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Analysis of Different Vertical and Horizontal Smile Characteristics

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Abstract

BACKGROUND: Improving smile aesthetics is the main reason patients seek different treatments.

AIM: This study aimed to evaluate some of the smile characteristics in patients with completed orthodontic treatment and patients with different types of dentoalveolar malocclusion using the method of photogrammetric analysis.

MATERIALS AND METHODS: The sample consisted of 52 young adults aged 16–35 years. A standardized smile analysis was used to evaluate ten smile characteristics. Two frontal digital photographs were taken for each individual, one at rest and the other with a posed smile.

RESULTS: A student's t-test was used to evaluate the differences between the mean values of the smile characteristics of each type of malocclusion in untreated and treated patients. Comparing the characteristics of the smile in the study groups of treated and untreated patients with a subgroup of Class I and Class III malocclusion, no significant difference was observed in the mean values of the studied parameters. A statistically significant difference was observed only in the mean values of upper incisor exposure and left buccal corridor between untreated and treated patients with class II malocclusion.

CONCLUSION: Knowledge of the correlation between hard and soft-tissue anatomy and smile esthetics has important clinical significance; therefore, the components of the smile should be considered as a guide to assist in orthodontic diagnosis and treatment planning.

Introduction

The influence of facial expression and appearance in social life has been extensively researched in the literature. Individuals defined as more attractive in their social interactions tend to be more successful in most aspects of life in today's society [1], [2]. The smile plays a significant role in everyday social interactions, more than any other physical feature [3]. It creates a perception of joy and happiness and is associated with various personality traits such as self-esteem [4], [5], [6], and [7]. Improving smile aesthetics is the main reason patients seek different treatments. Excessive display of the gingiva when smiling, the so-called "gummy smile", is often associated with hypermobility of the upper lip [8]. In adult patients, dissatisfaction with the appearance of their smile is the main motivating factor for seeking orthodontic treatment [9]. The number of patients seeking orthodontic treatment in terms of esthetic care is increasing daily [10]. A person's lips form the outer frame of a smile and can show or hide different irregularities and asymmetries of the teeth and tissues [11], [12]. Increased tooth visibility during a smile in patients with malocclusions has a significant influence on the psychosocial aspects of the person. Therefore, an attractive smile is the most desired result of orthodontic treatment, along with the establishment of a functional occlusion. Patients seek orthodontic treatment not only to improve oral function but also to improve their appearance and increase their chances of social acceptance [13].

Smile analysis is essential in the stages of diagnosis and treatment planning in modern orthodontics. There are a number of parameters that form an individual's natural smile. Norms for smile characteristics can vary among different populations, so ethnicity should also be considered. Smile analysis and obtaining mean values for the various smile components provide a strategy for creating aesthetic and attractive smiles. In addition to aligning teeth, orthodontists control and modify facial growth and improve harmony between facial hard and soft-tissue components [14], [15]. Therefore, it is important that orthodontists fully understand the soft-tissue changes that occur after hard tissue alterations during different types of treatment [16]. Despite the large number of published studies, there is no consensus on the effects of orthodontic treatment on patients' smiles. The effect of treatment on a particular group of patients has been shown to be significant in some studies and non-significant in others [17], [18], [19], and [20]. Several studies have even dispelled the long-established concern about the specific orthodontic treatment characterized by premolar extraction [20], [21]. Smiles can be posed or spontaneous [22]. They can be classified as stages I

and II or into two basic types: social smile and enjoyment smile [23], [24]. The social smile is a smile that is most often used in everyday life, mostly when we are greeting people [25], [26]. An enjoyable smile causes full lip expansion, maximum gingival display, and maximum display of anterior teeth [25], [27]. Each type of smile includes different anatomical features in the display zone. Certain characteristics of the smile are the result of the static and dynamic association between the dentoskeletal and soft-tissue features of the face. Smile analysis is treated as a separate entity from cephalometry and dental cast analysis in orthodontic diagnosis and treatment planning.

In the literature, there is extensive research about the hard and soft-tissue characteristics of smiles. Assessment of smile characteristics is imperative to achieve consistency in orthodontic treatments; for that reason, it is necessary to identify the components and factors that can influence these characteristics.

