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Research Article

Distribution of Gingival Biotypes of Anterior Teeth in Egyptian Adults with Skeletal Class II and Skeletal Class III Jaw Relations and Different Vertical Facial Patterns: A Cross-Sectional Study

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Abstract

Aim: Studying the distribution of gingival biotypes and evaluation of width of keratinized gingiva of anterior teeth in Egyptian adults with skeletal class II and skeletal class III jaw relations and different vertical facial patterns.

Methodology: This cross-sectional study included 182 Egyptian orthodontic patients with skeletal class II and skeletal class III pattern (74 males, 108 females) who applied for orthodontic treatment in faculty of Dentistry, Cairo University starting from November 2018 October 2019. They were included in the study based on Wits appraisal measured on lateral cephalometric radiograph taken as a routine record before orthodontic treatment. They were further divided into six subgroups based on vertical facial pattern according to facial axis angle. Gingival biotypes for the anterior teeth have been classified either thick biotype or thin biotype using probe transparency method. Width of keratinized gingiva has been measured for each anterior tooth using digital caliper.

Results: There was a statistical significant decrease in the percentage of thin gingival biotypes in upper anterior teeth in skeletal Class II patients with hyperdivergent facial pattern. Also there was a statistical significant increase in the distribution of thin gingival biotypes in lower anterior teeth in skeletal class II patients with normo-divergent facial pattern and skeletal class III patients with hyperdivergent facial pattern. Width of keratinized gingiva of anterior teeth has demonstrated no correlation with different skeletal sagittal and vertical malocclusion patterns.

Conclusion: Thin gingival biotype is more distributed in lower anterior teeth in skeletal class II patients with normo-divergent facial pattern and skeletal class III patients with hyperdivergent facial pattern. Thick gingival biotype is more prevalent in upper anterior teeth in all skeletal malocclusion groups with the most prevalence in skeletal class II patients with hyperdivergent facial pattern.

Keywords: Skeletal Malocclusion; Gingival Biotype; Facial Pattern; Keratinized Gingival Width

Introduction

A successful orthodontic treatment depends largely on maintaining a healthy periodontium during the phase of active orthodontic treatment, which necessitates formulating a treatment plan that biologically respects the periodontal structures. The periodontium in humans consists of alveolar bone, gingiva, periodontal ligament and cementum. It serves as the supporting apparatus for the teeth not only in static occlusal relationships, but also during function.

One of the common complications that may occur during or after orthodontic treatment is gingival recession [1]. Among the factors that has been suggested in causing gingival recession during orthodontic treatment was gingival biotype. Gingival biotype (GT) is a term used to define the facio-lingual thickness of the gingiva. It can be classified into two types: thick and thin. A GT of ≤ 1 mm is classified as thin biotype, while a GT of > 1 mm is classified as thick biotype [2]. Thin gingival biotype is considered to be one of

the predisposing factors for gingival recession [3]. There is also a positive association between gingival thickness, keratinized tissue and underlining bone morphotype [4]. So paying attention to the gingival biotype and gingival thickness will give us a clue about the condition of the underlying bone morphotype. Since thin gingival biotype is considered one of the indirect risk factors for gingival recession and associated with thinner underlining bone morphotype, then proper clinical evaluation of gingival biotype will help the orthodontists during decision making when labial movement of the incisors is planned.

Zawawi., *et al*. (2012) studied prevalence of different gingival biotypes and the association between gingival biotype and different dental malocclusions based on Angle's classification in a group of 200 patients, and found no significant association between dental malocclusions and the presence of thin gingival biotype [5]. In 2014, Zawawi., *et al.* studied the association between gingival biotypes and inclination and position of the maxillary and mandibular incisors and found a significant association between mandibular incisor inclination and position and thin gingival biotype, while there was no association between the maxillary incisor inclination and gingival biotypes [6].

Matarese., *et al*. (2016) [7] conducted a study to evaluate if the gingival biotypes were related with the different types of Angle's classification of malocclusion. Gingival biotypes were assessed based on translucence of a periodontal probe through the gingival margin. Angle's classification of malocclusion was also recorded according to molar relation. There was no significant association between type of malocclusion and gingival biotype (P = 0.143). There was however a prevalence of thick gingival biotype in patient with class II malocclusion and a slight prevalence of thin gingival biotype in patient with class I malocclusion.

Alkan., *et al.* (2018) [8] performed a cross-sectional study to assess the relationship of gingival thickness and width of keratinized gingiva of the maxillary anterior teeth with different malocclusion groups and amount of crowding. They enrolled 181 periodontally healthy subjects in their study and then they divided them into three malocclusion groups: Angle Class I, Angle Class II, and Angle Class III according to the molar relation. Each group was divided into subgroups based on the amount of dental crowding, mild (0-3 mm), moderate (4-6 mm), and severe (more than 6mm). The width of keratinized gingiva was calculated as the distance between mucogingival junction and free gingival margin, whereas gingival thickness was measured by a transgingival probing technique. If the gingival thickness was <1 mm, the gingiva was considered as thin biotype; while if it was >1 mm, the gingiva was considered as thick biotype. The results of this study showed that upper maxillary canines were observed to have thin gingival biotype. The width of keratinized gingiva for the maxillary canines was narrower in the severe crowding group than in the moderate and mild crowding groups. However, the relationship of gingival thickness and width of keratinized gingiva with Angle classification was found to be insignificant.

Although several studies have been published that evaluated the correlation between gingival biotypes and malocclusion, most of these studies were concerned with dental malocclusion based on Angle's classification, crowding of anterior teeth, or incisors' inclination and position. Evaluation of gingival biotypes in adults in relation with abnormal skeletal jaw relations has not been widely investigated. It was suggested by many authors that other parameter such as skeletal characteristics and profile type should be correlated with gingival biotype instead of angle's classification [7,9], because it was demonstrated that patients with dolichifacial face are more subjected to have a thinner gingival biotype in comparison to patients with brachyfacial or mesofacial face [10]. Thus, the aim of the present research was to evaluate and study the influence of abnormal skeletal jaw relations on gingival biotypes and width of keratinized gingiva of anterior teeth in Egyptian adults.

