Original Article

Gingival biotype and its relation to incisors' inclination and dentopapillary complex: An *in vivo* study

ABSTRACT

Objectives: To study the gingival biotype and its relation to maxillary and mandibular incisor inclination and its relation to dentopapillary complex.

Materials and Methods: This cross-sectional study included 150 consecutive patients seeking orthodontic treatment at JSS Dental College, Mysore. Gingival biotype was assessed for maxillary and mandibular incisors using a digital vernier caliper. Maxillary and mandibular incisors' inclination and position were measured using cephalometric analysis. Parameters of dentopapillary complex were recorded from the dental casts.

Results: The prevalence of thin gingival biotype was 42.66% for maxillary and 39.33% for mandibular incisors. A significant association was found between mandibular incisor inclination and thin gingival biotype, whereas there was no association between maxillary incisor inclination and gingival biotype. There was a significant correlation between gingival biotype and crown length, area of papilla, area of crown, and papilla length with $P = 0.001$ each.

Conclusion: Mandibular incisor proclination is associated with thin gingival biotype, whereas no association is found in the maxilla. The correlation between gingival biotypes and dentopapillary complex is confirmed in this study. Evaluation of gingival biotype is of paramount importance during treatment planning for orthodontic patients.

Key words: Dehiscence; dentopapillary complex; gingival biotype.

Introduction

The human periodontium is comprised specialized hard and soft tissues such as the periodontal ligament, cementum, gingiva, and alveolar bone surrounding the tooth socket. Fixed appliance orthodontic therapy has been shown to produce deleterious effects on the periodontium, ranging from gingivitis to bone loss.[1] Many of these sequelae can be attributed to plaque accumulation due to the difficulty of maintaining adequate oral hygiene in the presence of bands and brackets. One long-term complication of orthodontic treatment, however, is gingival recession. Numerous studies have shown that irreversible recession can be caused by fixed appliance therapy in 1.3%–10% of treated cases.[2,3] Gingival recession can be generalized or localized, affecting one tooth surface or more, and might lead to an esthetic impairment.[4,5]

It is believed that during orthodontic movement, soft-tissue attachment moves with the tooth.[6] In recent years, there have been several investigations regarding the limits to the degree of incisor proclination in the dental arch.[7-10] There was decrease in the width of keratinized gingiva with either minimal movement or some labial movement of the mandibular incisors, whereas some cases had an increase in keratinized gingiva associated with significant lingual positioning of the lower incisors.[3] It is widely accepted that 2 mm of keratinized gingiva is enough to withstand

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orthodontic forces and prevent recession, but preexisting mucogingival defects can be exacerbated during tooth movement.[11] Therefore, it is important to recognize and correct areas of actual or potential stress before orthodontic therapy.[11]

It has been suggested that mandibular incisors would be most likely to exhibit this type of pathologic recession because the tooth-arch relationship results in labially prominent teeth covered with a thin or nonexistent labial plate of bone and inadequate or absent keratinized gingiva.[3] Consequently, much research has been directed at this region of the oral cavity.

Thick gingival biotype is also called as flat-thick gingiva. It has a large amount of keratinized tissue, the gingival thickness being ≥2.0 mm, and width of 5–6 mm. It generally corresponds to a tooth with squared facial form, distinct cervical convexity, and relatively broad, more apically located contact areas.[12] It is associated with flat soft tissue and bony architecture, with thick bony plates and thick marginal bone. Gingival margins usually are coronal to the cementoenamel junction. Gingiva is fibrotic and resistant to surgical procedures with a tendency for deep pocket and intrabony defect formation following disease. Thick biotype has a large amount of attached gingiva and a thick underlying osseous form; thick tissue is resistant to acute trauma.

Thin gingival tissue which is also called as scalloped thin gingiva has been suggested to be associated with tapered or triangular crown form, subtle cervical convexity, and minute proximal contact areas located near the incisal edge of the tooth.[12] It has pronounced scalloped soft tissue and bony architecture. Thin gingival tissue tends to be delicate and almost translucent in appearance; the tissue appears friable with a minimal zone of keratinized attached gingiva which escalates the risk of recession following the crown preparation and periodontal or implant surgery. Thin gingival margins also allow visibility of a metal substructure, thereby compromising esthetics in the anterior region of the mouth.[13] Dehiscence and fenestrations are usual findings in thin underlying bone. Thin marginal bone is usually present.[14]

Differences in gingival and osseous architecture have a significant impact on the outcome of treatments. Therefore, gingival biotype should be evaluated at the start of the treatment plan for the most esthetic results.

