Original Article

Which Factors Affect Dental Esthetics and Smile Attractiveness in Orthodontically Treated Patients?

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Abstract

Objectives: This study aimed to find the factors that affect dental esthetics and smile attractiveness in orthodontically treated patients according to laypeople's judgment, and to determine whether there is any relationship between dental and smile esthetics.

Materials and Methods: Using the Q-sort technique, 60 laypersons (30 males, 30 females) rated dental and smile photographs of 48 orthodontically treated patients based on their degree of attractiveness. Dental and smile parameters of each rated image were measured by Smile Analyzer software. The Student's t-test and chi-square test were used to compare dental and smile parameters between attractive and unattractive images. The logistic regression was used to assess which variables predicted dental and smile esthetics in treated individuals.

Results: The philtral to commissural height ratio and gingival display were significantly different in attractive and unattractive smiles (P=0.003 and P=0.02, respectively). None of the dental variables were found to be a determinant of dental esthetics at the end of the orthodontic treatment (P>0.05). According to the judgment of all raters (female and male) and the male raters' judgment, smile attractiveness could be predicted by philtral to commissural height ratio and buccal corridor ratio (P<0.05). There was no statistically significant relationship between dental esthetics and smile attractiveness in orthodontically treated patients (P>0.05).

Conclusion: The philtral to commissural height ratio and buccal corridor ratio can be considered as predictors of smile attractiveness in orthodontically treated patients. Achieving dental esthetics at the end of orthodontic treatment does not guarantee smile attractiveness.

Key Words: Smiling; Esthetics; Dental; Attractiveness; Orthodontic treatment; Q-sort

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INTRODUCTION

Facial attractiveness including dental and smile esthetics not only impacts social interactions, but also exerts a significant influence on self-concept, psychological well-being and social behavior [1]. Attractive individuals are more successful at school, in job interviews and even in mate selection [2-5].

Orthodontic treatment is primarily aimed to establish a functioning and esthetic dentition and an attractive smile. Orthodontic patients hope to increase their self-esteem and quality of life [6,7]. During treatment planning, in order to enhance esthetics, the orthodontist should determine which smile indices or dental characteristics must be preserved and which ones should be corrected. It is believed that a string of dental and soft tissue factors influence the esthetic outcome of orthodontic therapy. However, it is not clear which factors most predominantly contribute to dental esthetics and smile attractiveness at the end of the treatment. Furthermore, the relationship between dental esthetics and smile attractiveness has not been sufficiently investigated in orthodontically treated individuals. Therefore, the purpose of this study was to find the factors that affect dental esthetics and smile attractiveness in orthodontically treated patients based on laypersons' judgment. The other objective of this study was to determine whether a relationship exists between dental esthetics and smile attractiveness in orthodontic patients.

MATERIALS AND METHODS

The study sample consisted of frontal intraoral photographs of dental occlusion and frontal close-up photographs of posed smiles of 48 female patients taken after completion of their orthodontic treatment.

In order to be included in the study, the female patients had to meet the following criteria:

1. Fifteen to 24 years of age at the end of orthodontic treatment
2. No missing, supernumerary or misshapen teeth
3. No craniofacial anomaly or obvious facial asymmetry
4. Extraction of the upper first bicuspids with/without extraction of the lower bicuspids
5. Skeletal Class I (n=24) and skeletal Class II (n=24) patients, based on the pre-treatment ANB angle and Wits appraisal (patients with ANB>4° and Wits>1mm were categorized as skeletal Class II)
6. Photographs taken no later than three months post-treatment

Photographs were taken under the same conditions by the same photographer. Using Adobe Photoshop software (Adobe Systems Inc., San Jose, CA, USA), each set of photographs (i.e. posed smile and dentition) were cropped to omit distracting parts and resized according to their magnification ratio. The images were turned into gray scale pictures to eliminate the effect of facial complexion and make-up. All photographs were printed in the same size (10 cm × 15 cm).