Subjects and Methods

Ethics

The protocol of this cross sectional study was approved by the institutional review boards/ethical committees (IRBs/ECs) of the Faculty of Dentistry, Cairo University. The clinical trial was registered on www.clinicaltrials.gov (Code: NCT03493477).

Selection of subjects

All included patients signed an informed consent after the explanation of the involved procedures and the possible risks. The Sample of the present study consisted of 182 Egyptian adults orthodontic patients who were collected from the outpatient clinic in the Orthodontic department, Faculty of Dentistry, Cairo University. They were recruited into the study before beginning orthodontic treatment in the department clinic.

Sample size

Convenient consecutive sampling was applied by recruiting adult patients seeking orthodontic treatment with skeletal Class II and Class III jaw relations based on clinical and cephalometric evaluation. Using the power of 80%, a level of significance of 5%. A total 170 patients from both groups would be necessary. A total number of 182 patients were recruited for 12 months, starting first of November 2018 to the last of October 2019. Sample size was calculated using G*power program (university of Dusseldorf, Dusseldrof, Germany).

Inclusion and exclusion criteria

The included patients were adult patients having an age range of 18 -30 years with skeletal Class II and Class III jaw relation. Patients with fair oral hygiene with absence of any active periodontal disease were selected. Patients with history of previous periodontal surgery or orthodontic treatment, patients with extensive restorations on the anterior teeth and patients taking medication affecting the periodontal tissues were excluded from the study.

Methods

- Determination of patients' skeletal malocclusion and vertical skeletal pattern.
- Determination of gingival biotype and width of keratinized gingiva for each anterior tooth.

Determination of patients' skeletal malocclusion and vertical skeletal pattern

For the purpose of collecting eligible subjects for the study, careful diagnosis was done through clinical examination and diagnostic records to include only adult patients with skeletal Class II and skeletal Class III patterns, and exclude patients with skeletal Class I malocclusion.

Many patients were excluded due to age, syndromatic conditions, history of trauma to the jaws, abnormal functions or harmful habits that reflected on the skeletal pattern. Diagnostic chart was written for each patient by the primary orthodontist treating the patient .Lateral cephalometric analysis was performed for each patient by the primary researcher for the purpose of confirming the skeletal pattern of the subjects and distributing them into the corresponding skeletal malocclusion group. Wits appraisal of Jacobson [11] was used as an indicator for sagittal skeletal discrepancy. According to Jacobson, it is the distance between points AO and point BO. Points AO and BO are points of intersection between the occlusal plane and perpendicular lines drawn from point A and point B respectively (Figure 1). In the current study, Wits appraisal was measured using digital software for cephalometric tracing[1]. The lateral cephalometric x-ray was imported into the software and calibrated using the calibration tool in the software. Ten mm (10 mm) calibration segment was used in the software, and then by the use of the ruler in front of the patient's forehead in the Cephalostat, Ten mm were indicated in the lateral head film. The following points were selected on the digital film: A point, B point, Anterior, middle and posterior occlusal points. Then the software calculates Wits appraisal and provides the final value. Wits appraisal for Egyptian population was (0 ± 1) [12]. The calibration step is mandatory in order to eliminate the magnification effect.

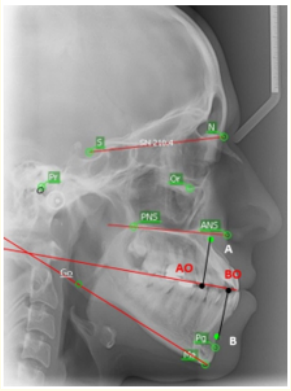

Figure 1: Digital lateral cephalometric x-ray showing measuring the Wits appraisal by determining the A point, B point and the occlusal plane then measuring the distance between Ao and Bo.

After digital analysis of each patient's lateral cephalometric x-ray they were allocated into two groups according to their Wits appraisal.

- **Group 1 (Skeletal Class II):** Included patients with Wits appraisal more than (1mm).
- **Group 2 (Skeletal Class III):** Included patients with Wits appraisal less than (-1mm).

[1] OrisCEPH ® (ver. 7 .2.3)

After allocating subjects into the two major groups using wits appraisal, assessment of the vertical skeletal pattern of the subjects was performed radiographically using the facial axis angle. It is the angle between a line constructed from the posterosuperior aspect of the pterygomaxillary fissure (PT) to Gnathion (GN) relative to the Cranial base Ba-Na. Mean value is (90 ± 3) for normal vertical facial pattern (normo-divergent). Less than the mean value will indicate hyperdivergent facial pattern, more than mean value will indicate hypodivergent facial pattern (Figure 2). Facial axis angle was used in the current study as it demonstrates little changes during growth [13].

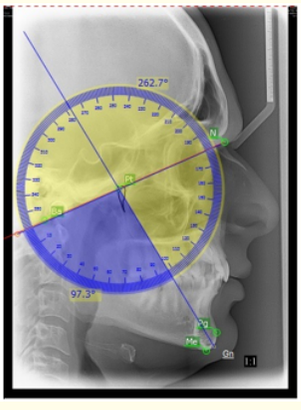

Figure 2: Digital lateral cephalometric radiograph showing patient with class II skeletal pattern and hypodivergent vertical facial pattern.

After measuring the facial axis angle on the lateral cephalometric, each major group was subdivided according to their vertical skeletal pattern into three subgroups as follows:

Group 1 of skeletal class II subjects was subdivided into:

- **Subgroup A**: Included subjects with skeletal Class II and facial axis angle equal to 90° ± 3° indicating normo-divergent facial pattern.
- **Subgroup B**: Included subjects with skeletal Class II and facial axis angle less than 87° indicating hyperdivergent facial pattern.
- **Subgroup C**: Included subjects with skeletal Class II facial axis angle more than 93° indicating hypodivergent facial pattern.

