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Influence of Smile Arc on Esthetic Perception in Relation to Gingival Display: A Cross-Sectional Study on an Iranian Population

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A B S T R A C T

Objectives: This study aimed to evaluate and compare the Iranian's perception of smile arc esthetics and its relationship with gingival display.

Materials and Methods: Two sets of digitally-altered images of a female and a male model were presented to orthodontists and laypeople. Sixteen images with four different smile arcs (including reverse, flat, consonant, and exaggerated) in combination with four gingival display values (-4mm, -2mm, 0mm, and +2mm) were displayed in each set, sorted by gingival display. The raters were asked to rank the smile arcs from the most attractive (1) to the least attractive (4) for each amount of gingival display. The Kruskal-Wallis H and Mann-Whitney U tests were employed to statistically analyze the relationship of gingival display with smile arc esthetics.

Results: Totally, 200 laypeople and 22 orthodontists participated in this study. Laypeople preferred flat smile arcs, and orthodontists believed that flat and consonant arcs were the most attractive in all gingival display values for female and male smiles. Reverse arc was mostly disliked in lower amounts of gingival display, and excessive arc was mostly disregarded in higher amounts of gingival display.

Conclusion: As the preferred smile arcs were flat and consonant types regardless of the amount of gingival display, and reverse and exaggerated arcs were ranked the lowest in lower and upper extremes of gingival display, respectively, it may be concluded that the relationship between the gingival display and smile arc esthetics is more significant when considering unattractiveness.

Keywords: Esthetics, Dental; Perception; Smiling

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INTRODUCTION

Following a rise in income levels, people started to invest on their appearance. Many of them sought orthodontic treatment mainly to obtain a more appealing face [1,2]. Resultantly, the esthetic goals of orthodontic treatment became more significant than improvement of function; thus, occlusion is no longer the only focus of treatment planning in modern orthodontics.

The final esthetic outcome of orthodontic treatment is intertwined with soft and hard tissue parameters [3]. Smile is a facial expression associated with happiness, joy, and amusement. Accordingly, it is regarded as the

second center of attention- after eyes- during conversations, affecting facial attractiveness. Smile is believed to affect attractiveness, social acceptance, and performance [4].

Smiling has various characteristics that can influence smile esthetics to a specific extent, e.g., gingival display, level of gingival margins, buccal corridor, the height-width ratio of the teeth, tooth angulation, and smile arc. Many of these factors have been scrutinized in previous studies [5,6]. The smile arc is commonly believed to have a significant effect on the esthetic perception of the smile. However, a recent systematic review reported that smile arc did not affect smile esthetics [7]. On the other hand, gingival display has been shown to affect the esthetic perception of smile [8]. The interaction among these variables is complex. For instance, the combined effect of gingival display, smile arc, and buccal corridor on smile attractiveness has already been studied [9,10]. When it comes to beauty standards, many factors are involved, namely culture, ethnicity, age, gender, socioeconomic status, educational level, and income [11]. Consequently, when assessing smile esthetics, some differences may exist in the opinion of laypeople and dentists, especially orthodontists; moreover, it would not be surprising to find different trends in different countries.

Considering the effect of culture and socioeconomic status on the perception of beauty, and also the contradictory results on this topic, the exact effect of smile arc and its relationship with gingival display on the perception of smile esthetics still remains unknown particularly in Iran. In this regard, this present study aimed to find the most attractive smile arc in presence of different degrees of gingival display.

MATERIALS AND METHODS

This observational study was approved by the ethics committee of Hamadan University of Medical Sciences (IR.UMSHA.-.REC.1399.573).

One frontal extraoral and one intraoral photograph of a male and a female candidate with perfectly aligned teeth and beautiful lips were captured. Next, the teeth and gingiva on the intraoral image were cropped and substituted for the corresponding section on the extraoral photograph using the layer function of Adobe Photoshop software version 22.5. The original smile arcs were consonant with respect to the upper border of the lower lip. In the second step, three different smile arcs, including a flat smile arc, a reverse smile arc, and an exaggerated smile arc with a curvature greater than that of the consonant arc were created through symmetrical vertical repositioning of the anterior teeth. The scale was determined using the height of the right central incisors, and the lips were repositioned accordingly. In the final step, the two layers were superimposed such that four different amounts of gingival display were obtained, including -4mm, in which lips covered 4mm of the central incisors (the gingival margin of central incisors was considered as the reference), -2mm, 0mm, and +2mm. Ultimately, a total of 32 images (16 of the female candidate and 16 of the male candidate) were created by considering four different amounts of gingival display for four different types of smile arcs. Afterwards, a photo album with 8 pages was created; each page contained different smile arcs for one specific amount of gingival display in a random order (Figs. 1-4).