Sixty laypersons (30 males and 30 females) in the age range of 35 to 55 years were requested to rank, in the order of attractiveness, 48 smile and 48 dentition photographs. The judges were selected among persons in the waiting room areas of School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran. Half the raters were asked to first rate the smile images and the other half were requested to first rate the dentition photographs. The judges were trained on how to rank the pictures using the Q-sort technique. This technique is a nine-step sorting procedure that results in a relatively normal distribution of different levels of esthetics in the sample. Although first proposed for a sample size of 96, Q-sort has been shown to be acceptable for sample size of 48 as well [8,9]. To use the Q-sort technique for smile photographs, the raters were first asked to select the two most and the two least attractive photographs and place them in their corresponding positions in the Q-sort chart. Then, the next four most and four least attractive smiles were chosen. In the same way, the next five and then the next eight most and least attractive smiles were selected and placed in the appropriate positions in the chart. The 10 remaining images were considered to have neutral attractiveness. According to the position of each photo in the nine-step chart of attractiveness, a number between zero (the least

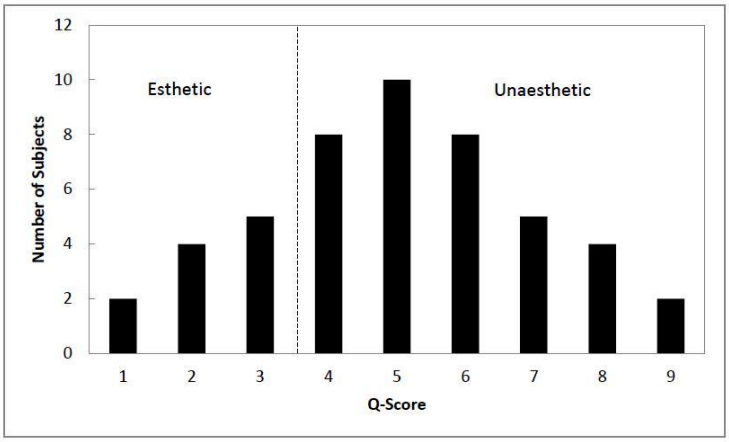

Fig. 1. Assignment of scores to the point of differentiation used to separate "esthetic" and "unaesthetic" dentitions in the Q-sort distribution. The line between columns 3 and 4 was given a score of 3.5.

attractive) and eight (the most attractive) was assigned to each image. The point of differentiation between attractive and unattractive smiles was also marked on the chart by each judge. The mean attractiveness score for each photograph, as well as the average score for the point of differentiation between attractive and unattractive smiles, were calculated. The same procedure was followed for the dentition photographs.

Using Smile Analyzer software [10], the following parameters were measured or calculated on each intraoral dental photograph:

1. Crown height and width of the upper right central incisor and its width/height ratio.
2. Width of the upper central and lateral incisors and the upper canines. These were used to calculate the lateral incisor/central incisor width ratio and the canine/lateral incisor width ratio (golden ratio).

Furthermore, on the posed smile photographs, the following variables were measured or calculated:

1. Gingival display of the upper central incisor.
2. Philtral to commissural height ratio. This was calculated by dividing the philtral height [11] by the commissural height [11] and multiplying the result by 100.
3. Smile index [12], which was calculated by dividing the smile width,i.e. the outer commissure width by the interlabial gap.
4. Buccal corridor ratio [13] or the percentage of the inner commissure width not occupied by the upper dentition. This was calculated by dividing the difference between the maximum upper dentition width and the inner commissure width by the inner commissure width and multiplying the result by 100.
5. Smile arc [14] (either consonant or non-consonant).
6. The last visible maxillary tooth when smiling.

In order to calculate the magnification ratio, the width of the upper right central incisor of each patient was clinically measured using a digital caliper with an accuracy of 0.01 mm and then this was entered into the software.

To determine the systematic error of the measurements, 12 dental and 12 smile photographs were selected and the measurements were repeated one week later. Paired sample t-test revealed no significant difference between the two measurements on dental and smile photographs ($P>0.05$). The logistic regression test of the SPSS software (version 16, SPSS for Windows, Microsoft, Chicago, IL, USA) was employed to assess which dental or smile indices would predict whether a smile or a dentition photograph is attractive or unattractive.

