An evaluation of the gingival biotype and the width of keratinized gingiva in the mandibular anterior region of individuals with different dental malocclusion groups and levels of crowding

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Objective: To evaluate the relationship of gingival thickness (GT) and the width of keratinized gingiva (WKG) with different malocclusion groups and the level of crowding. **Methods:** A total of 187 periodontally healthy subjects (121 females and 66 males) who presented at the Faculty of Dentistry in Yüzüncü Yıl University for orthodontic treatment were enrolled in the study. The individuals involved in the study were divided into three groups; Angle Class I malocclusion, Angle Class II malocclusion, and Angle Class III malocclusion. Each group was classified as mild, moderate, or severe according to the level of crowding. WKG was determined as the distance between the mucogingival junction and the free gingival margin. GT was determined by the transgingival probing technique. Factorial variance analysis and the Duncan multiple comparison test were employed to identify the extent to which a difference was apparent between the groups according to these parameters. **Results:** It was determined that teeth in the mandibular anterior region display the thin gingival biotype. WKG and GT were observed as being higher at the mandibular incisor teeth in the severe crowding group and at the mandibular canine teeth in the mild crowding group. The GT of the mandibular right central and lateral incisors was found to be thinner in the Angle Class III group. **Conclusions:** Within the limits of this study, the results demonstrate that, there is no significant relationship of WKG and the mean GT in the mandibular anterior region according to the Angle classification.
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Key words: Crowding, Gingival thickness

INTRODUCTION

Gingival biotype is a term used to define the bucco-lingual thickness of the gingiva. Gingival thickness (GT) is determined by the shape and size of the dental root, and contour of the alveolar bone. It can be classified into two types: thick and thin.[1,2] A GT of ≤ 1 mm is classified as belonging to the thin biotype, while a GT of > 1 mm is classified as belonging to the thick biotype.[1]

GT is considered as an important factor in the success of periodontal and orthodontic treatment.[3,4] Careful evaluation of GT is important during the treatment planning stage in order to prevent pathological periodontal problems, such as gingival recession due to orthodontic treatment.[2,5] It has been reported that movements of teeth made within the anatomical limits of the alveolar bone by applying controlled orthodontic force do not cause any pathological problems. Dehiscence and fenestrations have been observed as a result of tooth movements exceeding the anatomical limits of the alveolar bone, and it has been noted that this causes gingival recession, especially in individuals who display the thin gingival biotype; nevertheless, this is largely dependent on the extent to which the alveolar bone supports the loss of the gingiva.[6,7]

Long-term studies evaluating the association between gingival recession and orthodontic treatment have led to the conclusion that gingival recession is more prevalent in individuals who have been treated orthodontically, as opposed to those who have not received such treatment.[6,8] In addition, the body of scholarly research demonstrates that mandibular incisors are more prone to gingival recession than other teeth.[6] In studies evaluating the association between lower incisor protrusion and orthodontic treatment, it has been stated that there is no statistically significant relationship between these two factors.[9,10] However, Yared et al.[11] investigated the relationship between gingival recession and the health status of periodontal tissue, the type and amount of tooth movement, the width of keratinized gingiva (WKG), and GT, and concluded that gingival recession is characterized by a greater prevalence in certain contexts. Specifically, the condition is more frequent when GT is < 0.5 mm, WKG is < 2 mm, and lower incisors protrude at an angle that is greater than 95°. The researchers also noted that GT is a factor with greater importance than protrusion movement.

Although a number of studies have been published that relate to an evaluation of the correlation between GT and malocclusions, no studies in the extant literature have evaluated the association between keratinized gingival width and malocclusions. Therefore, the aim of the present study was to investigate the relationship of GT and WKG with different malocclusion groups and levels of crowding. The null hypothesis is that the GT and WKG of lower anterior teeth will change on the basis of the different malocclusion groups and levels of crowding.

MATERIALS AND METHODS

A total of 187 subjects (121 females and 66 males) were enrolled in the present study, all of whom presented at the Department of Orthodontics, Faculty of Dentistry, Yüzüncü Yıl University between June 2014 and June 2015 for orthodontic treatment. Following the provision of a description of the study, written and informed consent was obtained from all participants. The study was commenced after obtaining the approval of the Research Ethics Committee of Faculty of Medicine in Yüzüncü Yıl University (B.30.2.YYU.0.01.00.00/141).

The exclusion criteria were as follows: history of previous orthodontic treatment; the presence of attachment loss or a pocket deeper than 4 mm; congenital anomaly; dental structural disorder; crowns or extensive restoration; pregnancy or lactation; any systemic problems and related medications that could have an impact on the thickness of gingival tissues; the administration of antibiotic premedication due to any disturbance within the recent six months; and smoking. Correspondingly, periodontally healthy subjects with complete permanent dentition (with the exception of third molars) were included in the study.

