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Perception of Midline Discrepancy and Smile Arc by Orthodontists and Laypeople in Libya

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ABSTRACT

Objective: This study compared the perceptions of smile aesthetics between Libyan orthodontists and laypeople regarding maxillary midline deviation and smile arc. It also assessed the influence of age and education level on laypeople's preferences.

Method: In this cross-sectional study, a web-based questionnaire was administered to 120 laypeople and 20 orthodontists from Benghazi, Libya. Participants rated the attractiveness of a digitally altered female smile photograph featuring variations in midline discrepancy (0–5 mm) and smile arc (consonant, flat, reversed, excessive) using a 0–100 slider scale. Non-parametric statistical tests were used for analysis, with significance set at $*p < .05$.

Results: Both orthodontists and laypeople rated the 5 mm midline deviation and the reversed smile arc as the least attractive, while both groups preferred the coincident midline and consonant smile arc. No significant differences were found between the groups' perceptions of the individual variables. The acceptability threshold for midline deviation among laypeople was 3 mm. older laypeople demonstrated greater tolerance for larger discrepancies in both midline and smile arc, whereas education level had no significant effect on preferences.

Conclusion: Libyan orthodontists and laypeople show a significant agreement in their preferences for smile aesthetics concerning midline discrepancy and smile arc.

Keywords: Visual Perception, Smile Aesthetics, Dental Midline, Smile Arc, Age Differences, Education Level

Introduction

Malocclusion has been shown to adversely affect self-esteem and social interaction, with most individuals seeking orthodontic treatment primarily for aesthetic rather than functional reasons [1,2,3]. Consequently, orthodontics has evolved from a traditional focus on achieving ideal occlusion to a more patient-centered approach that emphasizes smile and facial aesthetics [4,5].

One of the key aspects of smile aesthetics is the accurate evaluation of the maxillary dental midline relative to the facial midline, as this relationship serves as a central point of facial symmetry

[6,7]. While orthodontists can detect even minor deviations of 1–2 mm, laypeople generally tolerate discrepancies up to 2–4 mm before perceiving them as unattractive [8,9,7,10,11].

Another critical factor in smile aesthetics is the smile arc, defined as the curvature relationship between the maxillary incisal edges and the contour of the lower lip during a posed smile [12]. Originating from the work of Frush and Fisher (1958) and later refined in orthodontic literature, an ideal or consonant smile arc occurs when these curves are harmoniously aligned, while flat or reverse arcs deviate from this ideal [13,14]. Studies have shown that orthodontic treatment can sometimes flatten the smile arc, thereby reducing perceived attractiveness [15,16]. Hence, maintaining and enhancing the natural smile arc is a crucial element of orthodontic diagnosis and treatment planning [17].

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Previous research consistently indicates that orthodontists tend to be more critical in evaluating smile discrepancies than laypeople, although some studies report similar perceptions between both groups [10,14,18,19]. Despite the global interest in smile aesthetics, there is limited evidence addressing this topic among the Libyan population. Therefore, the present study aims to compare the perception of smile attractiveness between orthodontists and laypeople in Benghazi, Libya, and to assess how age, and education level influence laypeople's evaluation of different smile characteristics.

Materials and Methods

Study Design

This comparative study performed in an observational and cross-sectional design, data were collected using an electronic web-based questionnaire using the web application 1KA.

Sample Size and Sampling Method

Using G*Power, ($d = 0.5$, $\alpha = 0.05$, power = 0.95) determined that 92 participants per group were required [20]. The study was conducted in Benghazi and included 120 lay participants who were Libyan nationals aged 18 years or older and had no prior orthodontic treatment or dental background. Participants were recruited both in person, mainly parents of orthodontic patients, and online through a questionnaire distributed via social media to ensure a diverse sample. Additionally, orthodontists were selected from a compiled list of practitioners and postgraduate students registered with the Libyan Orthodontic Society in Benghazi. Out of approximately 35 orthodontists invited, 20 completed the questionnaire, yielding a 57.14% response rate.

