|
| **Mean AGW** | Pearson correlation | 1 | -0.030 | -0.345** |
| | *p* | | 0.807 | **0.003** |
| | n | 71 | 71 | 71 |
| **Age (years)** | Pearson correlation | -0.030 | 1 | 0.116 |
| | *p* | 0.807 | | 0.329 |
| | n | 71 | 73 | 73 |
| **Mean GSD** | Pearson correlation | -0.345** | 0.116 | 1 |
| | *p* | **.003** | 0.329 | |
| | n | 71 | 73 | 73 |

## Discussion

Few studies have been reported regarding the attached gingiva and its related characteristics in peoples of the African continent. To the best of our knowledge this is the first report of the attached gingival width in a group of healthy Nigerian adults. The present study used the visual method with a Williams periodontal probe, which is in line with similar studies (Tenenbaum and Tenenbaum, 1986; Ainamo and Löe, 1966; Jacob and Zade, 2009). This method was adopted because of its simplicity, low cost, patient's acceptance, and relative ease of application. A recent study comparing the visual and histochemical methods in the identification of the mucogingival junction to calculate the width of attached gingiva found no significant differences comparing the two methods (Bhatia *et al.,* 2015). The mid-facial tooth surface was used because of the good access it provided to the examiners, as noted in other studies (Bhatia *et al.,* 2015; Jacob and Zade, 2009). Our study found a wide variation (0 - 10 mm) in the attached gingival width in different areas of the mouth, a pattern consistent with early studies (Bowers, 1963; Jacob and Zade, 2009; Subbaiah and Manohar, 2012). This buttresses the fact that there is considerable variation in the width of the attached gingiva in the same individual and between different individuals and is consistent with the pattern found by Bowers (1963). The greatest attached gingival width in the maxilla was found in the central incisors (4.79 mm), while in the mandible it was the lateral incisors (3.31 mm). This is consistent with similar studies that reported the attached gingival width of maxillary teeth to be generally greater than that of mandibular teeth. (Bhatia *et al.,* 2015; Bowers, 1963; Jacob and Zade, 2009). The study by Bhatia *et al.* (2015) found a variation in the width of attached gingiva in different areas of the jaw as well as an increase with age. Their findings were not affected by the method (visual, functional or histochemical) used in assessing the attached gingival width. Bowers (1963) observed in his study subjects that an attached gingival width of 1 mm or less was still compatible with clinical health, while the absence was associated with freely movable and frequently inflamed remaining tissue. Furthermore, Bowers (1963) demonstrated that the position of the tooth, particularly its degree of displacement facially in the arch, affected the attached gingival width. He also reported the association of high frenum and muscle attachments with narrow attached gingival width. Examination of the attached gingival width of specific teeth found the maxillary central incisors to have the widest, contrary to the maxillary lateral incisors reported by Ainamo and Löe (1966) and Bowers (1963). This difference may be partly attributed to variations in the degree of eruption and subsequent crown height of the lateral incisors owing to ethnic variations. Furthermore, the attached gingival width has been reported to increase with supra-eruption of the teeth (Fiorellini *et al.,* 2012). The anatomic crown height was not the focus of our study and was not measured. It would be interesting to consider this in future studies.

The average attached gingival width of the teeth examined in our study population was generally greater than that reported in the studies by Bhatia *et al.* (2015), Jacob and Zade (2009), and Kolte *et al.* (2014), but comparable to the findings of Bowers (1963). The higher attached gingival width in our study compared to other studies might be due to racial differences and age differences. It was proposed by Ainamo and Ainamo (1978) that whilst the mucogingival junction remained stable during tooth eruption, there appeared to be an increase in the band of attached gingiva. Although the presence of an "adequate" width of attached gingiva was advocated in earlier reports as being essential for the maintenance of a healthy periodontium (Lang and Löe, 1972), our findings suggest the compatibility of a narrow attached gingival width with a healthy periodontium, provided gingival inflammation is absent or minimal. Considering the extra force applied in patients undergoing orthodontic treatment, there may be a need for some caution in patients with a narrow attached gingival width by ensuring minimal gingival inflammation through effective plaque control. Furthermore, the risk of gingival recession in patients with a narrow attached gingival width requiring orthodontic treatment may need to be investigated. According to Wennstrom (1987), the gingival recession observed in individuals with narrow attached gingival width is not necessarily the effect of the narrow attached gingiva itself, but rather from poor plaque control. It is also necessary to note the attached gingival width compatible with health in different regions of the mouth prior to periodontal or orthodontic treatment.