Next, the lower third of the face on each image was cropped in order to minimize the effect of other facial components on smile assessment. Each rater received a questionnaire with a brief written description for ratings. They were then requested to rank the images on each page from the most attractive (1) to the least attractive smile (4).

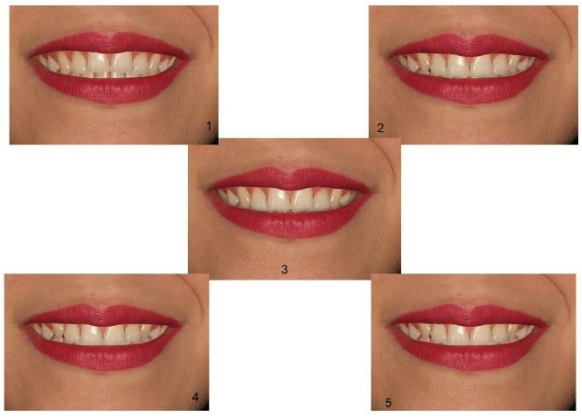

Fig 1. Female model smile arcs in -2mm of gingival show

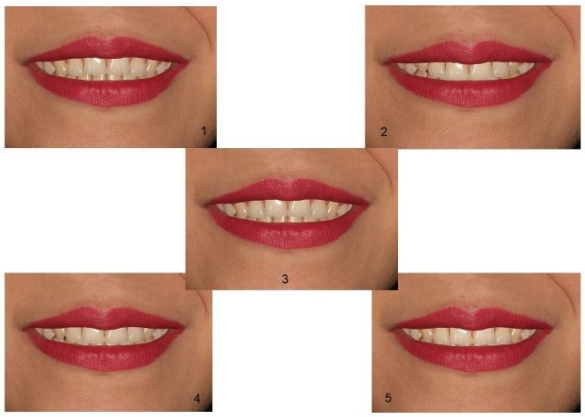

Fig 2. Female model smile arcs in -4mm of gingival show

Fig 3. Male model smile arcs in -4mm of gingival show

Fig 4. Male model smile arcs in -2mm of gingival show

In order to evaluate intra-rater reliability, a modified album was created. One of the photographs on each page (gingival display) was randomly duplicated. This modified album was presented to 20% of the study population.

Personal opinion of two groups of orthodontists with a minimum of 2 years passed since their graduation and laypeople (adults with no dental background and no history of dental treatment over the past 5 years) was sought.

All statistical analyses were performed using SPSS version 16.0. The difference between the ranks of each gingival display was assessed by the Kruskal-Wallis H test followed by pairwise comparisons with the Mann-Whitney U test, when required. P values less than 0.05 were considered statistically significant, and Bonferroni adjustment was applied to control type I error in multiple comparisons.

RESULTS

A total of 200 laypeople between 19 to 65 years (mean age of 31±11 years) and 22 orthodontists between 29 to 65 years with 3 to 23 years of clinical professional experience (mean of 9 years) completed the questionnaire. Females constituted 56% and 45.4% of the participants in each group of laypeople and orthodontists, respectively.

The frequency of ranks for each model is listed in Tables 1 and 2. Regarding the photographs of the female candidate, laypeople ranked the flat smile arc the highest, regardless of the amount of gingival display ($P<0.01$); however, this smile arc and the consonant smile arc were equally attractive to orthodontists ($P>0.05$).

From the perspective of laypeople, the exaggerated arc with +2 and 0mm of gingival display was considered as the least attractive smile. As the amount of gingival display decreased, the participants seemed more inclined to an excessive arc. The statistical difference between the exaggerated and the reverse arc was not significant in presence of -2 and -4mm of gingival display ($P>0.008$). Accordingly, it was ranked as the third most attractive smile arc in presence of -4mm, as opposed to the reverse arc, which was considered as the least attractive.