Many methods (both invasive and noninvasive) have been used to evaluate the thickness of facial gingival and other parts of the masticatory mucosa. These methods include conventional histology on cadaver jaws, injection needles, transgingival probing, histologic sections, cephalometric radiographs, probe transparency, ultrasonic devices, and cone-beam computed tomography.[15-34]

Materials and Methods

This cross-sectional study consisted of 150 consecutive orthodontic patients (74 males and 76 females) of the age group 12–30 years who were seeking orthodontic treatment at the Department of Orthodontics, JSS Dental College and Hospital, Mysore, from January 2016 to July 2016. The study was reviewed and approved by the Research Ethics Committee at JSS Dental College and Hospital and was carried out in compliance with the Helsinki declaration. Informed consent was obtained from participants before their enrollment in the study. Patients seeking fixed orthodontic treatment and satisfying the inclusion criteria were selected for the study irrespective of gender. Patients with general good health status, clinically and radiological healthy periodontal tissues, good oral hygiene, and requiring fixed orthodontic treatment were included in the study. Patients with missing maxillary or mandibular anterior teeth, gingival inflammation, crowns or extensive restorations on their anterior maxillary or mandibular teeth, pregnant or lactating female patients, patients taking certain medications with known effects on the periodontal soft tissues or requiring antibiotic premedication before dental examination, and with a history of previous periodontal surgery or orthodontic treatment were all excluded from the study.

Methodology

The evaluation of gingival biotype was assessed for every patient by one calibrated investigator. Gingival biotype was assessed using direct measurement with a digital vernier caliper with calibration to 0.01 mm. When the thickness of the gingiva was <1 mm, it was classified as thin; if the gingival thickness was >1 mm, it was considered thick. The measurement was done at the level of marginal gingiva just apical to free gingival groove, after administration of infiltration anesthesia [Figure 1]. Inclination (proclination/retroclination) and position (protrusion/retrusion) of the maxillary and mandibular incisors were assessed on lateral

Figure 1: Measurement of gingival thickness in maxillary and mandibular arch

cephalometric radiographs using the Planmeca ProMax digital panoramic and cephalometric system (Planmeca ProMax; Planmeca Oy, Helsinki, Finland, UK). The exposure parameters for all the lateral cephalometric radiographs were in the range of 65–70 kV, 10 mA for a duration of 6–7 s. Each participant's head was stabilized by positioning the ear-rods of the cephalostat machine in the external auditory meatus with the Frankfort plane parallel to the horizon and sagittal plane at right angle to the path of the X-ray and the teeth in centric occlusion with the lips in a closed and relaxed position. The cephalogram images were then imported into Planmeca Romexis Software, Helsinki, Finland and traced by one investigator.

Reference lines used were as follows:

- Maxillary incisor inclination: The angle formed by the intersection of a line from nasion to A point (NA) with a line drawn along the maxillary central incisor long axis (U1)
- Maxillary incisor position: The distance formed from the most labial point on the upper central incisor (U1) to the NA line
- Mandibular incisor inclination: The angle formed by the intersection of a line drawn along the mandibular plane (Gonion–Menton) with a line drawn along the mandibular central incisor long axis (L1)
- Mandibular incisor position: The distance formed from the most labial point on the mandibular incisor (L1) to the NB line.

Selected participants were seated for the appointment on the dental chair in a comfortable position. Elastomeric impressions of selected study participants were made and poured with dental stone. Gingival thickness on maxillary anterior teeth which was earlier clinically recorded was categorized into thick or thin based on the measurement of the gingival thickness with a digital vernier caliper. Dental casts were obtained, and the following parameters were recorded.

- Crown length (CL) was measured between the incisal edge of the crown and the free gingival margin, or if discernible, the cementoenamel junction [Figure 2]
- Crown width (CW), i.e., the distance between the approximal tooth surfaces was recorded at the border between the middle and the cervical portion [Figure 3]
- Papillary height was assessed to the nearest 0.5 mm using the same caliper at the mesial and distal aspect of both central incisors. This parameter was defined as the distance from the top of the papilla to a line connecting the mid-facial soft-tissue margin of the two adjacent teeth. The mean value was calculated for the three papillae [Figure 4]
- Papillary width (PW) was calculated at the base of papilla between two approximated tooth surfaces [Figure 5].