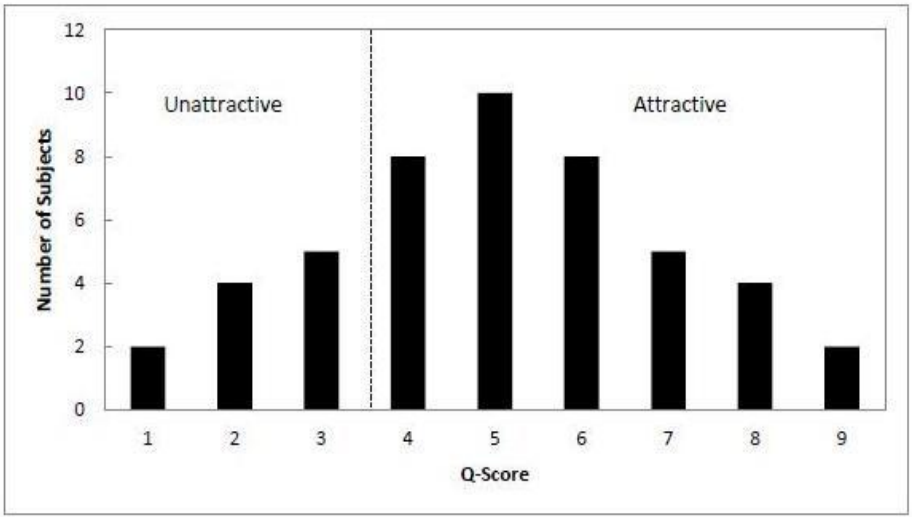

Fig. 2. Assignment of scores to the point of differentiation used to separate "attractive" from "unattractive" smiles in the Q-sort distribution. The line between columns 3 and 4 was given a score of 3.6.

In addition, using independent sample t-test and chi-square test, the differences between the measured variables in attractive and unattractive smiles or dentitions were compared. The chi-square test was also employed to assess any significant relationship between dental esthetics and smile attractiveness in the sample. All tests were performed at the significance level of $P<0.05$.

RESULTS

Fig. 1 shows the average score for the point of differentiation between esthetic and unaesthetic dentitions in the Q-sort chart. The average score separating attractive from unattractive smiles in the Q-sort distribution is presented in Fig. 2.

Table 1 presents the mean and standard deviation values of the dental variables in esthetic and unaesthetic dentition photographs, based on the judgment of female, male and both female and male raters. Table 1 also shows the results of the independent sample t-test, which indicated no statistically significant differences in the amount of dental parameters between the esthetic and unaesthetic images ($P>0.05$).

Table 2 reports the mean and standard deviation values of the quantitative variables in the attractive and unattractive smile photographs, based on the judgment of female, male and both female and male raters. The independent sample t-test showed that the philtral to commissural height ratio and gingival display were significantly different in attractive and unattractive smiles ($P=0.003$ and $P=0.02$, respectively).

Table 3 depicts the number and percentage of consonant and non-consonant smile arcs, as well as the last visible maxillary tooth in the attractive and unattractive smile photographs, based on the judgment of the raters.

Regarding the distribution of these two variables, the chi-square test revealed no significant differences between the attractive and unattractive images, as assessed by the female, male and both female and male raters ($P>0.05$).

Fig. 3 shows the six most attractive and the six most unattractive smile photographs in their positions on the Q-sort chart as judged by both female and male raters. The same is presented in Fig. 4 for dentition photographs.