Orthodontists ranked the excessive arc the least attractive in presence of +2, 0, and -2mm of gingival display. However, in presence of minimum amount of gingival display (-4mm), reverse arc was ranked as the least attractive. But, the difference between these two arcs was not significant (Table 3).

Table 1. Frequency of ranks for smile arcs in each gingival display value for the female candidate's smiles

Gingival display	Ranks	Laypeople Responses%				Orthodontists Responses%			
		F	C	EX	R	F	C	EX	R
-4mm	1st	37*	21	23	18	40.9	31.8	18.2	13.6
	2nd	29	30	21	19.5	40.9	22.7	31.8	9.1
	3rd	20	36	28	15.5	4.5	36.4	31.8	27.3
	4th	13.5	12	27.5	47	13.6	9.1	18.2	50
-2mm	1st	55	22.5	8	14.5	40.9	27.3	9	27.3
	2nd	20.5	37	18.5	24	31.8	50	13.6	4.5
	3rd	19	35.5	28.5	17	18.2	22.7	45.5	13.6
	4th	5	5	45	44.5	9.1	0	31.8	54.5
0mm	1st	30	26	13.5	30.5	45.5	18.2	13.6	18.2
	2nd	37.5	29.5	14.5	18.5	31.8	45.5	9.1	22.7
	3rd	17.5	31	34	17.5	13.6	31.8	27.3	27.3
	4th	15	13.5	38	33.5	9.1	4.5	50	31.8
+2mm	1st	38.5	11	12	28.5	59.1	18	18.2	4.5
	2nd	37.5	36.5	12.5	16	18.2	40.9	4.5	36.4
	3rd	14.5	34	30	19	18.2	40.9	18.5	22.7
	4th	9.5	18.5	45.4	36.5	4.1	0	59.1	36.4

*37% of the respondents ranked this image as the most attractive; F: flat smile arc; C: consonant smile arc; Ex: exaggerated smile arc; R: reverse arc

Table 2. Frequency of ranks for smile arcs in each gingival display value for the male candidate's smiles

Gingival display	Ranks	Laypeople Responses%				Orthodontists Responses%			
		F	C	EX	R	F	C	EX	R
-4mm	1st	46.5	20.5	15	17	54.5	31.8	9	0
	2nd	17.5	34	19.5	28	17.3	36.4	27	4.5
	3rd	14.5	31.5	36	21	19.1	27.3	54.5	22.7
	4th	21.5	14	29.5	34	9.1	4.5	9.1	72.7
-2mm	1st	54.5	13.5	17	14	58.2	18.2	9.1	0
	2nd	19	42	21	17	13.6	54.5	18.2	9.1
	3rd	15	35.5	36.5	16	28.2	22.7	63.6	9.1
	4th	11.5	9	25.5	53	0	4.5	9.1	81.8
0mm	1st	57	9	12	21	68.2	22.7	0	9.1
	2nd	21.5	39	23.5	15	13	68.2	4.5	13.6
	3rd	12.5	29	36.5	25	18.2	9.1	36.4	36.4
	4th	9	23	28	39	0	0	59.1	40.9
+2mm	1st	60.5	12	12.5	14.5	63.6	31.8	4.5	0
	2nd	22	36.5	15.5	26.5	31.8	50.9	9.1	27.3
	3rd	7.5	35	31.5	26.5	4.5	17.3	45.5	31.8
	4th	10	16.5	40.5	32.5	0	0	40.9	40.9

F: flat smile arc; C: consonant smile arc; Ex: exaggerated smile arc; R: reverse arc

Table 3. Mean and median ranks for each smile arc assorted with different gingival display values