The participants were divided into three groups; Angle Class I malocclusion, Angle Class II malocclusion, and Angle Class III malocclusion. For the Angle Class I relationship, the mesio-buccal cusp of the maxillary first permanent molar occluded with the mesio-buccal groove of the mandibular first permanent molar. Additionally, further attention was directed towards the distal surface of the disto-buccal cusp of the upper first permanent molar and the way in which it contacted with the mesial surface of the mesio-buccal cusp of the lower second molar; furthermore, the mesio-palatal cusp of the upper first permanent molar occluded with the central fossa of the lower first permanent molar. The mesio-buccal grove of the mandibular first permanent molar was positioned distally to the mesio-buccal cusp of the maxillary first permanent molar in the Angle Class II relationship and mesially in the Angle Class III relationship.[12]

Each Angle classification group was divided into subgroups according to the level of dental crowding in the mandibular anterior region. The mesio-distal width of each tooth, including the canine teeth, was measured from plaster models with a Boley gauge. Where the contact points were broken, the required space for each tooth was calculated by subtracting the mesio-distal width of the tooth from the available space. This study

determined the level of crowding by the sum of the lack of all space, and it was classified in three ways; mild (0–3 mm), moderate (4–6 mm), and severe (> 6 mm).[13]

Measurements of the plaque index (PI),[14] gingival index (GI),[15] and probing depth (PD) of the periodontal pocket were conducted from the mesial and distal surfaces; furthermore, this took place from the vestibular midpoint and palatial midpoint of the subjects' mandibular anterior teeth using a periodontal probe (PQW7, Williams; Hu-Friedy Mfg. Co., LLC, Chicago, IL, USA). The WKG was measured from the mucogingival junction to the free gingival margin at the buccal area of the mandibular anterior teeth.

A digital caliper with a sensitivity of 0.01 mm was used to determine GT. The GT of each patient was assessed by a single researcher (YK) prior to the orthodontic treatment. Measurements were carried out from two points on the buccal aspect of the mandibular anterior teeth (canine–canine): apical to the free gingival margin and coronal to the mucogingival junction (Figure 1).

After marking the measurement points with a marking pen, xylocaine spray (Vemcaine 10% lidocaine; Vem, Istanbul, Turkey) was administered to the patient or alternatively, a local anesthetic (Maxicaine, lidocaine hydrochloride; Vem) was used to reduce pain when necessary. For the patients for whom a local anesthetic was necessary, the anesthetic solution was injected slowly at a dose of 0.1 mL to prevent an anesthesia-related increase of the mucosal volume. The required measurements were performed 10–20 minutes after the injection was administered, and took place from the marked points by perpendicularly inserting a 10-mm endodontic spreader (Golden Star Medical Co., Ltd., Guangdong, China). This involved the placement of a silicone stopper to the gingiva until the alveolar bone w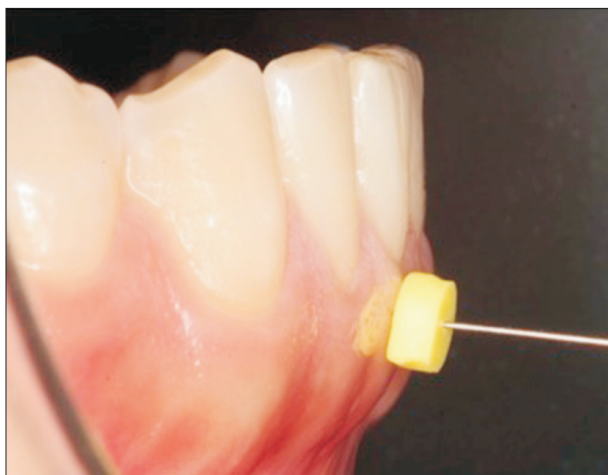as reached. Since the application of excessive force would cause the spreader to cross the soft tissue and go through the alveolar bone, careful attention was paid to apply a light force that was limited only to the soft tissue.

All measurements were repeated two times at 10-minute intervals by the same researcher and the average result was recorded as the final measurement for thickness at each location. It is notable that intra-examiner agreement was high (Pearson correlation coefficient = 0.901, $p < 0.001$). In addition, the random measurement error was calculated with Dahlberg's formula, and it was observed that these error values ranged from 0.034 to 0.022. The GT of each tooth was determined by the arithmetic mean of the GT values obtained from the apical part of the gingival sulcus and the coronal aspect of the mucogingival junction. The gingival biotype of the mandibular anterior teeth was determined by the ratio of the sum of GT of the mandibular anterior teeth to the number of teeth. If the obtained measurement values were less than 1 mm, the gingiva was classified as a thin biotype; where the obtained values were greater than 1 mm, it was classified as a thick biotype.