Group 2 of Skeletal Class III subjects was subdivided into:

- **Subgroup D**: Included subjects with skeletal Class III and facial axis angle equal to 90° ± 3° indicating normo-divergent facial pattern.
- **Subgroup E**: Included subjects with skeletal Class III and facial axis angle less than 87° indicating hyperdivergent facial pattern.
- **Subgroup F**: Included subjects with skeletal Class III facial axis angle more than 93° indicating hypodivergent facial pattern.

Determination of gingival biotype and width of keratinized gingiva for each anterior tooth

After completing the step of subject's allocation according to their Wits appraisal and facial axis angle values. Aim of the study and procedures was briefly explained to the participants and a written consent was obtained from each patient**.**

Evaluation of gingival biotype

The patient was instructed to be seated on the dental chair, and a cheek retractor was inserted into the patient mouth to retract the lips and the cheek away from the gingiva and oral mucosa of the anterior teeth. Under good illumination, gingival biotype was assessed using probe transparency method [14], in which probing is done in the sulcus at the mid facial aspect of maxillary and mandibular anterior teeth by a Graduated[2] periodontal probe [5]. Gingival thickness for each tooth was classified as thin when the underlying periodontal probe outline can be seen through the gingiva; otherwise, it was considered thick biotype (Figure 3, 4). Intra-examiner repeatability was tested by evaluating the gingival biotypes anterior teeth of 12 subjects not involved in the study at two different occasions, two weeks apart. The primary researcher was able to record the same results 90% of the time [6].

Measurement of width of keratinized gingiva

After gingival biotype determination for each of the twelve anterior teeth, width of keratinized gingiva was measured from the muco-gingival junction to the free gingival margin in the mid-labial of the crown of all maxillary and mandibular anterior teeth using a digital caliper[3] with a sensitivity of 0.01 mm [15-17] (Figure 5). The mucogingival junction was located using the visual method as the demarcating line between the attached gingiva and the movable alveolar mucosa. When there was a difficulty to locate the mucogingival junction visually, functional method for mucogingval junction determination was done by running a periodontal probe positioned horizontally from the vestibule to the gingival margin with light pressure, this method is also known as the "roll test" [18].

[2]Marquis periodontal probe (GC-AMERICAN , USA)

[3]Stainless Hardened 0-100 Digital Caliper (IOS,USA)

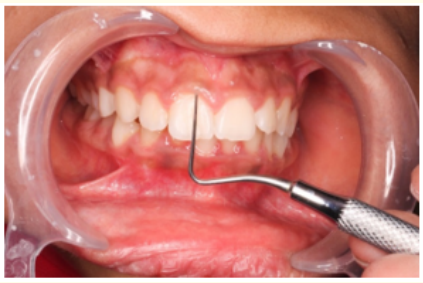

Figure 3: Thick gingival biotype related to upper right central incisor not showing the underlying periodontal probe outline.

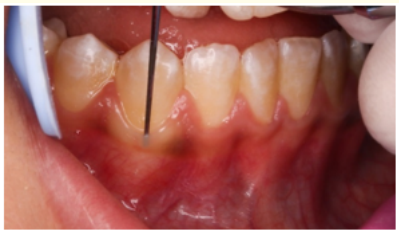

Figure 4: Thin gingival biotype related to lower right canine showing the underlying periodontal probe outline.

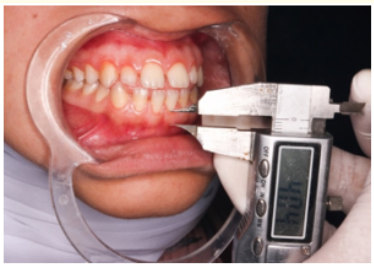

Figure 5: Measurement of the keratinized gingival width from the mid-labial of the free gingiva to the mucogingival junctional line using 0-100 Digital Caliper.

Statistical analysis

The collected data were statistically analyzed by Microsoft Excel ® 2016[4], Statistical Package for Social Science (SPSS)® Ver. 24[5]. and Minitab[6] ® statistical software Ver. 16.

Regarding thin biotype of gingiva and width of keratinized ginigva, comparison between the six subgroups of sckeletal malocclusion for each anterior upper and lower teeth were performed using One Way Analysis of Variance (ANOVA) followed by Tukey`s post hoc test for multiple comparisons.

Results

Descriptive analysis

In this cross-sectional study 182 patients were recruited {74 males (40.65%), 108 females (59.35%)}. The mean age for the whole sample was 21.01 ± 3.06 years. They were divided into two main groups according to their skeletal malocclusion; Group 1 (Skeletal Class II) where Wits appraisal = 4.17 ± 1.23 mm, Group 2 (Skeletal Class III) where Wits appraisal = -4.07 ± 1.54 mm. Total number in Group 1 was 98 patients (39 males, 59 females). Total number in Group 2 was 84 patients (35 males, 49 females) (Table 1).

Regarding age distribution among gender, Student`s t test was performed to evaluate the significance between male and female ages for each main group. It was revealed that there was insignificant difference between male and female as P-value > 0.05, as listed in table 1.

Each main group was subdivided into three subgroups according to vertical facial pattern as listed in (Table 2).

Student`s t test was performed to evaluate the significance between male and female ages for each subgroup. It was revealed that there was insignificant difference between male and female as P-value > 0.05 as listed in table 2.

Gingival biotypes of 1092 upper anterior teeth and 1092 lower anterior teeth were evaluated and determined. Regarding Upper anterior teeth, total number of upper anterior teeth in the whole sample with thick gingival biotype was 909 (83.24%), while total number of upper anterior teeth with thin gingival biotype in the whole sample was 183 (16.76%). Regarding lower anterior teeth, total number of lower anterior teeth with thick gingival biotype in the whole sample was 460 (42.12%), while total number of lower anterior teeth with thin gingival biotype was 632 (57.88%).

[4]Microsoft Cooperation, USA.

[5]IBM Product, USA.

[6]Minitab LLC, USA.