Gingival display	Smile arc	Female model			Male model		
		Laypeople Mean rank (median)	Orthodontists Mean Rank (median)	P value	Laypeople Mean rank (median)	Orthodontists Mean rank (Median)	P value
-4mm	F	2.89 (3)	3.09 (3)	0.68	2.89 (3)	3.27 (4)	0.06
	C	2.63 (3)	2.7 (3)	0.56	2.61 (3)	2.95 (3)	0.22
	Ex	2.4 (2)	2.5 (2.5)	0.52	2.28 (2)	2.36 (2)	0.34
	R	2.08 (2)	1.86 (1.5)	0.09	2.2 (2)	1.31 (1)	0.000*
-2mm	F	3.25 (4)	3.04 (3)	0.067	3.16 (4)	3.5 (4)	0.13
	C	2.77 (3)	3.04 (3)	0.06	2.6 (3)	2.86 (3)	0.23
	Ex	1.89 (2)	2 (2)	0.07	2.29 (2)	2.18 (2)	0.48
	R	2.08 (2)	2.04 (1)	0.1	1.92 (1)	1.27 (1)	0.007*
0mm	F	2.82 (3)	3.13 (3)	0.06	3.26 (4)	3.5 (4)	0.12
	C	2.68 (3)	2.77 (3)	0.10	2.34 (3)	3.13 (3)	0.000*
	Ex	2.03 (2)	1.86 (1.5)	0.06	2.19 (2)	1.45 (1)	0.06
	R	2.46 (2)	2.27 (2)	0.07	2.18 (2)	1.90 (2)	0.14
+2mm	F	3.05 (3)	3.31 (4)	0.23	3.3 (4)	3.59 (4)	0.23
	C	2.66 (3)	2.77 (3)	0.45	2.44 (3)	3.04 (3)	0.004*
	Ex	1.91 (2)	1.81 (1)	0.48	2 (2)	1.77 (2)	0.07
	R	2.37 (2)	2.09 (2)	0.026*	2.23 (2)	1.86 (2)	0.063

* Significant (P<0.05); F: flat smile arc; C: consonant smile arc; Ex: exaggerated smile arc; R: reverse arc

With regard to the male model, laypeople preferred the flat smile arc. However, orthodontists found the flat arc as appealing as the consonant arc (P>0.008).

The exaggerated and reverse arcs attained the lowest ranks by the laypeople and orthodontists (P<0.008). The reverse arc was the least attractive, and in the opinion of orthodontists, the statistical difference between these two smile arcs was significant in presence of the two lower amounts of gingival display.

By assessing the inter-group difference using pairwise comparisons, both groups rated the female smiles similarly attractive except in presence of +2mm of gingival display, in which the reverse arc was more interesting to laypeople. However, this was not the case for the male smiles; in presence of -4 and -2 mm of gingival display, laypeople significantly designated higher ranks to reverse arc. In presence of +2 and 0mm of gingival display, orthodontists strongly preferred the consonant arc.

Female and male orthodontists rated the images in the same way (P>0.05). In this regard, laywomen obviously preferred reverse smile arcs to exaggerate arcs in all amounts of gingival displays (P<0.05) except for +2mm, at which the two smile arcs obtained similar scores. This was particularly true for the female candidate's smiles; while no significant difference was observed in opinion between the female and male raters for the male candidate's smiles.

The Mann-Whitney U test showed no significant difference in scoring of the duplicate images (P>0.05), indicating optimal intra-rater reliability.

DISCUSSION

The present study assessed the attractiveness of different smile arcs in presence of four different amounts of gingival display. The effect of smile arc in combination with buccal corridor on smile attractiveness has been previously evaluated [11]. However, to the best of the authors' knowledge, only one study has addressed this effect in presence of different amounts of gingival display to date [9]. The results revealed that gingival display could affect the perception of smile attractiveness. Given that every

individual has a pre-determined gingival display, which rarely changes during orthodontic treatment, the altered photographs were sorted based on gingival display to find the most attractive smile arc at a specific gingival display. Subsequently, the smile arcs in each gingival display were presented alongside and apart from other gingival display values; this methodology was different from that of previous studies in which the images were viewed independently [5,9]. The present methodology was beneficial for the following two reasons: (I) it did not baffle the respondents with copious images, and (II) they were less likely to either forget the previous images or underrate an image on the assumption that the upcoming ones would be better.

The participants were asked to rank the images from the most attractive to the least attractive one. Most similar studies [9,10] used a visual analog scale or other scoring systems in order to rate the images. Schabel et al, [12] and Phillips et al, [13] in their study suggested that in studies assessing smilemethods are more preferred. It is likely that some raters might neglect some parts of the scale and that the respondents perceive identical increments as different ones.