Statistical analysis

Statistical analysis was carried out using the program IBM SPSS Statistics for Windows, version 22.0 (IBM Co., Armonk, NY, USA). The sample size was determined by considering the minimum 80% power value and the 5% type 1 error. Descriptive statistics for the considered parameters were presented as mean, standard deviation, and maximum and minimum values. Additionally, the Kolmogorov-Smirnov test was performed to determine the normality of the variables, and Levene's test was also used to determine the homogeneity of variances. After these tests, Factorial Variance Analysis was performed to determine whether any differences existed with regard to the Angle classification and the level of crowding. Following the factorial variance analysis, Duncan's multiple-range test was performed to assess the nature of the crowding groups and the different classes of Angle classification. In turn, the chi-square test was implemented in order to identify the nature of the relationship between the gingival biotype, Angle classification, the level of crowding, and gender. The level of statistical significance was 5%.

RESULTS

There was no statistically significant difference between the genders in terms of number and the mean age of patients. The study group consisted of a total of 187 patients aged between 10 and 28.2 years, of whom 121 were female (mean age, 17.5 ± 4.25 years) and 66 were male (mean age, 15.8 ± 3.17 years). No statistically significant difference was found between the genders in

Figure 1. Gingival thickness measurement.

terms of number and mean age of patients.

The number of patients in the Angle Class I, II, and III malocclusion groups was 76 (40.6%), 80 (42.8%), and 31 (16.6%), respectively. In addition, the number of patients in the mild, moderate, and severe crowding groups was 101 (54.0%), 50 (26.7%), and 36 (19.3%), respectively (Table 1). There was no statistically significant difference between the groups in terms of the number of patients.

In Tables 2, 3, and 4, the vertical columns describe the crowding levels and the horizontal columns describe the Angle classification groups. Interpretations were conducted in accordance with general means. The distribution of PI, GI, and PD measurements, used in determining the periodontal status of patients, are

displayed in Table 2, according to Angle classification and the level of crowding. The PI values were significantly higher in the severe crowding group than in the mild crowding group; this was also the case in the Angle Class III malocclusion group, compared to the Angle Class II malocclusion group ($p = 0.042$). There was no statistically significant difference between groups in terms of GI values. In addition, PD values were higher in terms of statistical significance in the Angle Class III malocclusion group than they were in the Angle Class I malocclusion group ($p = 0.101$).

The WKG of the lower anterior teeth according to Angle classification and the level of crowding is displayed in Table 3. No statistically significant difference was observed between the WKG of the lower anterior teeth according to Angle classification. The WKG values for the mandibular left central and lateral incisors and the mandibular right lateral incisor were higher in the severe crowding group ($p < 0.05$). In addition, it should also be noted that, while the WKG of the mandibular right central incisor was higher in the severe crowding group, the difference was not statistically significant. The WKG values of mandibular canines were higher in the mild crowding group ($p < 0.05$).

Table 4 summarizes and displays the GT of the lower anterior teeth on the basis of Angle classification and the level of crowding. It was observed that teeth in

Table 1. Distribution of patients according to Angle classification and crowding amount

Classification	Amount of crowding		
	Mild	Moderate	Severe
Angle Class I	42	23	11
Angle Class II	46	20	14
Angle Class III	13	7	11

Chi-square = 6.955; $p = 0.138$.

Table 2. Distribution of plaque index, gingival index and probing depth measurements according to Angle classification and crowding amount

Variable	Mild crowding	Moderate crowding	Severe crowding	Total	*p*-value*
Plaque index					
Angle Class I	1.16 ± 0.28	1.06 ± 0.08	1.22 ± 0.22	1.14[ab] ± 0.23	
Angle Class II	1.12 ± 0.17	1.06 ± 0.12	1.12 ± 0.14	1.11[b] ± 0.15	
Angle Class III	1.19 ± 0.23	1.13 ± 0.23	1.30 ± 0.27	1.22[a] ± 0.25	
Total	1.07[B] ± 0.12	1.15[AB] ± 0.23	1.21[A] ± 0.22	1.14 ± 0.21	0.042
Gingival index					
Angle Class I	0.35 ± 0.45	0.47 ± 0.53	0.30 ± 0.42	0.38 ± 0.47	
Angle Class II	0.37 ± 0.50	0.29 ± 0.45	0.44 ± 0.54	0.36 ± 0.49	
Angle Class III	0.21 ± 0.35	0.19 ± 0.21	0.30 ± 0.41	0.24 ± 0.34	
Total	0.34 ± 0.46	0.36 ± 0.47	0.36 ± 0.46	0.35 ± 0.46	0.334
Probing depth					
Angle Class I	1.77 ± 0.54	1.64 ± 0.42	1.64 ± 0.78	1.71[b] ± 0.55	
Angle Class II	1.82 ± 0.39	1.81 ± 0.37	1.78 ± 0.66	1.81[ab] ± 0.44	
Angle Class III	1.93 ± 0.33	1.99 ± 0.30	1.87 ± 0.30	1.92[a] ± 0.31	
Total	1.81 ± 0.45	1.75 ± 0.40	1.76 ± 0.61	1.79 ± 0.47	0.101

Values are presented as mean ± standard deviation.
[A,B]Statistically significant difference between amount of crowding ($p < 0.05$).
[a,b]Statistically significant difference between Angle classification ($p < 0.05$).
*Two-way (factorial) ANOVAs were performed and interaction was not statistically significant.