Study group	N	Male			Female			P-value for age distribution among gender	Wits Appraisal (M ± SD)
		N	%	Age	N	%	Age		
Group 1 (Skeletal Class II)	98	39	39.8	20.63 ± 3.48	59	60.2	20.9 ± 2.78	0.26	4.17 ± 1.23
Group 2 (Skeletal Class III)	84	35	41.67	20.94 ± 2.74	49	58.33	21.6 ± 3.26	0.19	-4.07 ± 1.54

Table 1: Description of Sample and Wits Appraisal and in 2 Main Groups of Skeletal Malocclusion.

Subgroup	N	Male			Female			P-value for age distribution among gender	Mean Facial axis angle
		N	%	Mean age	N	%	Mean age		
Subgroup A	28	9	32.14%	19.33 ± 2.18	19	67.86%	21.11 ± 3.38	0.16	90.23 ± 1.63
Subgroup B	38	18	47.37%	21 ± 3.76	20	52.63%	20.7 ± 2.25	0.76	84.86 ± 1.13
Subgroup C	32	12	37.50%	21.58 ± 4.5	20	62.50%	20.9 ± 2.71	0.59	95.2 ± 1.22
Subgroup D	25	13	52.00%	19.46 ± 1.27	12	48.00%	21.08 ± 3.37	0.11	90.06 ± 1.40
Subgroup E	35	12	34.29%	22.17 ± 4.06	23	65.71%	20.87 ± 3.18	0.30	84.72 ± 1.27
Subgroup F	24	10	41.67%	21.2 ± 2.9	14	58.33%	22.93 ± 2.92	0.16	95.68 ± 1.28

Table 2: Description of Sample, P-value for age distribution among gender, and Facial Axis Angle in the 6 Subgroups of Sagittal and Vertical Skeletal Malocclusion.

After dividing the sample into six subgroups, thin and thick gingival biotypes were distributed in each subgroup as listed in (Table 3).

The mean width of keratinized gingiva for upper anterior teeth in the studied patients was (5.27 ± 1.2) mm, while the mean width of keratinized gingiva for lower anterior teeth in the studied patients was (3.68 ± 0.93) mm.

The mean width of keratinized gingiva for upper anterior teeth in Group 1 (skeletal class II malocclusion) was (5.22 ± 1.07) mm, while the mean width of keratinized gingiva for lower anterior teeth was (3.74 ± 0.92) mm. The mean width of keratinized gingiva for upper anterior teeth in Group 2 (skeletal class III malocclusion) was (5.34 ± 1.33) mm, while the mean width of keratinized gingiva for lower anterior teeth was (3.62 ± 0.95) mm (Table 4).

.	Skeletal Class II						Skeletal Class III					
	Subgroup A		Subgroup B		Subgroup C		Subgroup D		Subgroup E		Subgroup F	
	Normal		Hyperdivergent		Hypodivergent		Normal		Hyperdivergent		Hypodivergent	
	N	%	N	%	N	%	N	%	N	%	N	%
Total Upper Teeth	168		228		192		150		210		144	
Count of Upper Teeth with Thin Biotype	41	24.40%	9	3.95%	29	15.10%	23	15.33%	51	24.29%	30	20.83%
Count of Upper Teeth with Thick Biotype	127	75.60%	219	96.05%	163	84.90%	127	84.67%	159	75.71%	114	79.17%
Total Lower Teeth	168		228		192		150		210		144	
Count of Lower Teeth with Thin Biotype	125	74.40%	117	51.32%	93	48.44%	70	46.67%	147	70.00%	80	55.56%
Count of Lower Teeth with Thick Biotype	43	25.60%	111	48.68%	99	51.56%	80	53.33%	63	30.00%	64	44.44%

Table 3: Representing number and percentage of thin and thick gingival biotypes in upper and lower teeth in 6 subgroups of skeletal malocclusion.

	Skeletal Class II	Skeletal Class III
Total Number of Upper Teeth	588	504
Mean Width of keratinized gingiva in Upper Teeth	5.22 ± 1.07	5.34 ± 1.33
Total Number of Lower Teeth	588	504
Mean Width of keratinized gingiva in Lower Teeth	3.74 ± 0.92	3.63 ± 0.95

Table 4: Width of Keratinized Gingiva for Upper and Lower Teeth in Skeletal Class II and Skeletal Class III malocclusion.

Relation between thin gingival biotypes and different skeletal malocclusion subgroups

Upper teeth

Thin gingival biotypes of upper anterior teeth were counted for each tooth for all six subgroups. One-way analysis of variance (One Way ANOVA) followed by Tukey`s post hoc test for multiple comparisons for each tooth between different subgroups to detect statistical significance.

Concerning upper canines, there was a significant difference between all 6 subgroups of skeletal malocclusion (P-value < 0.05) ,with the highest count of thin gingival biotypes was in subgroup E (hyperdivergent skeletal class III), followed by subgroup A (skeletal class II normal vertical pattern) in both right and left side, listed in (Table 5).

Concerning upper lateral and central incisors in both sides, there was insignificant difference between the counts of thin gingival biotypes in all 6 subgroups of skeletal malocclusions.

Moreover, thin biotypes of all upper anterior teeth were observed and counted as percentages for upper arch for all six skeletal malocclusion subgroups, One-way analysis of variance (One Way ANOVA) was performed to compare between thin biotype percentages of all upper anterior teeth in all six subgroups of skeletal malocclusion and revealed significant difference between them (P<0.05) followed by Tukey`s post hoc test for multiple comparisons which revealed decrease in the percentage of thin gingival biotypes in upper anterior teeth in subgroup B (hyperdivergent class II) with a statistical significant difference (P < 0.05) (Table 6, Figure 6).

Thin Gingival Biotype Upper Normal		Skeletal Class II			Skeletal Class III			P-value
		Normo-divergent	Hyperdi-vergent	Hypodi-vergent	Normodiver-gent	Hyperdiver-gent	Hypodi-vergent	
Right Side	Canine	16 [a]	1 [b]	6 [b]	8 [b]	20 [a]	10 [b]	0.00**
	Lateral Incisor	4 [a]	2 [a]	6 [a]	5 [a]	3 [a]	4 [a]	0.436*
	Central Incisor	3 [a]	0 [a]	5 [a]	1 [a]	4 [a]	1 [a]	0.16*
Left Side	Central Incisor	0 [a]	0 [a]	2 [a]	1 [a]	6 [a]	1 [a]	0.06*
	Lateral Incisor	5 [a]	2 [a]	8 [a]	3 [a]	2 [a]	4 [a]	0.131*
	Canine	13 [b]	4 [a]	2 [a]	5 [a]	16 [b]	10 [a]	0.00**

Table 5: Thin Biotypes of Abnormal Sagittal and Vertical Skeletal Jaw Relations for Upper Teeth.