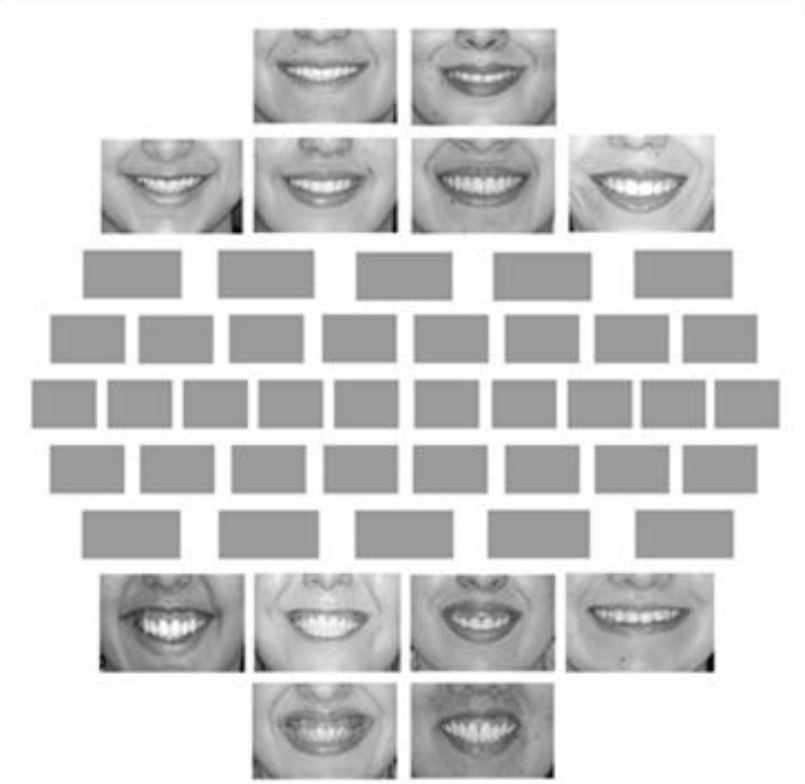

Fig. 3. The six most attractive and the six most unattractive smile photographs in their positions in the Q-sort chart as judged by both female and male raters

The logistic regression model revealed that none of the dental variables could predict dental esthetics, based on both female and male raters' opinions or each of the female and male raters' judgment. Regarding the smile photographs, based on both female and male raters' judgment, smile attractiveness could be predicted by two parameters, namely the philtral to commissural height ratio and the buccal corridor ratio. Female raters believed that only the philtral to commissural height ratio could predict smile attractiveness at the end of the orthodontic treatment. Based on the male raters' judgment, both the buccal corridor ratio and the philtral to commissural height ratio were predictors of smile attractiveness. Table 4 demonstrates the relationship between dental esthetics and smile attractiveness based on the opinion of both female and male raters.

The results of the chi square test showed that there was no statistically significant relationship between dental esthetics and smile attractiveness according to both female and male raters' judgment and each of the female and male raters' opinions ($P>0.05$).

DISCUSSION

One of the most important objectives of orthodontic treatment is to improve facial attractiveness, which is achieved by the enhancement of dental and smile esthetics. Thus, knowing more about the factors affecting dental and smile attractiveness significantly contributes to a successful orthodontic treatment. In the current study, the post-treatment photographs were analyzed. These belonged to 24 skeletal Class I and 24 skeletal Class II patients, whose treatment plan consisted of at least two upper first bicuspid extractions. The sample included both Class I

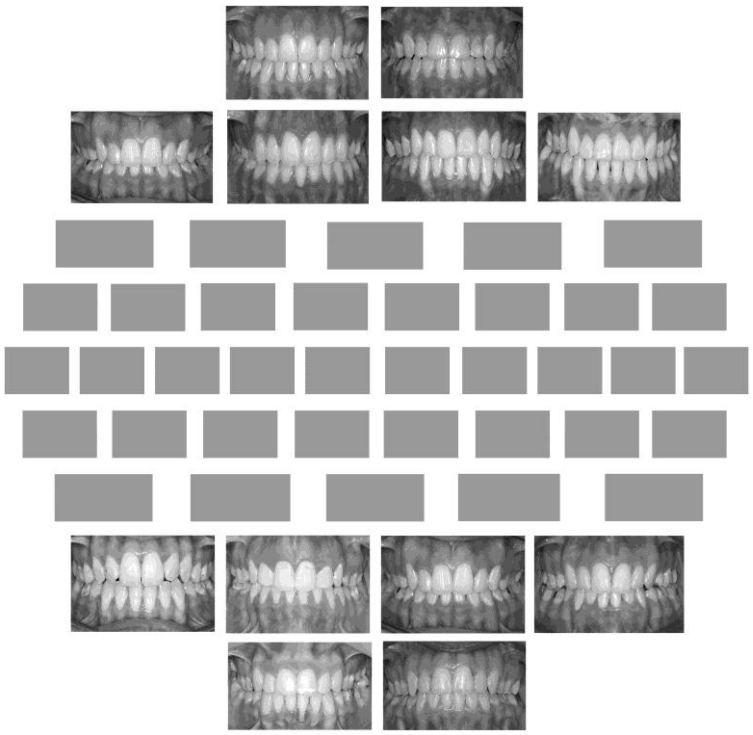

Fig. 4. The six most esthetic and the six most unaesthetic dentition photographs in their positions on the Q-sort chart as judged by both female and male raters