Table 3. Width of keratinized gingiva (WKG) of mandibular anterior teeth according to Angle classification and amount of crowding

Angle classification	Mild crowding	Moderate crowding	Severe crowding	Total
WKG of tooth number 31				
Angle Class I	2.72 ± 1.19	2.60 ± 1.47	2.50 ± 1.37	2.65 ± 1.29
Angle Class II	2.44 ± 1.39	2.32 ± 1.71	3.32 ± 1.71	2.56 ± 1.55
Angle Class III	2.19 ± 1.42	1.28 ± 0.75	3.31 ± 1.97	2.38 ± 1.68
Total	2.52^{AB} ± 1.31	2.31^{B} ± 1.54	3.06^{A} ± 1.70	2.57 ± 1.47
WKG of tooth number 32				
Angle Class I	3.69 ± 1.39	3.82 ± 1.64	4.40 ± 1.77	3.83 ± 1.52
Angle Class II	3.75 ± 1.43	4.07 ± 2.49	4.42 ± 1.91	3.95 ± 1.82
Angle Class III	2.96 ± 1.46	2.42 ± 1.53	5.04 ± 1.85	3.58 ± 1.93
Total	3.62^{B} ± 1.42	3.73^{B} ± 2.05	4.61^{A} ± 1.82	3.84 ± 1.72
WKG of tooth number 33				
Angle Class I	2.42 ± 1.30	1.78 ± 1.37	1.50 ± 0.94	2.09 ± 1.32
Angle Class II	2.45 ± 1.73	1.80 ± 1.27	1.46 ± 1.10	2.11 ± 1.57
Angle Class III	2.07 ± 1.23	1.57 ± 0.93	2.04 ± 1.57	1.95 ± 1.28
Total	2.39^{A} ± 1.50	1.76^{B} ± 1.25	1.65^{B} ± 1.21	2.08 ± 1.42
WKG of tooth number 41				
Angle Class I	3.19 ± 1.15	3.34 ± 1.70	2.68 ± 1.53	3.16 ± 1.39
Angle Class II	3.01 ± 1.49	2.77 ± 1.53	3.28 ± 1.60	3.00 ± 1.51
Angle Class III	2.65 ± 1.28	1.42 ± 0.78	3.63 ± 2.56	2.72 ± 1.91
Total	3.03 ± 1.31	2.85 ± 1.64	3.20 ± 1.91	3.02 ± 1.54
WKG of tooth number 42				
Angle Class I	3.88 ± 1.24	4.06 ± 1.86	4.13 ± 1.18	3.97 ± 1.43
Angle Class II	3.84 ± 1.45	3.92 ± 2.23	4.57 ± 1.77	3.99 ± 1.73
Angle Class III	2.73 ± 1.48	2.50 ± 1.44	5.00 ± 2.52	3.48 ± 2.17
Total	3.71^{B} ± 1.41	3.79^{B} ± 2.00	4.56^{A} ± 1.87	3.90 ± 1.70
WKG of tooth number 43				
Angle Class I	2.46 ± 1.29	1.82 ± 1.18	1.54 ± 1.08	2.13 ± 1.27
Angle Class II	2.23 ± 1.54	1.50 ± 1.22	1.60 ± 1.52	1.94 ± 1.48
Angle Class III	2.15 ± 1.08	1.57 ± 1.09	1.81 ± 1.10	1.90 ± 1.08
Total	2.32^{A} ± 1.38	1.66^{B} ± 1.17	1.65^{B} ± 1.24	2.01 ± 1.33

Values are presented as mean ± standard deviation.
Two-way (factorial) ANOVAs were performed and interaction was not statistically significant.
[A, B]Statistically significant difference between amount of crowding ($p < 0.05$).
There were no statistically significant differences among Angle classifications ($p > 0.05$).

the lower anterior jaw displayed thin gingival biotype, and yet there was no statistically significant difference observed between Angle classification and the GTs of the mandibular left central and lateral incisors, and the mandibular canines. However, the GTs of the mandibular right central and lateral incisors was observed to be significantly lower in the Angle Class III malocclusion group ($p < 0.05$). The GTs of the mandibular left central and lateral incisors, and the mandibular right lateral incisor were significantly higher in the severe crowding group ($p < 0.05$). Notably, although the GT of the mandibular right central incisor was higher in the severe crowding group, the difference was not statistically significant. The GTs of the mandibular canines were higher in terms of statistical significance in the mild crowding group ($p < 0.05$).