P; Probability Level , *Insignificant Difference, **Significant Difference

Data with same superscript letter in the same row were insignificant different

Data with different superscript letter in the same row were significant different.

Upper	Skeletal Class II			Skeletal Class III			P-value
	Normal	Hyperdivergent	Hypodivergent	Normal	Hyperdivergent	Hypodivergent	
Thin Biotype	41 [a]	9 [b]	29 [c]	23 [c]	51 [a]	30 [c]	0.00**
Total UpperTeeth	168	228	192	150	210	144	
%	24.40	3.95	15.10	15.33	24.29	20.83	

Table 6: Percentages of Thin Gingival Biotypes of Abnormal Vertical Jaw Relations.

%; Percentage, P; Probability Level

Data with same superscript letter in the same row were insignificant different

Data with different superscript letter in the same row were significant different

**significant Difference

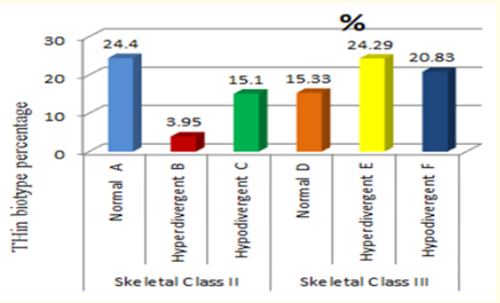

Figure 6: Bar Chart represents Percentages of Thin Gingival Biotypes of Upper Anterior Teeth in All Six Subgroups.

Lower teeth

Thin gingival biotypes of lower anterior teeth were counted for each tooth for all six subgroups of skeletal malocclusion, and comparison was performed between all six subgroups in all anterior teeth by using one-way analysis of variance (One Way ANOVA) followed by Tukey`s post hoc test revealed a significant difference between highest and lowest counts of thin gingival biotypes ($P < 0.05$) in all lower anterior teeth except lower left central incisors ($P > 0.05$) as presented in table 7.

Moreover, thin biotypes of all lower anterior teeth were observed and counted as percentages for all six subgroups, and it was demonstrated that highest percentage of thin biotype was revealed in subgroup A (Skeletal Class II normal vertical pattern) (74.4 %) followed by subgroup E (hyperdivergent class III) (70%), as listed in table 8 and showed in figure 7. One-way analysis of variance (One Way ANOVA) was performed to compare between thin biotype percentages of all lower anterior teeth in all 6 subgroups of skeletal malocclusion and revealed significant difference between them ($P<0.05$), then; Tukey's post hoc test was performed for multiple comparisons between the six subgroups which revealed statistical significant increase in the percentage of thin biotypes in subgroup A and subgroup E ($P > 0.05$), as listed in table 8 and figure 7.

Thin Gingival Biotype Lower Normal		Skeletal Class II		Skeletal Class III			P-value
		Normo-divergent	Hyperdiver-gent	Hyperdi-vergent	Normo-divergent	Hypodi-vergent	
Right Side	Canine	19 [a]	18 [b]	13 [b]	28 [a]	14 [b]	0.034**
	Lateral Incisor	20 [a]	16 [a]	7 [b]	17 [a]	12 [a]	0.044**
	Central Incisor	24 [a]	25 [a]	13 [b]	27 [a]	13 [b]	0.047**
Left Side	Central Incisor	25 [a]	23 [a]	16 [a]	25 [a]	17 [a]	0.135*
	Lateral Incisor	14 [a]	17 [a]	5 [b]	20 [a]	9 [b]	0.03**
	Canine	23 [a]	18 [b]	16 [b]	30 [a]	15 [b]	0.004**

Table 7: Thin Gingival Biotypes of Abnormal Sagittal and Vertical Skeletal Jaw Relations for Lower Anterior Teeth.

P; Probability Level

*Insignificant Difference

**Significant Difference

Data with same superscript letter in the same row were insignificant different

Data with different superscript letter in the same row were significant different.

Lower	Skeletal Class II			Skeletal Class III			P-value
	Normal	Hyperdivergent	Hypodivergent	Normal	Hyperdivergent	Hypodivergent	
Thin Biotype	125[a]	117[b]	93[c]	70[c]	147[a]	80[c]	0.02**
Total Lower Teeth	168	228	192	150	210	144	
%	74.40	51.32	48.44	46.67	70.00	55.56	

Table 8: Percentages of Thin Gingival Biotypes of Abnormal Vertical Jaw Relations for lower anterior teeth.

%; Percentage, P; Probability Level

Data with same superscript letter in the same row were insignificant different

Data with different superscript letter in the same row were significant different

**significant Difference.

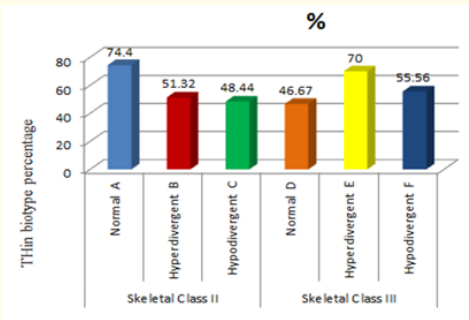

Figure 7: Bar Chart represents Percentages of Thin Gingival Biotypes of Lower Anterior Teeth in All Six Subgroups.

Relation between width of keratinized gingiva and different skeletal malocclusion subgroups

Upper teeth

The width of keratinized gingiva in upper anterior teeth was observed and counted as means and standard deviations for each tooth separately and for all upper anterior teeth regarding all six subgroups of skeletal malocclusion, as listed in table 9.