Figure 2: Measurement of crown length

Figure 3: Measurement of crown width

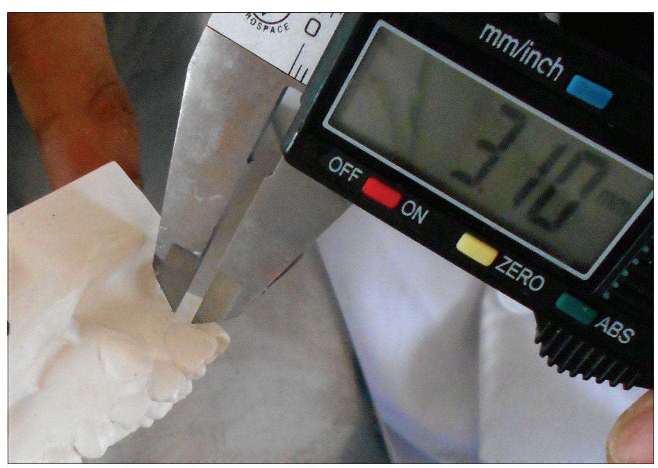

Figure 4: Measurement of papilla length

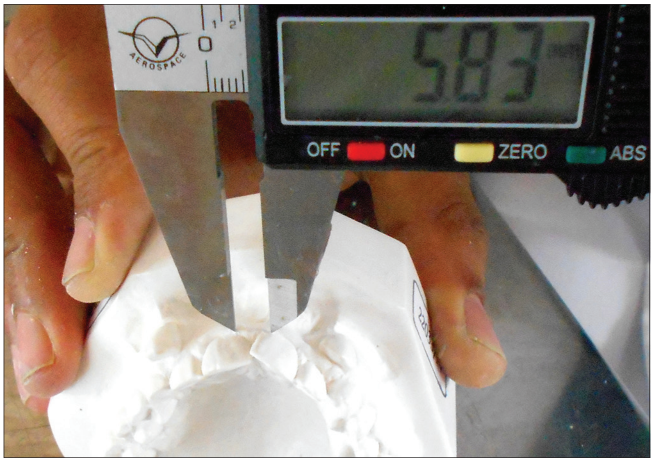

Figure 5: Measurement of papilla width

Apart from the measured values on the dental casts, a few values were calculated from the values which were obtained. Area of crown (AC) was calculated as the product of CL and CW. Area of papilla (AP) was calculated as the product of papilla length (PL) and PW. The ratio of AP/AC was also calculated for all the values.

Statistical methods applied

Both descriptive and inferential statistics were employed for data analysis. In the present study, the following descriptive statistics have been employed:

a. Mean and
b. Standard deviation
c. Correlation–product moment.

Results

Table 1 shows the bivariate comparisons between thin and thick gingival biotypes with regard to incisor inclination and position for the maxillary and mandibular teeth. For the maxillary incisors, there were no significant differences in the means of maxillary inclination and position between thin and thick gingival biotypes. For the mandible, the incisor inclination and position were significantly greater in the thin gingival biotype when compared to the thick gingival biotype.

Table 2 shows the comparative analysis of mean values of all dentopapillary complex parameters in thin and thick gingival biotype groups. There was a highly significant correlation between gingival biotype and CL and AP with $P = 0.001$ each. Significant correlation was also found between AC and PL with $P = 0.001$ each. The results of discriminant function analysis [Table 3] showed that average CL was the best single determinant of biotype and AP was the next best choice. These findings are in similar to those of a study conducted by Malhotra *et al*.[35] which showed that there was a highly significant association between gingival biotype and CL and AP. The results of discriminant function analysis in a study by Lee[36] showed that area of facial papilla was the single best determinant of biotype and papillary length was the second best choice in the study population.

Discussion

The term gingival biotype[8,13,37-39] has been used widely in the literature to describe the thickness of the gingiva in the faciopalatal dimension. It has been suggested that a direct correlation exists between gingival biotype and the susceptibility to gingival recession following orthodontic, surgical, and restorative procedures.[19,38,40] Therefore, an accurate diagnosis of gingival tissue biotype by the orthodontist is of the utmost importance in devising an appropriate treatment plan and achieving a predictable esthetic outcome.

Periodontium biotypes are generally of two types: Thick periodontium (prevalence: 85%) and thin periodontium (prevalence: 15%). Furthermore, there are few cases which have features of both thick and thin biotypes.[16] Thick periodontium is characterized by dense gingival tissue with a fairly large zone of attachment and is said to be associated with periodontal health. The gingival topography is relatively flat with the suggestion of a thick underlying bony architecture.[41] Surgical evaluation of these areas often reveals relatively thick underlying osseous forms. It is considered that thick gingival tissue allows better tissue manipulation, encourages creeping attachment, improves implant esthetics, reduces clinical inflammation, and renders predictable surgical outcomes. On the other hand, thin gingival tissue tends to be delicate, friable, and almost translucent in appearance. There is a minimal zone of the attached gingiva. The soft tissue is highly accentuated and often suggestive of thin or minimal bone over the roots labially. Moreover, thin gingival tissues are frequently characterized by osseous defects such as fenestration and dehiscence.[16] Thin periodontium usually exhibits pathological changes such as gingival recession when subjected to inflammatory, traumatic, or surgical insults. Scientific reports found that an orthodontic force and appliances may cause gingival recession in cases of thin periodontium.[42]

In general, gingival biotype can be evaluated by direct visual assessment, visual assessment with the aid of a periodontal probe, and by direct measurements which record true gingival thickness. Visual assessment relies heavily on the clinical experience of the examiner and is, therefore, subjective.