Table 4. Gingival thickness (GT) of mandibular anterior teeth according to Angle classification and amount of crowding

Angle classification	Mild crowding	Moderate crowding	Severe crowding	Total
GT of tooth number 31				
Angle Class I	0.70 ± 0.19	0.71 ± 0.27	0.70 ± 0.23	0.70 ± 0.22
Angle Class II	0.69 ± 0.16	0.59 ± 0.20	0.74 ± 0.14	0.68 ± 0.17
Angle Class III	0.61 ± 0.23	0.47 ± 0.16	0.77 ± 0.19	0.64 ± 0.23
Total	0.69[AB] ± 0.18	0.63[B] ± 0.24	0.74[A] ± 0.18	0.68 ± 0.20
GT of tooth number 32				
Angle Class I	0.73 ± 0.20	0.84 ± 0.28	0.94 ± 0.26	0.80 ± 0.24
Angle Class II	0.76 ± 0.16	0.76 ± 0.30	0.92 ± 0.31	0.79 ± 0.24
Angle Class III	0.65 ± 0.22	0.84 ± 0.47	0.89 ± 0.16	0.78 ± 0.29
Total	0.74[B] ± 0.19	0.81[B] ± 0.31	0.91[A] ± 0.25	0.79 ± 0.25
GT of tooth number 33				
Angle Class I	0.70 ± 0.21	0.67 ± 0.20	0.49 ± 0.15	0.66 ± 0.21
Angle Class II	0.72 ± 0.19	0.62 ± 0.23	0.59 ± 0.19	0.67 ± 0.21
Angle Class III	0.61 ± 0.21	0.64 ± 0.27	0.64 ± 0.13	0.63 ± 0.19
Total	0.70[A] ± 0.20	0.64[AB] ± 0.22	0.57[B] ± 0.17	0.66 ± 0.21
GT of tooth number 41				
Angle Class I	0.75 ± 0,19	0.74 ± 0.18	0.72 ± 0.27	0.75[a] ± 0.20
Angle Class II	0.72 ± 0.17	0.67 ± 0.22	0.79 ± 0.19	0.72[a] ± 0.19
Angle Class III	0.63 ± 0.23	0.48 ± 0.13	0.74 ± 0.21	0.63[b] ± 0.22
Total	0.72 ± 0.19	0.68 ± 0.21	0.75 ± 0.22	0.72 ± 0.20
GT of tooth number 42				
Angle Class I	0.79 ± 0.18	0.84 ± 0.29	0.97 ± 0.38	0.83[ab] ± 0.26
Angle Class II	0.80 ± 0.18	0.82 ± 0.27	1.09 ± 0.42	0.85[a] ± 0.28
Angle Class III	0.67 ± 0.20	0.63 ± 0.22	0.86 ± 0.27	0.73[b] ± 0.24
Total	0.78[B] ± 0.18	0.81[B] ± 0.28	0.98[A] ± 0.37	0.82 ± 0.26
GT of tooth number 43				
Angle Class I	0.71 ± 0,21	0.61 ± 0.23	0.56 ± 0.18	0.66 ± 0.22
Angle Class II	0.68 ± 0.22	0.61 ± 0.31	0.59 ± 0.19	0.65 ± 0.24
Angle Class III	0.63 ± 0.21	0.52 ± 0.25	0.59 ± 0.17	0.59 ± 0.20
Total	0.69[A] ± 0.22	0.60[B] ± 0.26	0.58[B] ± 0.17	0.64 ± 0.23

Values are presented as mean ± standard deviation.
Two-way (factorial) ANOVAs were performed and interaction was not statistically significant.
[A, B]Statistically significant difference between amount of crowding ($p < 0.05$).
[a, b]Statistically significant difference between Angle classification ($p < 0.05$).

Table 5 presents an overview of the mean GT of the mandibular anterior region on the basis of Angle classification and the level of crowding. It was determined that the mean GT of the mandibular anterior region is 0.71 ± 0.17 mm and, moreover, displays the thin gingival biotype. It did not exhibit any significant association with Angle classification or the level of crowding ($p = 0.140$ and 0.321, respectively).

DISCUSSION

There is a range of risk factors associated with gingival recession, especially in the area of the mandibular incisors during orthodontic treatment. These include the following: the age of the patient, the health status of the periodontal tissues, the duration of the treatment, the amount and type of tooth movement, the WKG, and GT.[9,16] Nevertheless, owing to the lack of research

Table 5. Gingival thickness (GT) of the mandibular anterior region according to Angle classification and amount of crowding

Variable	GT of mandibular anterior region	p-value
Angle Class I	0.73 ± 0.17 (0.299–1.388)	0.140
Angle Class II	0.72 ± 0.16 (0.333–1.182)	
Angle Class III	0.66 ± 0.17 (0.275–0.961)	
Mild crowding	0.71 ± 0.16 (0.324–1.218)	0.321
Moderate crowding	0.69 ± 0.21 (0.275–1.388)	
Severe crowding	0.75 ± 0.14 (0.448–1.056)	
Total	0.71 ± 0.17 (0.275–1.388)	