Comparison was performed between all six subgroups regarding all upper anterior teeth by using one-way analysis of variance (One Way ANOVA) followed by Tukey`s post hoc test for multiple comparison and revealed insignificant difference between highest and lowest mean value ($P > 0.05$) in all upper anterior teeth except upper right central incisors which had slight increase in the mean value of keratinized gingiva in subgroup D ($P < 0.05$), as presented in table 9.

Lower teeth

The width of keratinized gingiva in lower anterior teeth was observed and counted as means and standard deviations for each tooth separately and for all lower anterior teeth regarding six all subgroups of skeletal malocclusion, as listed in table 10.

Comparison was performed between all six subgroups in all lower anterior teeth by using one-way analysis of variance (One Way ANOVA) followed by Tukey`s post hoc test for multiple comparison and revealed insignificant difference between highest and lowest mean value ($P > 0.05$) in all lower anterior teeth except lower right lateral incisors which had slight increase in the mean value of keratinized gingiva in subgroup B and subgroup C ($P < 0.05$), as presented in table 10.

Upper Normal		Skeletal Class II			Skeletal Class III			P -value
		Normo-divergent	Hyperdiver-gent	Hypodiver-gent	Normodi-vergent	Hyperdiver-gent	Hypodiver-gent	
Right Side	Canine	5.14 ± 1.4 [a]	5.14 ± 0.98 [a]	4.41 ± 0.9 [a]	4.98 ± 1.26 [a]	4.62 ± 1.72 [a]	4.85 ± 1.14 [a]	0.115*
	Lateral Incisor	5.62 ± 0.79 [a]	5.58 ± 1.06 [a]	5.05 ± 0.87 [a]	5.62 ± 1.32 [a]	5.83 ± 1.38 [a]	5.73 ± 1.14 [a]	0.096*
	Central Incisor	5.25 ± 0.81 [a]	5.47 ± 0.94 [a]	4.92 ± 0.93 [a]	5.82 ± 1.08 [b]	5.54 ± 1.29 [a]	5.27 ± 1.33 [a]	0.043**
Left Side	Central Incisor	5.32 ± 0.84 [a]	5.57 ± 0.98 [a]	5.01 ± 1.01 [a]	5.64 ± 0.94 [a]	5.53 ± 1.22 [a]	5.23 ± 1.31 [a]	0.168*
	Lateral Incisor	5.73 ± 1.126 [a]	5.77 ± 1.3 [a]	5.06 ± 0.99 [a]	5.74 ± 1.02 [a]	5.67 ± 1.31 [a]	5.6 ± 1.35 [a]	0.133*
	Canine	4.84 ± 1.43 [a]	5.32 ± 0.96 [a]	4.64 ± 1.05 [a]	4.91 ± 1.14 [a]	4.83 ± 1.55 [a]	4.77 ± 1.11 [a]	0.311*
All Upper Anterior teeth		5.32 ± 1.12 [a]	5.48 ± 1.02 [a]	4.85 ± 0.99 [a]	5.40 ± 1.2 [a]	5.40 ± 1.45 [a]	5.2 ± 1.28 [a]	0.132*

Table 9: Width of Keratinized Gingiva of Abnormal Sagittal and Vertical Skeletal Jaw Relations for Upper anterior teeth.

Mean, SD; standard Deviation, P; Probability Level.

Data with same superscript letter in the same row were insignificant different.

Data with different superscript letter in the same row were significant different.

*insignificant Difference, **significant Difference.

Lower Normal		Skeletal Class II			Skeletal Class III			P-value
		Normo-divergent	Hyperdiver-gent	Hypodiver-gent	Normodiver-gent	Hyperdi-vergent	Hypodiver-gent	
Right Side	Canine	3.3 ± 0.67 [a]	3.7 ± 0.85 [a]	3.6 ± 1.05 [a]	3.8 ± 0.92 [a]	3.6 ± 1.05 [a]	3.8 ± 1.04 [a]	0.255*
	Lateral Incisor	3.7 ± 0.98 [a]	4.2 ± 0.76 [b]	4.2 ± 0.83 [b]	3.8 ± 0.95 [a]	4.0 ± 1.09 [a]	3.6 ± 0.86 [a]	0.035**
	Central Incisor	3.6 ± 1.02 [a]	3.6 ± 0.92 [a]	3.6 ± 0.91 [a]	3.6 ± 1 [a]	3.7 ± 0.92 [a]	3.5 ± 0.99 [a]	0.993*
Left Side	Central Incisor	3.4 ± 1.09 [a]	3.5 ± 0.9 [a]	3.4 ± 0.79 [a]	3.4 ± 0.93 [a]	3.4 ± 0.77 [a]	3.3 ± 0.94 [a]	0.939*
	Lateral Incisor	3.9 ± 0.81 [a]	4.1 ± 0.82 [a]	3.5 ± 0.85 [a]	3.8 ± 0.75 [a]	4.1 ± 0.92 [a]	3.6 ± 0.86 [a]	0.175*
	Canine	3.4 ± 0.97 [a]	3.7 ± 0.73 [a]	3.6 ± 0.99 [a]	3.6 ± 1.03 [a]	3.4 ± 0.91 [a]	3.3 ± 0.88 [a]	0.379*
All lower anterior teeth		3.5 ± 0.95 [a]	3.8 ± 0.86 [a]	3.7 ± 0.93 [a]	3.6 ± 0.93[a]	3.7 ± 0.97 [a]	3.4 ± 0.93[a]	0.434*

Table 10: Width of Keratinized Gingiva of Abnormal Sagittal and Vertical Skeletal Jaw Relations for Lower Teeth.

Mean, SD; standard Deviation, P; Probability Level.

Data with same superscript letter in the same row were insignificant different.

Data with different superscript letter in the same row were significant different.

*insignificant Difference, **significant Difference.

Discussion

Careful evaluation of the periodontal status of orthodontic patients is of critical importance. The characteristics and thickness of the gingival tissue plays an important role in esthetics, especially in the maxillary anterior area. The association between gingival recession and orthodontic treatment is still a matter of de-bate [19]. Previous studies reported that when thickness of the attached gingiva is more than 1 mm, the risk of gingival recession was reduced [3]. Hence, a thicker attached gingiva may be significant in avoiding gingival recession even when the alveolar bone is reduced or absent.