and Class II malocclusions in order to be representative for a wide range of patients undergoing orthodontic treatment. Since orthodontic treatment of skeletal Class III patients rarely requires extraction of the upper first bicuspids, the sample was limited to skeletal Class I and Class II subjects. Two methods are usually recommended to evaluate esthetics: the Visual Analogue Scale (VAS) and the Q-sort.

The Q-sort is a nine-step scoring procedure that results in a relatively normal distribution of different levels of esthetics in a sample. According to Schabel et al [15], Q-sort is more reliable than VAS for the assessment of smile esthetics. The importance of dental and smile parameters evaluated in our study is discussed separately in the following section.

Dental esthetics

It is widely believed that, for better esthetics, a golden ratio should exist among the widths of the upper anterior teeth. In other words, the apparent width of the lateral incisor must be about 62% of that of the central incisor. The same ratio must be seen between the upper canine and the lateral incisor teeth. In the current study, the golden ratio existed neither between the widths of the central and lateral incisors nor between the widths of the lateral incisor and canine teeth. The lateral to the central incisor width ratio and the canine to the lateral incisor width ratio were measured to be 67% and 77%, respectively, in both esthetic and unaesthetic images. The ideal range for the central incisor width to height ratio is 66% to 80% [16].

Table 1. The mean and standard deviation (SD) of dental variables in esthetic and unaesthetic images and the results of independent sample t-test for their comparison, according to the raters' opinions

	Female raters					**Male raters**					**Both female and male raters**				
	Unaesthetic (n=18)		**Esthetic (n=30)**		**p**	**Unaesthetic (n=18)**		**Esthetic (n=30)**		**p**	**Unaesthetic (n=18)**		**Esthetic (n=30)**		
	Mean	**SD**	**Mean**	**SD**		**Mean**	**SD**	**Mean**	**SD**		**Mean**	**SD**	**Mean**	**SD**	
Lateral to central incisor width ratio	0.67	0.04	0.67	0.04	0.96	0.67	0.04	0.67	0.04	0.75	0.67	0.05	0.67	0.04	0.86
Canine to lateral incisor width ratio	0.75	0.11	0.79	0.09	0.13	0.77	0.09	0.77	0.10	0.99	0.77	0.09	0.77	0.10	0.94
Central incisor width to height ratio	0.87	0.06	0.84	0.07	.09	0.86	0.04	0.85	0.08	0.55	0.87	0.06	0.84	0.07	0.24

Table 2. The mean and standard deviation (SD) of the quantitative parameters of smile in attractive and unattractive images and the results of independent sample t-test for their comparison according to the raters' opinions

	Female raters					Male raters					Total female and male raters				
	Unattractive (n=17)		Attractive (n=31)		P	Unattractive (n=15)		Attractive (n=33)		P	Unattractive (n=17)		Attractive (n=31)		P
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Gingival display (mm)	2.28	2.23	0.41	0.87	<0.001*	2.40	2.24	0.47	1.00	<0.001*	1.85	2.21	0.65	1.25	0.02*
Philtral to commissural height ratio (%)	93.65	10.97	106.61	15.08	0.003*	94.86	13.04	105.28	14.88	0.02*	93.57	12.29	106.65	14.49	0.003*
Smile index	5.13	1.69	5.88	1.82	0.17	5.24	1.73	5.79	1.82	0.33	5.30	1.72	5.79	1.84	0.37
Buccal corridor ratio (%)	6.48	3.01	5.61	4.02	0.49	7.50	4.24	5.20	3.93	0.07	6.71	4.46	5.49	3.94	0.33

* Statistically significant difference at P<0.05

In our study, this ratio was 84% in esthetic and 87% in unaesthetic intraoral dental photographs (according to both female and male raters' judgment). Our study showed that dental esthetics could not be predicted by any of the dental parameters evaluated including the lateral to the central incisor width ratio, the canine to the lateral incisor width ratio and the central incisor width to height ratio. This finding is in accordance with that of Levin [17] who stated that the golden ratio among the apparent widths of the upper anterior teeth was not a prerequisite to achieve dental esthetics. Preston [18] also reported that the golden ratio between the lateral and the central incisors' widths was only present in 17% of the cases and this ratio was not observed between the widths of the lateral incisor and canine teeth.