Aims

This study aimed to evaluate some of the smile characteristics in patients with completed orthodontic treatment and patients with different types of dentoalveolar malocclusion using the method of photogrammetric analysis.

Materials and Methods

The sample for this study consisted of 52 young adults between the ages of 16 and 35. The selected individuals were without significant skeletal asymmetry, hypodontia, a history of maxillofacial surgery, or anterior prosthetic restorations. For each subject (after signing informed consent), a clinical intraoral examination was performed. The type of malocclusion (if present) was determined for each subject individually.

The participants who met the inclusion criteria in terms of the angle classification are divided into the following two groups: Group 1 includes patients with successfully completed orthodontic treatment in class I with subgroups classified before the start of treatment: malocclusion class I, malocclusion class II, and malocclusion class III, as well as group 2 of patients who have not been orthodontically treated and a class I, II, or III malocclusion is present. Each group has 26 respondents. For the research, frontal photos of the whole face were taken.

Smile analysis

Photographs were taken using a Nikon Z6 II–24.5 MP professional digital camera (Nikon Corporation) with a NIKKOR Z 85 mm f/1.8 lens and a Godox AD200 flash. Photographs are captured in RAW format, exported to JPG, in shooting mode with manual exposure, a shutter speed of 1/160 s and ISO-800, and an aperture of F-stop f/6.3. To obtain quantitative and qualitative data, the distance between the patient and the camera lens is standardized to 100 cm for each patient. One individual takes all photos with the same height of the chair and a white background. The camera is fixed to a tripod, parallel to the floor, and directed to the lower third of the patient's face. All subjects have a neutral head position in the sitting position with the FH plane and the interpupillary line parallel to the floor. To obtain a posed smile, each subject was asked to smile naturally several times, and a photograph was taken when the smile was successfully repeated (Figures 2 and 3).

A self-adhesive measuring tape of 10 mm was placed on each participant during the photographing to check and avoid errors during the magnification and to calibrate the photograph. Olympus CellSens Standard software (2011 Olympus Corporation) was used to calibrate the digital photographs (Figure 4).

One researcher measured ten smile characteristics. The following smile parameters were evaluated: upper lip length, lower lip length, lower lip to upper incisor, incisal display, interlabial gap, intervermillion distance, buccal corridor right, buccal corridor left, smile width, and smile arc. The obtained results are saved in an Excel table directly through the Olympus CellSens standard software. The data obtained during the research is statistically processed.

Results

The study analyzed the parameters of a total of 52 respondents (35 women and 17 men) who met the criteria and were included in this study. The participants were divided into two groups: treated and untreated patients. Figure 1a and b show the number of respondents in each subgroup as well as gender dimorphism in each of them.

Table 1 shows the mean value and standard deviation of the investigated smile characteristics in untreated and treated patients with class I, II, and III malocclusion.

A student's t-test was used to evaluate the differences between the mean values of the smile characteristics of each type of malocclusion in untreated and treated patients. Comparing the characteristics of the smile in the study groups of treated and untreated patients with a subgroup of class I malocclusion, no significant difference was observed in the mean values of the studied parameters (Table 2).

The 95% confidence interval and student's t-test results for the comparison between smile