Questionnaire Design and Administration

Participation in the study was voluntary and anonymous. The online survey began with a brief explanation of the study's purpose and estimated completion time (10–15 minutes), though no time limit was imposed. The questionnaire consisted of two sections: the first gathered demographic data (age, gender, place of birth, profession, and education level), while the second evaluated perceptions of smile attractiveness. Participants first selected the most and least attractive smiles from a randomized set of photographs, then rated each image individually on a 0–100 slider scale Figure 1, where 0 represented the least attractive and 100 the most attractive smile. Multiple viewings were allowed, and the specific dental variables under study were not disclosed to avoid bias. Reliability was ensured by repeating the evaluation of the ideal smile image, following the method of McLeod et al. [18], to confirm consistency in participants' ratings.



Figure 1: Slider Bar Used for Measuring Perception (from 0–100)

Image Manipulation

A close-up smile photograph of a female patient treated at the University of Benghazi was used, showing smile features close to standard norms. The image, captured with a Nikon D5600 DSLR camera, excluded the nose and chin to prevent distraction, and written consent was obtained for digital manipulation. The

photo, showing the lips, teeth, and mento-labial fold, was edited in Adobe Photoshop CC (2018) to create a symmetrical smile and calibrated using the actual mesiodistal width of the right maxillary central incisor to correct magnification [21,10].

Maxillary Midline to Face Discrepancy

The ideal alignment was considered to be when the maxillary midline coincides with the philtrum, then simulated moving the upper front teeth to the patient's left by 1 millimeter at a time up to a 5 mm following the method by Kokich et al, while adjusting the buccal segment teeth to keep the buccal corridors even (Figure 2) [14,10].

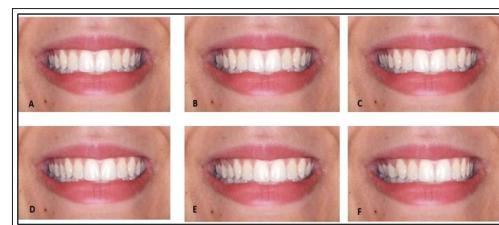


Figure 2: Midline adjustments: Midline was moved to left in 1-mm increments (A, control; B, 1 mm; C, 2 mm; D, 3 mm; E, 4 mm; F, 5 mm).

Smile Arc

For the evaluation of the smile arc, the image was adjusted by flattening and accentuating the curvature of the anterior teeth in relation to the curvature of the lower lip. This modification allowed for the creation and assessment of consonant, flat, reversed, and excessive smile arcs, enabling a comprehensive analysis of how different degrees of curvature impact the overall smile aesthetics (Figure 3).

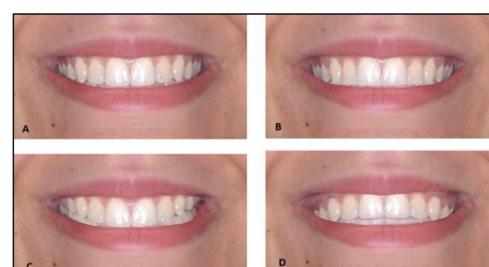


Figure 3: Smile arc adjustments: (A, Consonant; B, Flat; C, Excessive; D, Reversed).

Data Analysis

Data completeness was verified before analysis using IBM SPSS Statistics version 27. The intraclass correlation coefficient (ICC) assessed intraparticipant reliability, while descriptive statistics summarized demographic data. As most variables were non-normally distributed based on the Kolmogorov-Smirnov and Shapiro-Wilk tests, nonparametric analyses were applied. The Mann-Whitney U test compared perceptions between orthodontists and laypeople, and for laypeople, the Friedman test determined differences in aesthetic ratings among images, followed by Wilcoxon pairwise tests for post hoc comparisons. Spearman's correlation examined associations between age and smile perception, while the Kruskal-Wallis test assessed relationships with education level, with significance set at $p < 0.05$.

Results

Reliability and Reproducibility

Reliability was evaluated by repeatedly viewing and rating the ideal smile photograph to assess the consistency of ratings. Intraclass Correlation Coefficient (ICC) was calculated using a two-way mixed-effects model with absolute agreement. The ICC for average measures was 0.725 (95% CI), suggesting good reliability [22]. The results of this investigation therefore are considered to be reproducible and reliable.

Sociodemographic Characteristics of Study Participants

Table 1, shows the demographic characteristics of respondents. Laypeople participants came from varied educational backgrounds, table 2 summarize the sample participants.