Values are presented as mean ± standard deviation (range). Two-way (factorial) ANOVAs were performed and interaction was not statistically significant.

that has been conducted in order to evaluate each of these parameters, a range of conflicting opinions exist regarding the effect of mandibular incisor protrusion on periodontal tissues.[9,16] One group of researchers has published the claim that such orthodontic tooth movements are risk factors for gingival recession, due to the fact that the buccal alveolar bone of mandibular incisors is thin.[11,17] Contrastingly, another group has reported there is no such relation between the two.[9,10,18] Two notable studies, by Wennström et al.[18] and Yared et al.,[11] stated that among the parameters evaluated at the planning stage of orthodontic treatment, GT is a more important factor than WKG and protrusion movement. Therefore, the aim of the present study was to evaluate the relationship that exists between WKG and GT, both of which are considered to be significant risk factors for gingival recession that may be seen in the mandibular anterior region with different malocclusion groups and levels of crowding.

Literature review demonstrated that visual assessment,[1] ultrasonic devices,[19] the parallel profile radiography technique,[20] cone-beam computed tomography,[1,3] periodontal probes,[1,3] and transgingival probing[1,21] are the techniques that have been used for the purpose of determining GT. The most frequently used techniques in modern orthodontic practice for GT measurements are periodontal probing and transgingival probing. However, in studies which compare the reliability of periodontal probing in relation to transgingival probing,[22] cone beam computed tomography,[3,20] and parallel profile radiography techniques,[19] it has been determined that this technique is not reliable. Contrastingly, in studies that compared transgingival probing with surgical flap operations[21] and cone-beam computed tomography,[20] transgingival probing has been found to be a reliable way in which

to derive measurements of GT. It is for this reason that transgingival probing, which facilitates the evaluation of the gingiva at two points in millimeters, is preferred in our study.

It has been found that GT is affected by changes in the position of teeth during the eruption period.[23] Furthermore, it has been determined that this effect is decreased as age increases; this is because as connective tissue becomes denser, the cell count decreases, the epithelium becomes thinner, and keratinization increases.[24] It has been observed that age groups were constituted differently in studies which investigated the relation between GT and age. The present study group consisted of subjects aged less than 29 years who had all of their permanent teeth erupted, meaning that GT would not be influenced to a considerable degree by age-related factors.[25]

A range of opinions exists in the extant literature relating to the role that WKG plays in the maintenance of periodontal health during orthodontic treatment. Closs et al.[26] investigated the relationship between the initial WKG and gingival recession by examining 209 subjects treated with fixed orthodontic appliances, and concluded that no significant difference existed in the initial WKG for individuals who did or did not have gingival recession. However, it is important to note that, in this study, the mean WKG of all teeth was greater than 2 mm. In addition, while Yared et al.[11] suggested that a WKG of less than 2 mm is inadequate to maintain periodontal health, Coatoam et al.[17] suggested that such a width is adequate for individuals with good oral hygiene. In light of these results, it is important to note the findings of the present study: namely, that a WKG for mandibular anterior teeth of between 2.01 ± 1.33 – 3.90 ± 1.70 mm was found to be adequate for the maintenance of periodontal health.

The present study indicated that mandibular anterior teeth display the thin gingival biotype. Given this, it has been determined that, when the thickness of the gingiva is decreased in the bucco-lingual direction, the apico-coronal height also decreases.[18] Accordingly, the WKG of the thin gingival biotype is less than that of the thick gingival biotype.[1,3] It has also been determined that the tooth germs of the mandibular permanent canines are positioned in the same direction as the mandibular primary canine roots, thereby meaning that the WKG and GT of these teeth is less than that of mandibular incisor teeth. This is due to the fact that frequent eruptions on the vestibular position take place if there is insufficient space for them.[18,23,27] Consistent with these findings, the present study observed that the WKG and GT of mandibular canines are less than those of mandibular incisors. However, the difference between the GT of mandibular canines and that of tooth number

31 was not significant.

The tooth germs of mandibular permanent incisors are positioned lingually with respect to the mandibular primary incisors. Thus, there is a tendency for the mandibular permanent incisors to erupt somewhat lingually and in an irregular position, even in children who have normal dental arches. Furthermore, this position cannot be corrected in the event of crowding.[27] In addition, the extant literature reports that the tooth germs of mandibular lateral incisors are positioned more lingually compared to the tooth germs of mandibular central incisors and, in cases where crowding is an issue, this facilitates eruption in a more lingual position than mandibular central incisors.[27] Moreover, the WKG and GT of lingually erupting teeth are reported as being higher.[18,23] Consistent with these results, the present study demonstrated that the WKG and GT of mandibular lateral incisors are higher than those of mandibular central incisors.