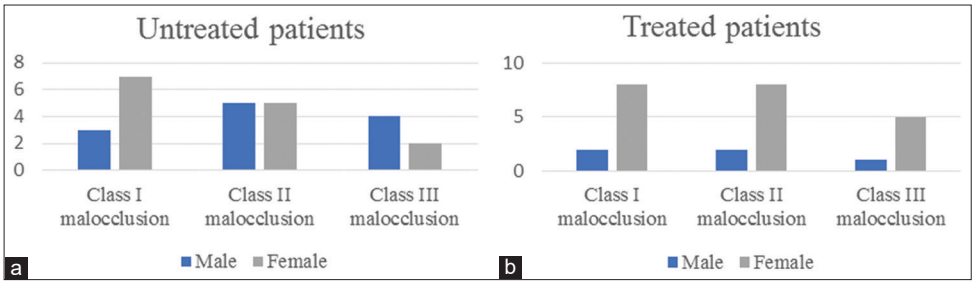

Figure 1: (a and b) Number of respondents and gender dimorphism

Table 1: Mean value and standard deviation of smile characteristics

Smile characteristics	Class I malocclusion		Class II malocclusion		Class III malocclusion	
	Untreated/Treated		Untreated/Treated		Untreated/Treated	
	Mean (мм) ± SD (n = 10)	Mean (мм) ± SD (n = 10)	Mean (мм) ± SD (n = 10)	Mean (мм) ± SD (n = 10)	Mean (мм) ± SD (n = 6)	Mean (мм) ± SD (n = 6)
Upper lip length	17.36 ± 2.24	16.27 ± 3.15	16.31 ± 3.06	16.00 ± 2.94	17.05 ± 4.76	14.72 ± 3.49
Lower lip length	44.11 ± 4.09	44.25 ± 4.15	41.38 ± 2.94	41.84 ± 4.16	47.89 ± 4.75	44.07 ± 4.33
Lower lip to upper incisor	0.63 ± 1.00	1.28 ± 1.03	1.37 ± 1.53	1.78 ± 0.99	3.9 ± 2.57	1.44 ± 0.80
Incisal display	7.75 ± 2.61	9.05 ± 0.89	7.69 ± 1.50	8.87 ± 0.84	6.38 ± 2.62	7.32 ± 1.13
Interlabial gap	8.57 ± 3.29	10.36 ± 0.97	9.17 ± 2.38	10.64 ± 1.35	10.1 ± 2.77	8.96 ± 1.17
Intervermillion distance	23.7 ± 4.98	25.53 ± 3.49	23.59 ± 3.42	25.17 ± 2.27	21.96 ± 4.12	24.36 ± 2.31
Buccal corridor left	1.6 ± 1.30	1.58 ± 0.84	2.59 ± 1.19	1.4 ± 0.82	3.39 ± 2.70	1.48 ± 0.83
Buccal corridor right	1.74 ± 0.87	1.83 ± 0.77	1.55 ± 1.15	1.49 ± 0.84	2.27 ± 1.79	2.42 ± 0.96
Smile width	63.86 ± 5.28	65.50 ± 3.12	64.97 ± 3.69	63.67 ± 4.12	66.28 ± 5.73	64.27 ± 5.66

SD: Standard deviation.

characteristic measurements for the class II and class III subgroups in untreated and treated patients are shown in Tables 3 and 4.

Table 2: Comparison of smile measurements among the malocclusion Class I

Smile characteristics	Class I malocclusion			
	Untreated patients (n = 10)/Treated patients (n = 10)			
	95% confidence interval	Standard error mean	t-value	p-value
Upper lip length	−1.4780–3.6580	1.222	0.8918	0.3843
Lower lip length	−4.0111–3.7311	1.843	−0.0760	0.9403
Lower lip to upper incisor	−1.6038–0.3038	0.454	−1.4318	0.1693
Incisal display	−3.1320–0.5320	0.872	−1.4908	0.1533
Interlabial gap	−4.0688–0.4888	1.085	−1.6503	0.1162
Intervermillion distance	−5.8701–2.2101	1.923	−0.9516	0.3539
Buccal corridor right	−1.0083–1.0483	0.489	0.0409	0.9679
Buccal corridor left	−0.8619–0.6819	0.367	−0.2450	0.8093
Smile width	−5.7145–2.4345	1.939	−0.8456	0.4089

From the obtained results, a statistically significant difference was observed only in the values for incisal display and left buccal corridor between untreated and treated patients with class II malocclusion.

The analysis of the smile arch in untreated and treated patients with class I, II, or III malocclusion is shown in Table 5 below, which indicates the representation of the consonant, straight, and reverse smile arch in the total number of respondents.