Differences in defining most and least attractive smile

Both groups agreed on the least attractive measurements for midline deviation (5mm), and smile arc (reversed), and preferred consonant smile arcs and midline alignment (0mm).

Differences in perception of altered smile aesthetics:

Orthodontists vs Laypeople:

Midline: No statistically significant differences were found at any level (all $P > .05$). Table 3 presents results of comparison between laypeople and orthodontists' perception of maxillary midline shift.

Smile arc: No statistically significant difference in rankings between orthodontists and laypeople for any category at the conventional significance level (all p -values $> .05$), table 4.

Table 1: Demography Of the Study Group

Age		Minimum	Maximum	Mean (SD)
	Laypeople	18	67	32.98 (11.01)
	Orthodontists	29	63	40(9.4)
				Frequency Percent
Gender	Laypeople	Female	101	84.2
		Male	19	15.8
		Total	120	100.0
	Orthodontists	Female	11	55.0
		Male	9	45.0
		Total	20	100.0

Table 2: Level of Education of Laypeople

level of education	Frequency	Percent%
Primary education	2	1.7
Secondary education	29	24.2
Higher education	89	74.2
Total	120	100.0

Table 3: Comparison of Perception of Midline Shift

Midline shift	Laypeople		Orthodontists		P value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
0mm	67.77 (25.85)	73.00 (37)	78.65 (12.72)	81.50 (14)	.119
1mm	63.92 (26.93)	70.50 (46)	71.50 (25.38)	84.00 (29)	.223
2mm	55.64 (27.84)	58.50 (44)	67.10 (18.60)	65.50 (22)	.129
3mm	58.18 (27.14)	61.00 (41)	58.15 (18.706)	60.00 (37)	.766
4mm	52.01 (28.65)	54.00 (48)	52.55 (22.938)	50.00 (43)	.953
5mm	41.79 (30.06)	37.50 (49)	39.10 (23.41)	33.50(45)	.915

Independent-Samples Mann-Whitney U Test

Table 4: Comparison of Smile Arc perception

Midline shift	Laypeople		Orthodontists		P value
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
Flat	59.18 (27.17)	64.00 (42)	55.90 (20.08)	53.00 (25)	.447
Consonant	70.58 (24.96)	75.00 (32)	82.55 (13.46)	85.00 (17)	.059
Reversed	32.63 (25.47)	27.50 (38)	40.90 (22.44)	41.50 (44)	.111
Excessive	47.71 (27.96)	44.00 (47)	55.20 (21.18)	52.50 (35)	.211

Independent-Samples Mann-Whitney U Test

Perception Of Laypeople to Altered Smile Aesthetics

Due to the limited number of orthodontists in our sample, the following analysis focused exclusively on perception and thresholds of acceptability of laypersons for altered smile aesthetics. Acceptability reflects the degree of attractiveness or approval within a given population. For this study, an acceptability threshold set at median ≥ 60 , a chosen value that

goes beyond a simple majority (50) to ensure a clearer, more decisive consensus [4].

Midline: Friedman test revealed significant differences in aesthetic ratings across midline shift ($\chi^2(5)=69.78$, $p < 0.001$). Post-hoc Wilcoxon for pair-wise comparison showed 0mm midline shift (Median= 73.00) was rated significantly higher than

3mm, 4mm, and 5mm (Median = 37.50). Ratings decreased with increasing displacement. Larger midline deviations (≥ 3 mm) are perceived as significantly less attractive than smaller deviations (1mm). Figure 4, A shows midline ratings by laypeople.

Smile Arc: The results suggest that consonant smile arc was rated most favorably, whereas reversed was consistently rated lowest. The highest median score was observed for Consonant (Median = 75.00), followed by Flat (Median = 64.00), Excessive (Median = 44.00), and Reversed (Median = 27.50). Rating demonstrated in Figure 4, B.

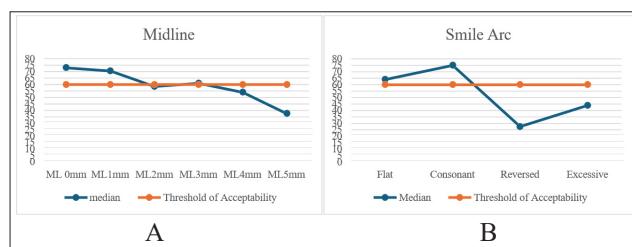


Figure 4: Laypeople rating: A: midline, B: Smile arc

Effect of Age and Level of Education of Laypeople Perception of Altered Smile Aesthetics: Age.