Table 1: Incisor inclination and position in participants with thin and thick gingival biotypes

Gingival biotype	Maxillary incisor inclination (°)	Maxillary incisor position (mm)	Mandibular incisor inclination (°)	Mandibular incisor position (mm)
Thin	26.10	5.35	97.2	6.98
Thick	26.26	5.48	94.13	4.91
P	0.84	0.717	0.001	0.001

Table 2: Comparative analysis of mean values of all dentopapillary complex parameters in both study groups

Gingival biotype	Crown length (mm)	Crown width (mm)	Papillary length (mm)	Papillary width (mm)	AP (mm)	AC (mm)	AP/AC
Thin	9.98	7.83	5.83	4.99	29.15	76.06	0.3721
Thick	8.69	7.88	4.7	4.95	23.29	68.31	0.3491
P	0.001	0.95	0.001	0.84	0.001	0.001	0.237

AP: Area of papilla, AC: Area of crown

Table 3: Correlations between variables using Pearson's correlation analysis

Parameters (P)	Average crown length (mm)	Average crown width (mm)	AC (mm^2)	Average papilla length (mm)	Average papilla width (mm)	AP (mm^2)	AP/AC
Average crown length	1.00	−0.168	0.805**	0.399**	0.068	0.280**	−0.046
Average crown width	−0.168	1.00	0.426**	−0.157	0.060	−0.042	−0.043
AC	0.805**	0.426	1.00	0.281**	0.082	0.221**	−0.083
Average papilla length	0.399**	−0.157	0.281**	1.00	−0.033	0.501**	0.366**
Average papilla width	0.068	0.060	0.082	−0.033	1.00	0.834**	0.778
AP	0.280**	−0.042	0.221**	0.501**	0.834**	1.00	0.877**
AP/AC	−0.046	−0.043	−0.083	0.366**	0.778**	0.877**	1.00

**Correlation is significant at the 0.01 level (two-tailed). AP: Area of papilla, AC: Area of crown

Assessment with a digital vernier caliper, on the other hand, provides some objectivity through direct measurement of the gingival thickness. It has previously been shown that gingival biotype identification by visual assessment is statistically significantly different from assessment with a periodontal probe and direct measurement.

While gingival disease must precede periodontal infection, not all gingival diseases progress to periodontitis. Because of the unpredictable nature of the disease progression, all orthodontic patients with inflamed gingiva must be considered to be at risk for periodontal damage. Gingival recession depends on the existence of a subjacent alveolar bone dehiscence and is always the result of a loss of attachment.[43] The predisposing factors are anatomical, whereas the precipitating factors consist of trauma or exacerbation of acceleration of gingival inflammation and alveolar bone dehiscences.[8] An association between orthodontic tooth movement and gingival recession has been mentioned in both the orthodontic and the periodontal literature.[44-46] Gingival recession can lead to poor esthetics, root sensitivity, loss of periodontal support, difficulties in maintenance of oral hygiene, and achieving successful periodontal repair as well as promoting increased susceptibility to caries.[44] It has been reported that 15% of teeth experience either the development or aggravation of gingival recession with orthodontic mechanics.[8] Geiger reported that the incidence of gingival recession with fixed orthodontic appliances ranges from 1.3% to 10%. Moreover, it is argued that preexisting mucogingival problems can be exacerbated with orthodontic force application.[47] The orthodontist must endeavor to identify gingival areas at risk for recession and advise patients of the anecdotal association, accordingly. Dorfman suggested that mandibular incisors may be more prone to recession than any other teeth.[3] He attributed this recession to a thin or nonexistent labial plate of bone, inadequate or absent keratinized gingiva, and labial prominence of teeth. When excessive orthodontic forces are applied, which do not permit repair or remodeling of bone during tooth movement, teeth with inadequate attached gingiva might show localized recession. Experimental studies[15,48-50] have demonstrated the formation of alveolar bone dehiscences in the vestibular area of the incisors after excessive anterior movement, particularly if expansion is combined with extrusion of the teeth.[48] Although the literature reports conflicting findings on possible associations between gingival recession and orthodontic mechanics, it seems prudent to emphasize the importance of a careful clinical examination, application of optimal forces, and control over tooth movement as a means to avoid or prevent this problem.