When the level of crowding increases, it is expected that the WKG and GT of the mandibular canines will decrease. This is primarily owing to the fact that they erupt in a more vestibular position and, in addition, the WKG and GT of the mandibular central and lateral incisors increases; this also takes place because they erupt in a more lingual position. In the extant literature relating to the WKG, no findings have been published regarding the relation between the WKG of each mandibular anterior tooth and the level of crowding. Our study indicates that the WKG of the mandibular left central and lateral incisors and mandibular right lateral incisor are significantly higher in the severe crowding group ($p < 0.05$), compared to the other groups. Although the WKG of the mandibular right central incisor is higher in the severe crowding group, the difference is not statistically significant. The WKG of the mandibular canines are significantly higher in the mild crowding group ($p < 0.05$), compared to the other groups.

Relatively few studies have been published in the extant literature that focus on evaluating the relationship between the gingival biotype and the level of crowding. Of the available studies, Zawawi and Al-Zahrani[28] stated that there is no significant association between the level of crowding and GT in the mandibular anterior region. In this study, it was observed that periodontal probing was used to measure GT; the space analysis was performed by including only mandibular incisors; and only the mandibular central incisor was taken as a reference to detect the gingival biotype of subjects. In our study, the relationship of the GT of each mandibular anterior tooth with the level of crowding was evaluated, primarily because the GT may be subject to variation depending on the position of the teeth in the dental arch.[18,23] In addition, space analysis was performed by including the canine teeth, and GTs of the mandibular left central and lateral incisors and mandibular right lateral incisor were observed to be significantly higher in the severe crowding group ($p < 0.05$). Although the GT of the mandibular right central incisor is higher in the severe crowding group, this difference is not statistically significant. In addition, it is noteworthy that the GT of the mandibular canines are significantly higher in the mild crowding group ($p < 0.05$).

The present study displayed no statistically significant relationship between the WKG and the Angle classification in the mandibular anterior region. Furthermore, it is worth noting that no study currently exists in the extant literature that has evaluated the relationship between these two variables.

A limited number of studies exist in the literature that have evaluated the association of gingival biotype with different dental malocclusion groups. Among these, Zawawi et al.[2] studied 200 individuals and reported that no statistically significant relationship was observed between the gingival biotype and Angle classification. Their study used periodontal probing to determine the gingival biotype and only the maxillary central incisor was used as a reference to determine the gingival biotype of subjects. However, Matarese et al.,[29] in a study focusing on 76 individuals, assessed biotype by employing periodontal probing at the mid-facial aspect of the maxillary central, lateral incisors, and canines, and found that no statistically significant relationship existed between the gingival biotype and Angle classification. The researchers also noted that the GT is subject to change on the basis of tooth position, facial characteristics, and profile, thereby warranting further study to evaluate the impact of these parameters. Consistent with these results, our study showed that there is no statistically significant relationship between the mean GT of the mandibular anterior region and Angle classification. It was also found that there is no statistically significant relationship of the GT of the mandibular left central and lateral incisors, and that of the mandibular canines with Angle classification. The GT values of the mandibular right central and lateral incisors are statistically lower in the Angle Class III malocclusion group ($p < 0.05$).

It is important to acknowledge the current study's limitations, and the primary limitation of this research has been the sole examination and evaluation of the relationship of the GT of the mandibular anterior jaw with Angle classification and the level of crowding. Given the fact that other parameters have an impact on GT, including vertical and sagittal skeletal relationship, tooth position, and overjet/overbite, further study to evaluate their impact is recommended.

CONCLUSION

The first critical finding of the current study is the observation that teeth in the lower anterior jaw display thin gingival biotype. Second, it has been found that, when the level of crowding increases, there is a corresponding increase in the WKG and GT of the central and lateral incisors; simultaneously, there is a corresponding decrease in the WKG and GT of canines. Third, there is no association between the Angle classification and the mean GT of the mandibular anterior region. The final conclusion is that the GT of the mandibular right central and lateral incisors is lower in the Angle Class III group.