The results of different studies on the most esthetic smile arc are somewhat inconsistent [10,11,14]. In the current study, laypeople gave the highest score to the flat smile arc in all gingival display values. On the other hand, orthodontists perceived the attractiveness of flat and consonant smile arcs similarly, which was in contrast to the findings of several studies reporting the flat smile arc as the least attractive [10,15,16]. The negative aspect of non-consonant arcs may seem too obvious to orthodontists that frequently encounter textbooks and literature with similar conclusions. However, some studies clearly contradicted this result: McNamara et al, [14] reported that the smile arc had no correlation with smile esthetics. Rodrigues et al, [11] , Almanea et al, [17] and Saffarpour et al, [18] indicated that smiles with reverse arcs were equally attractive and favored by the laypeople. In addition, Kaya and Uyar [9] demonstrated that flat smile arcs were more attractive in lower gingival display values, and exaggerated arcs seemed more pleasant in smiles with greater gingival display values. Another study concluded that flat arcs were more attractive than consonant arcs, which was consistent with the results of the present study [19]. A distinctive feature of the aforementioned study was that it was conducted in Pakistan which is close to Iran. People of the same area often tend to share the same cultural and traditional beliefs, which indicates the role of culture and ethnic backgrounds in esthetic perception [20]. Besides culture and ethnicity, there might be some other reasons for disagreement among studies, as the Form Concept theory suggests that the more frequently we observe a pattern in the society, the more we perceive it as correct [21]. Therefore, this topic was examined in the present study, yielding rather unexpected outcomes: flat smile arcs were found to be more popular in Iran in comparison to European nations that were the study population of the majority of relevant publications [6,22-24]. This may explain why the participants opted for flat smile arcs in the present study, but it is just a conjecture, and further studies are needed to verify this assumption.

A number of the above-mentioned studies also discussed the attractiveness of excessive smile arcs and reported that scores received by excessive smile arcs were similar to those of consonant arcs [10,24]. In the present study, similar to that of Gaikwad et al, [25] this arc ranked the last, especially in higher amounts of gingival display. This result was in contrast to the findings of the study by Kaya and Uyar [9] stating that vaulted arcs were preferred in smiles with greater gingival display. However, as they did not specify the proportion of curvature created by the edges of the teeth to that of the lower lip, these comparisons are slightly inaccurate. Of note, these disparities in esthetic perception might stem from cultural, ethnic, and socio-economical differences between the study populations. Furthermore, some inconsistencies were found to be associated with uncontrolled parameters (e.g., tooth size, tooth shape, lip form, facial pattern, buccal corridor, etc.) specific to models; therefore, they vary from one study to another. These parameters have been proven

to affect esthetic scores.

There is also controversy among studies on the correlation between orthodontists and laypeople's esthetic perceptions. In this regard, some studies confirmed a positive correlation between the perceptions of these two groups [10,24]; while, some others [5] reported a significant difference. The present study indicated a high correlation in most comparisons with the exception that the reverse smile arcs were inferior and the consonant arcs were thought to be superior in orthodontists' view and for some gingival display values. Accordingly, this might be due to the fact that the esthetic perception of orthodontists has been shaped not only under the influence of cultural norms, but also by their academic education, which disapproves reverse arcs and highlights the beauty of consonant arcs against flat smile arcs.

Many studies reported gender as an insignificant factor in esthetic evaluation [5,9]. Accordingly, in the present study, female and male orthodontists did not differ in esthetic perception. However, laywomen chose reverse arcs over the exaggerated arcs for female models, which was in line with the findings of a study by Chotimah et al, [26] who came to know that females were more fond of flat smile arcs. The point that sex did not affect the orthodontists' rankings may result from the fact that the participants came from similar educational and socioeconomic backgrounds.

The most critical clinical finding of the present study was that reverse arcs may be better tolerated in greater amounts of gingival display. Extrusion of canines to a limited degree may favor some individuals in achieving more physiological masticatory muscle activities [27]. On the other hand, excessive curves are not well-accepted, especially in greater amounts of gingival display. Notably, care must be taken to avoid over-intrusion of canines in proportion to incisors, particularly in higher gingival display values.

CONCLUSION

This study discussed that the smile arc affects smile attractiveness. The results suggest that the relationship between the gingival display and smile arc is more significant when it comes to smile unattractiveness. Flat smile arcs were evidently preferred by the Iranian laypeople. Moreover, it was shown that reverse arcs were the most disfavored in presence of lower amounts of gingival display, and excessive arcs were mostly considered unpleasant in presence of higher amounts of gingival display. Of note, knowledge level and personal preferences of patients should be taken into account when formulating this esthetic criterion.

CONFLICT OF INTEREST STATEMENT

None declared.

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