As with the study by Bowers (1963), no statistically significant difference was observed between the mean width of attached gingiva in male and female subjects, although males in our study had slightly greater mean attached gingival width (3.35 mm) than females (3.22 mm). The present study found no significant association with age, a pattern described by Jacob and Zade (2014) but quite contrary to the study by Bowers (1963), which reported an increase in mean width of attached gingiva from the deciduous dentition to the adult dentition. Reasons postulated for increasing attached gingival width with age is the constant eruption of teeth throughout one's life, which is believed to compensate for occlusal surface attrition, leading to coronal migration of the cemento-enamel junction while the mucogingival junction remains the same (Ainamo and Talari, 1976). The lack of an association between increasing age and attached gingival width may well point to the contribution of other factors, such as diet. The effect of dietary factors on attached gingival width should be clearly defined in future studies.

Another anatomical periodontal parameter that was determined was the gingival sulcus depth, or probing depth, which was indirectly used to determine the attached gingival width. In the present study, it was found to be 1.33 ± 0.36 mm. The gingival sulcus depth was not significantly associated with age or gender in the present study. This value is within the 2 mm accepted as the norm for a healthy periodontium (Fiorellini *et al.,* 2012). The definition of periodontitis is still based on probing depths of 4 mm (Armitage, 1999). Our study found the highest mean value for the gingival sulcus depth to be 1.52 mm, well below the 4 mm currently being used (Armitage, 1999). This may well imply a need to reconsider the definition criteria for periodontal pocket depths in chronic periodontitis, which has been highlighted by some researchers (Brown *et al.,* 1989; Nwhator and Ashiwaju, 2013). However, the findings of the present study should be interpreted with some caution considering the relatively small sample population. The negative correlation between the attached gingival width and gingival sulcus depth is not an unexpected finding in the present study, especially in a healthy periodontium. The orange peel or stippled appearance is a feature of healthy gingiva, and its observation in the majority of our study sample is consistent with previous literature (Fiorellini *et al.,* 2012). It has been reported (Greene, 1962) to be absent even in some individuals with a healthy periodontium, which is the pattern observed in our study. The study made no attempt to assess gingival recession, tooth position, and presence or absence of high frenal attachment in association with the width of attached gingiva.

## Conclusions

This study has provided some baseline values of the attached gingival width and gingival sulcus depth for the Nigerian population. The attached gingival width varies in different areas of the mouth, being greater in the maxillary than in the mandibular region, with the maxillary central incisors having the greatest width and the mandibular first premolars having the least. No significant relationship of attached gingival width was observed with age and gender. Our study is the first published literature to report the attached gingival width in a healthy adult Nigerian population, and our findings support the compatibility of a narrow attached gingival width with periodontal health in the presence of good plaque control. These values may help to determine deviation from the norm for the Nigerian population and identify individuals at risk for periodontal disease. The mean gingival sulcus depth was 1.33 mm, much lower than previously reported among Caucasians. There may be a need to revisit the criteria for diagnosing periodontitis. Future studies with larger samples with wider ethnic representations are needed to validate these findings among Nigerians. Future studies should also focus on soft tissue relationships, such as the frenal attachment and gingival recession, to the attached gingival width in both well aligned and mal-aligned teeth, as well as in patients with dental implants.

## Acknowledgments

The authors declare that there are no conflicts of interest in this study, nor did they receive any source of funding for this study.

## References

Ainamo A and Ainamo J. The width of attached gingiva on supraerupted teeth. *Journal of Periodontal Research* 1978; **13**:194-198.

Ainamo A, Ainamo J and Poikkeus R. Continuous widening of the band of attached gingiva from 23 to 65 years of age. *Journal of Periodontal Research* 1981; **16**:595-599.

Ainamo J and Löe H. Anatomical characteristics of gingiva. A clinical and microscopic study of the free and attached gingiva. *Journal of Periodontology* 1966; **37**:5-13.

Ainamo J and Talari A. The increase with age of the width of attached gingiva. *Journal of Periodontal Research* 1976; **11**:182-188.

Armitage GC. Development of a classification system for periodontal diseases and conditions. *Annals of Periodontology* 1999; **4**:1-6.

Baker DL and Seymour GJ. The possible pathogenesis of gingival recession. A histological study of induced recession in the rat. *Journal of Clinical Periodontology* 1976; **3**:208-219.

Bhatia G, Kumar A, Khatri M, Bansal M and Saxena S. Assessment of the width of attached gingiva using different methods in various age groups: A clinical study. *Journal of Indian Society of Periodontology* 2015; **19**:199-202.