Table 3: Comparison of smile measurements among the malocclusion Class II

Smile characteristics	Class II malocclusion			
	Untreated patients (n = 10)/Treated patients (n = 10)			
	95% confidence interval	Standard error difference	t-value	p-value
Upper lip length	−2.5092–3.1292	1.342	0.2310	0.8199
Lower lip length	−3.8443–2.9243	1.611	−0.2856	0.7785
Lower lip to upper incisor	−1.6207–0.8007	0.576	−0.7115	0.4859
Incisal display	−2.3222–0.0378	0.544	−2.1705	0.0436*
Interlabial gap	−3.2879–0.3479	0.865	−1.6989	0.1066
Intervermillion distance	−4.3071–1.1471	1.298	−1.2172	0.2392
Buccal corridor left	0.2299–2.1501	0.457	2.6039	0.0179*
Buccal corridor right	−0.8861–1.0061	0.450	0.1332	0.8955
Smile width	−2.3745–4.9745	1.749	0.7433	0.4669

Table 4: Comparison of smile measurements among the malocclusion Class III

Smile characteristics	Class III malocclusion			
	Untreated patients (n = 6)/Treated patients (n = 6)			
	95% confidence interval	Standard error difference	t-value	p-value
Upper lip length	−3.0390–7.6990	2.410	0.9670	0.3564
Lower lip length	−2.0266–9.6666	2.624	1.4558	0.1761
Lower lip to upper incisor	0.0116–4.9084	1.099	2.2387	0.0491
Incisal display	−3.5355–1.6555	1.165	−20.8070	0.4385
Interlabial gap	−1.5952–3.8752	1.228	0.9287	0.3749
Intervermillion distance	−6.6966–1.8966	1.928	−21.2446	0.2417
Buccal corridor left	−0.6594–4.4794	1.153	1.6563	0.1287
Buccal corridor right	−1.9976–1.6976	0.829	−20.1809	0.8601
Smile width	−5.3163–9.3363	3.288	0.6113	0.5546

Discussion

Improving the aesthetics of the face is nowadays considered the main goal in modern orthodontics. Adequate knowledge of the characteristics of the smile in each period of life and the changes that occur in relation to gender dimorphism and with age can help orthodontists obtain long-lasting and aesthetically attractive results [28]. Establishing norms is an important part of orthodontic diagnosis and treatment planning. It is reasonable to evaluate the parameters of the smile before the treatment in order to define not only what should be done but also what can be done and to discuss all this with the patients themselves and/or their parents. This study was done to evaluate and compare ten smile characteristics and their influence on the smile in individuals with malocclusions, which, according to the angle classification, are divided into three classes. The mean values and the standard deviation of the studied parameters in the two groups containing three sub-groups were determined.

Table 5: Type of smile arc in both groups of patients

Smile characteristic	Untreated patients			Treated patients		
Smile arc	Class I malocclusion	Class II malocclusion	Class III malocclusion	Class I malocclusion	Class II malocclusion	Class III malocclusion
Consonant	8	6	/	7	7	2
Flat	1	3	4	3	3	2
Reverse	1	1	2	/	/	2

Comparisons and correlations were made between the subgroups regarding the type of malocclusion from both groups to investigate the influence of different types of dentoalveolar malocclusion on smile characteristics and to provide a theoretical basis for clinical diagnosis and orthodontic treatment planning.

During a posed smile, the highest height of the upper lips is observed in patients with class I malocclusion. This result is consistent with several studies [29], [30], and [31]. However, it is contrary to other studies that reported that the height of the upper lip in class II malocclusion is higher compared to class I malocclusion [17], [32]. Upper lip height is one of the important factors that determine the amount of maxillary incisal visibility and gingival display when smiling and speaking. A reduced height of the upper lip is considered a reason for the presence of a gingival smile line, and controversial data exist in the literature regarding this [33], [34]. Regarding the height of the lower lip, in this study, the highest values of the height of the lower lip during a posed smile were observed in subjects with class III and class I malocclusion, respectively. While the lowest values when smiling were observed in subjects with class II malocclusion. These results were consistent with other studies showing that class III subjects had the highest lower lip height values [29], [30], and [31]. Reduced height of the lower third of the face is associated with a vertical maxillary deficit and a deep bite with retrognathism of the mandible.

Figure 2: Full-face frontal photograph at rest

In the study of Hamdany [31], the distance of the lower lip to the upper incisors is greater in subjects with class III malocclusion, which is in accordance with our results, where the mean value of this parameter is 3.9 ± 2.57.