It was reported that gingival biotype plays a significant role in the development of mucogingival problems [20]; therefore, in orthodontic treatment planning, assessment of the quality of periodontal tissues in the relevant region should be taken into account together with the width of keratinized gingiva. At this point, the present study aimed to evaluate the relationship of gingival biotype and the width of keratinized gingiva of the anterior teeth with different skeletal malocclusion groups in Egyptian adults.

Most of the published researches that have evaluated the correlation between gingival biotypes and malocclusion were concerned with dental malocclusion based on Angle's classification, crowding of anterior teeth, or incisors' inclination and position as mention previously. However, correlation between gingival biotypes and skeletal malocclusions has not been widely investigated. Moreover, no studies were conducted to evaluate gingival biotypes and width of keratinized gingiva in anterior teeth in different skeletal malocclusion groups in Egyptian population. So, this research was conducted to evaluate the distribution of different gingival biotypes of anterior teeth in different skeletal malocclusion patterns in Egyptian population.

This study is a cross sectional study that was done in the Department of Orthodontics, Cairo University. Patients were recruited by consecutive sampling into the study based on the inclusion criteria mentioned before. All eligible patients were recruited into the study for twelve months, starting first of November 2018 to the last of October 2019, as recommended by the Department of Evidence Based Dentistry, Cairo University. All the patients included in the study were adults to ensure that the growth of the jaws has ended and the patients have reached the final relation between maxilla and mandible, and also to ensure that passive eruption of the teeth has occurred and the keratinized gingival width will not undergo further gross change by continuation of passive eruption [21]. Patients with moderate or severe crowding were excluded from the study, and only subjects with acceptable alignment or minimal crowding were included to eliminate the effect of crowding on the gingival biotype [8]. All inclusion criteria were selected to assure

elimination of confounders in the sample, and to detect the sole correlation between gingival biotypes and different skeletal malocclusion groups.

Wits appraisal was used in the current study. It was chosen as a method for skeletal malocclusion assessment in the sagittal plane because it is not affected by the rotation of the skull base and it is not affected by the rotation of the jaws [11]. Furthermore, Wits appraisal depends mainly on two points (A point and B point) which were proven to be reliable and reproducible [22]. Besides, it is a simple and quick method that can be used with large samples.

Subjects were first divided into two main groups according to sagittal skeletal malocclusion using Wits appraisal. The first main group included skeletal class II patients (Group 1), while the second main group included skeletal class III patients (Group 2). The two major groups of skeletal malocclusions were divided each into three subgroups according to the vertical facial pattern as normodivergent facial pattern, hyperdivergent facial pattern and hypodivergent facial pattern. Facial axis angle was used in this study as a method for assessing the vertical facial pattern, as it does not change significantly during growth [13]. Y-axis angle technique has been excluded as it depends on the Frankfort horizontal plane whose reproducibility was occasionally questioned due to difficulties in visual estimation and accurate determination of Porion (Po) and Orbital (Or) points [23].

During the process of determining the skeletal malocclusion, a digital software was used for digital tracing as digital tracing was proven to be more efficient and accurate than manual tracing [24-27]. All lateral cephalometric x-rays of the patients were imported into the software and calibration step was done to eliminate the magnification factor as Wits appraisal is a linear measurement in millimeters.

Gingival biotype (GT) is classified into two types: thick and thin according to the gingival thickness. When gingival thickness is ≤ 1 mm, it is classified as thin biotype, while when the gingival thickness is > 1 mm; it is classified as thick gingival biotype [2]. A variety of methods can be used to determine the gingival biotype, from which is the probe transparency method [14] which has been used in the current study. This method was chosen for gingival biotype assessment due to its simplicity and reliability. It was proven to have high intra-examiner repeatability and reproducibility with 85% agreement between duplicate measurements substantiating the clinical usefulness of this method [28]. A thin graduated periodontal probe was used to facilitate gentle insertion in the gingival sulcus without causing trauma or bleeding which could have hindered visibility of periodontal probe beneath the gingival tissue [5].

As for the width of attached gingiva, it is the distance from mucogingival junction to the free gingival margin. It was decided to evaluate the width of keratinized gingiva of anterior teeth in different skeletal malocclusion groups as a secondary outcome due to its importance as the attached gingiva provides protection for periodontium and helps in maintaining the gingival margin at a stable position. The attached gingiva also minimizes the effect of functional forces that are applied by circum-oral muscles to gingival tissues [29,30].

Also an adequate zone of attached gingiva helps in decreasing plaque accumulation which might results in gingival inflammation that may cause soft tissue recession on the long term [29]. According to Bowers (1963) [31], gingival recessions were accompanied by narrow zones of attached gingiva.

Measuring the width of keratinized gingival has been done in previous researches either by graduated probe [9] or digital caliper [15-17]. It was decided in the current study to use digital caliper with 0-100 sensitivity for measuring the keratinized attached gingiva for more accurate and precise results.

Gingival biotypes and width of keratinized gingiva were evaluated for upper and lower anterior teeth in six subgroups of sagittal and vertical skeletal malocclusions, and comparison has been made between the six groups using One Way Analysis of Variance (ANOVA) followed by Tukey`s post hoc test for multiple comparisons.

Thick gingival biotype was more prevalent than thin gingival biotypes in the upper anterior teeth in the studied subjects with a percentage of (83.24%), while thin gingival biotype was more prevalent than thick gingival biotype in the lower anterior teeth in the studied subjects with a percentage of a (57.88%). This was consistent with the results of a previous study by Vandana, and Savitha. (2005) who concluded that maxillary arch had thicker gingiva as compared to mandibular arch [32].

When the count of thin gingival biotypes for each individual upper anterior tooth was compared between the six subgroups of

skeletal malocclusion, there was no statistical significant difference between upper anterior teeth except for upper canines which revealed significant increase in thin gingival biotypes in both right and left sides in subgroup E (skeletal class III hyperdivergent facial pattern), followed by subgroup A (skeletal Class II with normo-divergent facial pattern) as listed in table (5), and this increase was statistically significant ($P < 0.05$).