Smile attractiveness

According to the judgment of both female and male raters and the male raters' judgment, the buccal corridor ratio and the philtral to commissural height ratio could predict smile attractiveness.

Based on the female raters' opinion, only the philtral to commissural height ratio was a predictor of smile attractiveness at the end of the orthodontic treatment.

The buccal corridor ratio is the difference between the visible maxillary dentition width and the inner commissure width divided by the inner commissure width and is usually reported as percentage [19].

In other words, the buccal corridor ratio is a percentage of the inner commissure width not occupied by the maxillary dentition.

The results of previous studies on the effect of buccal corridor on smile esthetics have been controversial. While Roden-Johnson et al, [20] Ritter et al, [21] and Parekh et al. [22] did not consider the buccal corridor as a contributing factor to an esthetic smile, others [19,23] believed that the smaller the buccal corridor, the more attractive the smile. In the current study, the buccal corridor ratio was slightly lower in attractive smiles compared to unattractive smiles; but the difference was not statistically significant. However, based on the judgment of the male raters and that of both female and male raters, the buccal corridor ratio was a predictor of smile attractiveness. These findings imply that even small changes in buccal corridor ratio can be perceived by laypeople and may have a significant effect on smile esthetics at the end of orthodontic treatment.

Table 3. Smile arc and the last visible maxillary tooth in attractive and unattractive smile images according to the raters' opinions

			Female raters		Male raters		Both female and male raters	
			No.	**%**	**No.**	**%**	**No.**	**%**
Smile arc	Attractive	Consonant	27	56.3	28	58.3	27	56.3
		Non consonant	4	8.3	5	10.4	4	8.3
	Unattractive	Consonant	14	29.2	13	27.1	14	29.2
		Non consonant	3	6.2	2	4.2	3	6.2
Last visible maxillary tooth	Attractive	2nd premolar	20	41.6	19	39.6	19	39.6
		1st molar	11	22.9	13	27.1	12	25
	Unattractive	2nd premolar	9	18.8	10	20.8	10	20.8
		1st molar	8	16.7	6	12.5	7	14.6

While the absolute lengths of the philtrum and commissure seem to have no importance, the philtral to commissural height ratio proved to be a critical parameter in smile attractiveness. In a normal person, this ratio roughly equals one. In normal adolescents, however, the philtral height is less than the commissural height because of the delayed growth of the labial soft tissue [11].

Sarver and Rousso [24] believed that inadequate philtral height negatively affects smile esthetics and that lengthening the philtrum by surgery may be required to enhance esthetics. On the other hand, an increase in the philtral height due to aging raises esthetic concerns and can be improved by lip lift surgery [25]. In our study, the philtral to commissural height ratio was about 106% and 93% in attractive and unattractive smiles, respectively; this difference was statistically significant. In other words, when the philtral height increased relative to the commissural height, smile esthetics improved. According to the female, male and both female and male raters' judgment, the philtral to commissural height ratio was a predictor of smile attractiveness in orthodontically treated patients. The amount of gingival display in attractive and unattractive smiles differed significantly; but smile esthetics could not be predicted by the amount of gingival display in our study sample. This is probably due to the small clinical difference in the gingival display between the attractive and unattractive images (0.65 versus 1.85 mm, respectively as judged by both female and male raters), which was not perceived by the raters as a determinant of smile attractiveness.

Geron and Atalia [26] stated that the esthetic range for the gingival display was up to 1 mm for the upper and 0 for the lower incisors. Gul-e-Erum and Fida [27] reported that the whole crown height and 2 mm of the gingival tissue display was acceptable for women; while, for men, displaying the whole crown height was satisfactory.