In the present study, the prevalence of thin gingival biotype was independently assessed for the maxillary and mandibular incisors, and the results showed a prevalence of 43% in the maxillary and 40% in the mandibular incisors. The results demonstrated that mandibular incisor proclination and protrusion were significantly associated with thin gingival biotype [Table 1]. Conversely, there was no association between the gingival biotypes and inclination and position of the maxillary incisors [Table 1]. Reduced gingival thickness might contribute to periodontal tissue breakdown.[4] Hence, the direction and magnitude of orthodontic forces should be carefully controlled, especially in participants with thin gingival biotype. Certain patients with thin gingival biotype may benefit from gingival augmentation before orthodontic treatment. Therefore, further studies to evaluate this concept are merited.

If the tooth movement is expected to result in the establishment of an alveolar bone dehiscence, the volume (thickness) of the covering soft tissue must be considered as a factor that may influence the development of soft-tissue recessions during, as well as after, the phase of active orthodontic therapy. Orthodontic tooth movement *per se* will not cause soft-tissue recession, but the thin gingiva that will be the consequence of the facial tooth movement may have less resistance to microbial invasion and to developing soft-tissue defects in the presence of bacterial plaque and/or trauma caused by improper toothbrushing techniques. Before the orthodontic therapy is initiated, one should meticulously consider if the buccolingual thickness of the soft tissue on the pressure side of the tooth should be increased.[51]

A secondary objective of the present study was to assess the relation between gingival biotype and the measurements of dentopapillary complex, comprised by the CL, CW, PL, and papilla width. It has long been known that clinical appearance of healthy marginal periodontium differs from participant to participant and even among different tooth types. It has been suggested that different gingival entities have different tooth shapes.[12,40] The thick gingival biotype seems to be associated with a squared tooth shape with larger and more apically located contact points while a thin gingival biotype seems to be correlated with a triangular tooth form with a smaller and more coronal located contact area.[16,17] Recent reports have been conducted on the appearance of gingival papillae in relation to crown shape and gingival thickness. They found that gingival thickness was positively correlated with interproximal tissue height.

The objective of the present study was to evaluate the presence of different morphometric combinations in a large sample using simple diagnostic methods. Maxillary central incisors were used as reference teeth because differences between biotypes are most apparent for these teeth and because their specific features are easily found in other parts of the dentition.[16,17,37]

The results of the present study showed that there was a highly significant association between gingival biotype and CL and AP with $P = 0.001$ each [Table 2]. Significant association was found between AC and papillary length with $P = 0.001$ and 0.002 [Table 2]. The results of discriminant function analysis [Table 3] showed that average CL was the best single determinant of biotype and AP was the next best choice. The results of discriminant function analysis in a similar study by Lee[36] also showed that area of facial papilla was the single best determinant of biotype and papillary length was the second best choice in the study population. The findings of the present study are in accordance with those of a study conducted by Malhotra *et al*.[35] which showed a highly significant association between gingival biotype and CL and AP. However, the present study had the merit of recording accurate gingival thickness by direct measurement with a digital vernier caliper, as opposed to the former study[35] which based its evaluation of biotype on transparency of periodontal probe, a more subjective method of categorizing the gingival biotype.

The limitation of the present study is that it was cross-sectional and hence gives no indication of the sequence of events. Another limitation is that the sample was drawn from a pool of patients from one center and that may prejudice the findings. In conclusion, mandibular incisor proclination and protrusion are associated with thin gingival biotype while no association is found in the maxilla. The evaluation of the gingival biotype is essential during diagnosis and treatment planning for potential orthodontic patients. The orthodontist should balance the pros and cons when deciding to procline or protrude incisors, particularly in the mandible.

Conclusion

Although gingival disease must precede periodontal infection, not all gingival diseases progress to periodontitis. Because of the unpredictable nature of the disease progression, all orthodontic patients with inflamed gingiva must be considered to be at risk for periodontal damage. As new discoveries in molecular genetics and the science of virology and bacteriology progress, refinements in concepts of disease risk factors emerge almost annually. Thus, orthodontists must understand both the physiology and the pathophysiology of the foundational tissues as well as the coronal elements that have traditionally defined the specialty. Within these anatomical and disease entities, gingival biotype is considered to be a paramount local factor, which influences periodontal health. The orthodontist must take this factor into consideration during implementation of treatment planning.

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Conflicts of interest

There are no conflicts of interest.

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