REFERENCES

1. La Rocca AP, Alemany AS, Levi P Jr, Juan MV, Molina JN, Weisgold AS. Anterior maxillary and mandibular biotype: relationship between gingival thickness and width with respect to underlying bone thickness. Implant Dent 2012;21:507-15.
2. Zawawi KH, Al-Harthi SM, Al-Zahrani MS. Prevalence of gingival biotype and its relationship to dental malocclusion. Saudi Med J 2012;33:671-5.
3. Cook DR, Mealey BL, Verrett RG, Mills MP, Noujeim ME, Lasho DJ, et al. Relationship between clinical periodontal biotype and labial plate thickness: an in vivo study. Int J Periodontics Restorative Dent 2011;31:345-54.
4. Sin YW, Chang HY, Yun WH, Jeong SN, Pi SH, You HK. Association of gingival biotype with the results of scaling and root planing. J Periodontal Implant Sci 2013;43:283-90.
5. Bains VK, Gupta V, Srivastava R, Agarwal SK. Accretion of gingival height by gingival thickness augmentation: A clinical report. Asian J Oral Health Allied Sci 2013;3:25-31.
6. Renkema AM, Fudalej PS, Renkema AA, Abbas F, Bronkhorst E, Katsaros C. Gingival labial recessions in orthodontically treated and untreated individuals: a case - control study. J Clin Periodontol 2013;40:631-7.
7. Chatzopoulou D, Johal A. Management of gingival recession in the orthodontic patients. Semin Orthod 2015;21:15-26.
8. Slutzkey S, Levin L. Gingival recession in young adults: occurrence, severity, and relationship to past orthodontic treatment and oral piercing. Am J Orthod Dentofacial Orthop 2008;134:652-6.
9. Renkema AM, Fudalej PS, Renkema A, Bronkhorst E, Katsaros C. Gingival recessions and the change of inclination of mandibular incisors during orthodontic treatment. Eur J Orthod 2013;35:249-55.
10. Kamak G, Kamak H, Keklik H, Gurel HG. The effect of changes in lower incisor inclination on gingival recession. ScientificWorldJournal 2015;2015:193206.
11. Yared KF, Zenobio EG, Pacheco W. Periodontal status of mandibular central incisors after orthodontic proclination in adults. Am J Orthod Dentofacial Orthop 2006;130:6.e1-8.
12. Proffit WR. Malocclusion and dentofacial deformity in contemporary society. In: Proffit WR, Fields HW, Sarver DM, eds. Contemporary orthodontics. 4th ed. St. Louis, MO: Mosby Elsevier; 2007. p. 2-24.
13. Sayin MO, Türkkahraman H. Malocclusion and crowding in an orthodontically referred Turkish population. Angle Orthod 2004;74:635-9.
14. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1964;22:121-35.
15. Löe H, Silness J. Periodontal disease in pregnancy. I. Pregnancy and severity. Acta Odontol Scand 1963; 21:533-51.
16. Melsen B, Allais D. Factors of importance for the development of dehiscences during labial movement of mandibular incisors: a retrospective study of adult orthodontic patients. Am J Orthod Dentofacial Orthop 2005;127:552-61; quiz 625.
17. Coatoam GW, Behrents RG, Bissada NF. The width of keratinized gingiva during orthodontic treatment: its significance and impact on periodontal status. J Periodontol 1981;52:307-13.
18. Wennström JL. Mucogingival considerations in orthodontic treatment. Semin Orthod 1996;2:46-54.
19. Stein JM, Lintel-Höping N, Hammächer C, Kasaj A, Tamm M, Hanisch O. The gingival biotype: measurement of soft and hard tissue dimensions - a radiographic morphometric study. J Clin Periodontol 2013;40:1132-9.
20. Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong DJ, Wang HL. Tissue biotype and its relation to the underlying bone morphology. J Periodontol 2010;81:569-74.
21. Greenberg J, Laster L, Listgarten MA. Transgingival probing as a potential estimator of alveolar bone level. J Periodontol 1976;47:514-7.
22. Kan JY, Morimoto T, Rungcharassaeng K, Roe P, Smith DH. Gingival biotype assessment in the esthetic zone: visual versus direct measurement. Int J Periodontics Restorative Dent 2010;30:237-43.
23. Hirschfeld I. A study of skulls in the American museum of natural history in relation to periodontal disease. J Dent Res 1923;5:241-65.
24. Kolte R, Kolte A, Mahajan A. Assessment of gingival thickness with regards to age, gender and arch location. J Indian Soc Periodontol 2014;18:478-81.
25. Wara-aswapati N, Pitiphat W, Chandrapho N, Rattanayatikul C, Karimbux N. Thickness of palatal masticatory mucosa associated with age. J Pe-

riodontol 2001;72:1407-12.
26. Closs LQ, Branco P, Rizzatto SD, Raveli DB, Rösing CK. Gingival margin alterations and the pre-orthodontic treatment amount of keratinized gingiva. Braz Oral Res 2007;21:58-63.
27. Proffit WR. The development of orthodontic problems. In: Proffit WR, Fields HW, Sarver DM, eds. Contemporary orthodontics. 4th ed. St. Louis, MO: Mosby Elsevier; 2007. p. 72-106.

28. Zawawi KH, Al-Zahrani MS. Gingival biotype in relation to incisors' inclination and position. Saudi Med J 2014;35:1378-83.
29. Matarese G, Isola G, Ramaglia L, Dalessandri D, Lucchese A, Alibrandi A, et al. Periodontal biotype: characteristic, prevalence and dimensions related to dental malocclusion. Minerva Stomatol 2016;65:231-8.