Bouri Jr A, Bissada N, Al-Zahrani MS, Faddoul F and Nouneh I. Width of keratinized gingiva and the health status of the supporting tissues around dental implants. *International Journal of Oral Maxillofacial Implants* 2008; **23**:323-326.

Bowers GM. A study of the width of attached gingiva. *Journal of Periodontology* 1963; **34**:201-209.

Brown LJ, Oliver RC and Löe H. Periodontal diseases in the U.S. in 1981: Prevalence, severity, extent, and role in tooth mortality. *Journal of Periodontology* 1989; **60**:363-370.

Cairo F, Pagliaro U and Nieri M. Soft tissue management at implant sites. *Journal of Clinical Periodontology* 2008; **35**:163-167.

Ericsson I and Lindhe J. Recession in sites with inadequate width of the keratinized gingiva. An experimental study in the dog. *Journal of Clinical Periodontology* 1984; **11:**95-103.

Fiorellini JP, Kim DM, and Uzel NG. Chapter 2. The Anatomy of the Periodontium. In Newman MG, Takei HH, Klokkevold PR and Carranza FA. *Carranza's Clinical Periodontology* 11th Ed, Elsevier Saunders; 2012; 11-32.

Freedman AL, Green K, Salkin LM, Stein MD and Mellado JR. An 18-year longitudinal study of untreated mucogingival defects. *Journal of Periodontology* 1999; **70**:1174-1176.

Goldberg PV, Higginbottom FL and Wilson Jr TJ. Periodontal considerations in restorative and implant therapy. *Periodontology 2000* 2001; **25:**100-109.

Greene AH. A study of the characteristics of stippling and its relation to gingival health. *Journal of Periodontology* 1962; **33**:176-182.

Jacob SP and Zade RM. Width of attached gingiva in an Indian population: A descriptive study *Bangladesh Journal of Medical Science* 2009; **8**:64-67.

Kolte R, Kolte A and Mahajan A. Assessment of gingival thickness with regards to age, gender and arch location. *Journal of Indian Society of Periodontology* 2014; **18**:478-481.

Lang NP and Löe H. The relationship between the width of keratinized gingiva and gingival health. *Journal of Periodontology* 1972; **43**:623-627.

Löe H and Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontologica Scandinavica* 1963; **21**:533-551.

Lozdan J and Squier CA. The histology of the muco-gingival junction. *Journal of Periodontal Research* 1969; **4**:83-93.

Malathi K, Singh A, Rajula M, Prem B and Sabale D. Attached gingiva: A review. *International Journal of Scientific Research and Reviews* 2014; **3**:188-198.

Mehta P and Lim LP. The width of the attached gingiva--much ado about nothing? *Journal of Dentistry* 2010; **38**:517-525.

Nwhator SO and Ashiwaju MO. Confusion in periodontitis diagnostic criteria. *Journal of Dental and Orofacial Research* 2013; **9**:39-46.

Oh SL. Attached gingiva: Histology and surgical augmentation. *General Dentistry* 2009; **57**:381-385.

Schrott AR, Jimenez. Hwang JW, Fiorellini J and Weber HP. Five-year evaluation of the influence of keratinized mucosa on peri-implant soft tissue health and stability around implants supporting full arch mandibular prostheses. *Clinical Oral Implant Research* 2009; **20**:1170-1177.

Stetler KJ and Bissada NF. Significance of the width of keratinized gingiva on the periodontal status of teeth with submarginal restorations. *Journal of Periodontology* 1987; **58**:696-700.

Subbaiah R and Manohar B. Assessment of the width of attached gingival in different regions of the mouth in an Indian subpopulation. *Journal of Indian Dental Association* 2012; **6**:96-98.

Tenenbaum H and Tenenbaum M. A clinical study of the width of the attached gingiva in the deciduous, transitional and permanent dentitions. *Journal of Clinical Periodontology* 1986; **13**:270-275.

World Health Organization. Basic methods. 4. England: World Health Organization; 1997. Oral health surveys.

Wennstrom JL. Lack of association between width of attached gingiva and development of soft tissue recession. A 5-year longitudinal study. *Journal of Clinical Periodontology* 1987; **14**:181-184.

Wennstrom JL, Lindhe J, Sinclair F and Thilander B. Some periodontal tissue reactions to orthodontic tooth movement in monkeys. *Journal of Clinical Periodontology* 1987; **14**:121-129.