It is worth mentioning that the patients in the current study received non-surgical orthodontic treatment, indicating that there were no severe problems with the gingival display before the appliance placement.

The smile index is used to compare pre- and post-treatment smiles as well as smile esthetics among different individuals. A large smile index indicates a large outer commissural width and/or a small inter-labial gap or in other words, a limited smile area [28].

A large smile index, however, does not necessarily indicate unacceptable tooth or gingival display, since some authors believe that the most unpleasant smiles are characterized by a significantly smaller value of this parameter [9]. It has been shown that as a person ages, the smile index significantly increases [29].

Rashed and Heravi [30] reported that smile index is different in posed and unposed smiles due to different soft tissue movements. In the current study, smile index was 5.79 and 5.30 in attractive and unattractive images, respectively (both female and male raters' judgment) and was not an influential variable in smile attractiveness of orthodontically treated patients.

Isiksal et al, [12] also found that smile index did not significantly affect smile esthetics.

Table 4. The relationship between dental esthetics and smile attractiveness according to both female and male raters' judgment

Smile attractiveness	Dental esthetics		Total
	Unaesthetic	Esthetic	
Attractive	9 (18.8%)	22 (45.8%)	31 (64.6%)
Unattractive	5 (10.4%)	12 (25%)	17 (35.4%)
Total	14 (29.2%)	34 (70.8%)	48 (100%)

In our study, 27 subjects (56.3%) with consonant smile arc had attractive smiles; whereas 14 cases (29.2) with consonant smile arc were rated to have unattractive smiles (according to the female and both female and male raters' judgment). Out of seven patients showing non-consonant smile arc, four cases (8.3%) had attractive and three (6.2%) had unattractive smiles. Both flat and reverse smile arcs were considered as non-consonant in our study. It was found that the consonance of the smile arc was not a determinant of smile attractiveness. Janson et al. [31] showed that smile arc and buccal corridor ratio alone did not influence smile attractiveness. In contrast, Sarver [14] believed that a consonant smile arc significantly contributed to an esthetic smile.

Rashed and Heravi [30] reported that the first and second bicuspids were the most frequently seen last maxillary teeth in posed and unposed smiles, respectively. However, Maulik and Nanda [13] stated that, in a posed smile, the second bicuspid was mostly detected as the last visible maxillary tooth. In the current study, the last visible maxillary tooth was the second bicuspid in about 60% of the patients and the first molar in approximately 40% of the individuals. Needless to say, in our samples, the first upper bicuspids had been extracted for orthodontic treatment. The type of the last visible maxillary tooth was not a predictor of smile esthetics.

The relationship between dental esthetics and smile attractiveness

Based on the opinion of the raters in our study, there was no statistically significant relationship between dental esthetics and smile attractiveness. Therefore, it could be suggested that a beautiful dentition at the completion of the orthodontic treatment does not guarantee the achievement of smile attractiveness. This finding agrees with the study of Schabel et al, [32] in which it was reported that none of the parameters of the American Board of Orthodontics' grading system was able to predict whether a patient had an attractive or an unattractive smile. Schabel et al [32] recommended that parameters related to smile analysis should also be considered when assessing the outcomes of orthodontic treatment.

To further elucidate the relationship between dental esthetics and smile attractiveness, studies should be conducted on larger samples of patients with a wider range of dental and skeletal malocclusions.

CONCLUSION

Under the conditions used in this study, the following conclusions may be drawn:

1- None of the dental variables, including the lateral to the central incisor width ratio, the canine to the lateral incisor width ratio and the central incisor width to height ratio, could predict dental esthetics at the end of the orthodontic treatment.

2- Based on both female and male raters' judgment and the male raters' judgment, smile attractiveness could be predicted by the philtral to commissural height ratio and the buccal corridor ratio. The female raters, however, believed that only the philtral to commissural height ratio was a predictor of smile attractiveness.

3- Other smile-related variables (gingival display of the upper central incisor, smile index, smile arc and the last visible maxillary tooth) could not predict smile esthetics in post-orthodontic smile photographs.

4- There was no statistically significant relationship between dental esthetics and smile attractiveness in orthodontically treated subjects.

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