When the percentage of thin gingival biotypes for upper anterior teeth was compared between different subgroups of skeletal malocclusion, there was a decrease in the distribution of thin gingival biotype in subgroup B (skeletal Class II hyperdivergent facial pattern) with 3.95% as listed in table 6, this decrease was statistically significant when compared to the other five gropus ($P < 0.05$).

When the count of thin gingival biotypes for each individual lower anterior tooth was compared between the six subgroups of skeletal malocclusion, there was statistically significant difference for all lower teeth except for lower left central incisor, where higher percentages of thin gingival biotypes were observed alternatively in both subgroup A (skeletal class II with normo-divergent facial pattern) and subgroup E (skeletal class III with hyperdivergent facial pattern) with ($P < 0.05$) for all lower teeth except lower left central incisors as listed in table 7. Lower left central incisors displayed more distribution of thin gingival biotypes in all six groups which accounted for the insignificant difference between the six groups of skeletal malocclusions ($p > 0.05$).

When the percentage of thin gingival biotypes for lower anterior teeth was compared between different subgroups of skeletal malocclusion, there was an increase in the distribution of thin gingival biotypes in both subgroup A (skeletal Class II normo-divergent facial pattern) with (74.40 %) and subgroup E (skeletal Class III hyperdivergent facial pattern) with (70%) as listed in table 8, that increased distribution of thin gingival biotypes in these two subgroups was statistically significant when compared to the other four subgroups of skeletal malocclusion ($P < 0.05$).

The results of this study were inconsistent with the results of a previous study by Jing., *et al.* (2019) [33] which was conducted on skeletal class III Chinese patients regardless of their growth pattern. They found a low positive correlation between mandibular teeth and thick biotype where the prevalence of thick biotype was 66.1%. In the current study, the prevalence of thick biotype in mandibular anterior teeth in skeletal class III patients regardless of the growth pattern was 45.59%.

When the mean width of keratinized gingiva for all upper anterior teeth was compared between the six subgroups of skeletal malocclusion, there was no statistical significant difference between them for the mean width of keratinized gingiva with ($P > 0.05$). Comparison of the mean width of keratinized gingiva for each upper anterior tooth between the six groups revealed insignificant difference ($P > 0.05$) for all upper anterior teeth except upper right central incisors with slightly increased mean width of keratinized gingiva for this tooth in subgroup D (skeletal Class III with normo-divergent facial pattern) with statistical significant difference ($P <0.05$). However this slight increase seems to be clinically irrelevant (Table 9).

When the mean width of keratinized gingiva for all lower anterior teeth was compared between the six subgroups of skeletal malocclusion, there was no statistical significant difference between them for the mean width of keratinized gingiva with (($P > 0.05$). Comparison of the mean width of keratinized gingiva for each lower anterior tooth between the six subgroups revealed insignificant difference ($P > 0.05$) for all lower anterior teeth except for lower right lateral incisor with slightly increased mean width of keratinized gingiva for this tooth in subgroup B (skeletal Class II with hyperdivergent facial pattern) and subgroup C (skeletal Class II with hypodivergent facial pattern) with statistical significant difference ($P < 0.05$). However this slight increase seems to be clinically irrelevant (Table 10).

There are multiple factors that influence the gingival thickness and biotype, some factors due to genetic predisposition [34,35]. Racial and ethnic influence has also been suggested [36]. Other factors such as tooth size, length and shape have also been identified [35,37]. Biological and phenomenal factors such as age and gender and their effect on gingival biotype has been previously studied, where gingival thickness was found to be decreasing with age [38] which might be due to changes in the oral epithelium caused by ageing. As regarding gender; there was a controversy regarding prevalence of a specific biotype in a specific gender. Some studies concluded that thin gingival biotype is more prevalent in females [6,32], other studies concluded the exact opposite [37]. According to the findings of the current study; thin biotypes represented 20.27% in upper anterior teeth and 63.97% in lower anterior teeth in females. As for males, thin biotypes represented 13.72% in upper anterior teeth and 49.19% in lower anterior teeth, so in the

current study; thin biotype had a higher distribution in females more than males in both upper and lower anterior teeth. Regarding the age factor, the results of the current study could not be compared with the previous studies that investigated the gingival biotypes and age relationship because the sample consisted of young adults with narrow age range (18-30 years).

The exact cause and etiology behind the relationships between specific gingival biotypes and specific skeletal malocclusions that the current study has shown is still not clear, but since there is genetic influence on the skeletal malocclusion and facial patterns [39,40], and since gingival biotypes are also influenced by genetic factors [34,35], there might be a certain genetic mechanism responsible for the relationships suggested by the current study. Genetic and histological studies are required to discover the cause behind this relation. In addition, it is recommended that this study be conducted on larger samples and different racial groups to confirm the results.

Conclusions

Within the limitation of the present study and based on the results obtained, the following conclusions can be drawn

- Thin gingival biotype is more distributed in lower anterior teeth in patients with skeletal class II malocclusion and normo-divergent facial pattern, and in patients with skeletal class III malocclusion and hyperdivergent facial pattern.
- Thick gingival biotype is more prevalent in upper anterior teeth in all skeletal malocclusion groups with the most distribution in patients with skeletal class II malocclusion and hyperdivergent facial pattern.
- The relation between width of keratinized gingiva of upper and lower anterior teeth and different skeletal malocclusion subgroups seems to be statistically and clinically insignificant.

Recommendations

Careful assessment of gingival biotype of anterior teeth during clinical examination and orthodontic treatment planning should have more emphasis by orthodontists as an important factor to be considered during planning of the future position of the anterior teeth.

Future studies with larger samples, and different racial groups is also needed to discover distribution of gingival biotypes in different skeletal malocclusions in other populations. It is also suggested that distribution of gingival biotypes in the anterior teeth should be studied in patients with skeletal class I jaw relation with different vertical facial patterns.

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