In the current study, the largest vertical display of upper central incisors was observed during social smile in untreated and treated individuals with class I malocclusion, which is consistent with the study by Abdarazik *et al*. and the smallest in class III malocclusion [29]. In the study by Salehi *et al*. a significantly greater display of central incisors was observed in patients with class II malocclusion compared to those with class III malocclusion [35]. This is not surprising given the fact that protrusion of the upper incisors is a common feature of class II malocclusion. Another previous study showed a decrease in upper incisor display when smiling, regardless of whether it was a class II malocclusion or a class III malocclusion [36]. Although the increase in the vertical display of upper central incisors was significant only in class II malocclusion, the treatment of sagittal irregularities in occlusion also increased these values in both class II and III malocclusion, allowing improvement in the patients' smiles.

Figure 3: Full-face frontal photograph at smile

Salehi *et al*. [35] as well as Maganzini *et al*. [37] reported similar findings. This was consistent with studies showing that the most attractive and youthful smile displays 100% of the upper incisor and as much as 2 mm of gingival visibility [38], [39].

The highest mean value of the interlabial space in untreated patients was observed in class III malocclusion (10.1 ± 2.77), while the lowest mean value was in class I malocclusion (8.57 ± 3.29). In the study of Hamdany [31], the interlabial space is larger in the subjects with class II malocclusion, which contradicts the results of our research. As for the changes in the interlabial space, although the change is not significantly increased, there is an increase in its values in treated patients with all three types of malocclusions.

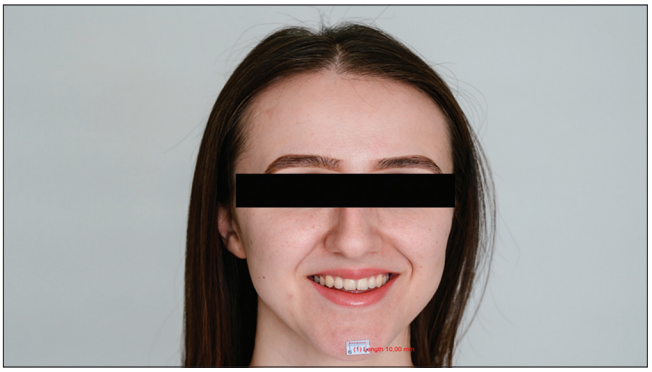

Figure 4: Photography with measuring tape for calibration

The highest mean values of the buccal corridors are observed in class III malocclusion. Malhotra *et al*. [40] studied the effect of specific hard and soft facial tissues on smile characteristics. It was noted that patients with class III malocclusion showed the smallest buccal corridors, which is contrary to our results. A statistically significant difference was observed in buccal corridors between untreated and treated patients with class II malocclusion.

The highest mean value of smile width was observed in class III malocclusion (66.28 ± 5.73), while the smallest values were obtained in class I malocclusion (63.86 ± 5.28). As for treated patients, the largest values were observed in class I malocclusion (65.50 ± 3.12), while the lowest were in class II malocclusion (63.67 ± 4.12).

The largest number of subjects with a consonant smile arch in the group of untreated patients had class I malocclusion, while no patient with a consonant smile arch was observed with class III malocclusion. These results are consistent with the study by Nouh *et al*. [30], but contradictory to the results obtained in the study by Tarnach *et al* [32].

There are many more studies in the literature that evaluate different characteristics of the smile and their influence on attractiveness. The three types of malocclusions were not significantly different in most of the examined characteristics in untreated and treated patients. One explanation is that the sample was small and most of the patients included in this study had dentoalveolar malocclusions, and those with severe skeletal class I, II, and III were excluded from the study.

Conclusion

Knowing the correlation between hard and soft-tissue anatomy and smile aesthetics can provide important clinical significance in orthodontic diagnosis and treatment planning. Patients with different types of malocclusions were not significantly different in terms of the studied smile characteristics, except for the vertical display of upper central incisors, which was greatest in untreated malocclusion class I patients and significantly increased in treated patients with malocclusion class II. A significant change was also observed in the buccal corridors between untreated and treated patients with class II malocclusion. The dynamic change of the smile is influenced by several factors. The advantage of using frontal photography for analysis in this study was simple and cost-effective. Obtaining a posed smile photograph was challenging because patients with certain types of malocclusions hesitate and feel shy when they need to smile.

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