A significant correlation was found between age and smiles with 5mm midline shift ($p=.038$), excessive smile arcs ($p = .031$). Table 5 summarize effect of age on smile perception. To assess the effect of age of laypeople participants on their perception, raters were categorized based on age into 2 groups; young adults (18-30) and older adults (31-and older), table 6 shows their distribution. Older age group has higher evaluation for all variables Figure 5.

Table 5: Effect of Age on the Perception of Smile Aesthetics: Correlation Analysis

Parameter	Level	ρ (Correlation)	p-value	Interpretation
Midline Shift	0mm	-0.116	.208	NS (Not Significant)
	1mm	+0.042	.648	NS
	2mm	-0.021	.819	NS
	3mm	+0.146	.111	NS
	4mm	+0.148	.107	NS
	5mm	+0.190*	.038	Weak significant relation
Smile Arc	Flat	+0.084	.363	NS
	Consonant	+0.044	.635	NS
	Reversed	+0.137	.135	NS
	Excessive	+0.197*	.031	Weak significant relation

Spearman's rank-order correlation

Table 6: Laypeople age groups

Frequency			Percent
	Group 1: 18-30 years	61	50.8
	Group 2: 31-and older	59	49.2
	Total	120	100.0

Level of Education

Test revealed no significant difference in smile perception based on education level for any variable. Given the unequal distribution of participants (19 males compared to 101 females), a reliable gender-based analysis of perceptions could not be conducted.

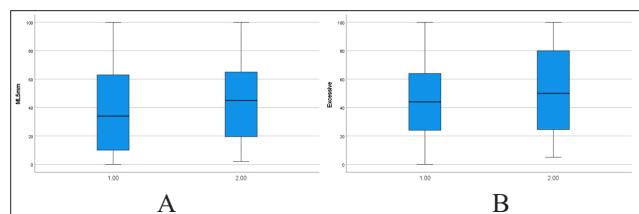


Figure 5: Perception of: A: 5mm midline shift , and B: excessive smile arc by two laypeople age groups.

Discussion

This study assessed smile aesthetics perception among orthodontists and laypeople in Benghazi, Libya. Two smile variables examined: maxillary midline discrepancy, and smile arc due to their well-documented influence on smile aesthetics. The Visual Analogue Scale (VAS), valued for simplicity and efficiency, has been used in both paper (VAS-P) and digital (VAS-D) formats with comparable reliability [23,24].

Online surveys are valid and reliable but require larger sample sizes (Hirao et al., 2021). Digitally manipulated images further enhance orthodontic aesthetics research.

This study used a web-based questionnaire via 1KA to evaluate digitally altered smile photographs with a slider scale. The orthodontist group included 20 participants out of an estimated 35 eligible specialists and postgraduate students in Benghazi, yielding a 57% response rate, consistent with the documented challenges of recruiting healthcare professionals for survey research [25,26]. The laypeople group included 120 participants, drawn from a broader and more accessible population. Although the sample sizes were unequal, the orthodontist group represents over half of the eligible population, supporting the relevance of their responses, while the larger laypeople sample ensures reliable evaluation.

A key finding was the agreement between laypeople and orthodontists regarding what constitutes an unattractive smile. Both groups consistently identified excessive midline deviation (5 mm), and a reversed smile arc as the least aesthetic features. This consensus aligns with Kokich et al study that have identified large deviations from the norm as highly unappealing to both dental professionals and the general public and lower ratings were given by all raters [10]. Furthermore, our results align with Mokhtar et al, who found that a reversed smile arc negatively impacted smile attractiveness and received the lowest

scores [28]. These findings suggest that there is a generally shared understanding of extreme deviations as unattractive, regardless of dental expertise. Also, both favored smiles with maxillary midline coinciding with facial midline, and smiles with consonant smile arcs.

Comparing differences between specialists and laypeople perception, this study found no significant differences. Krishnan et al and Mc Namara et al had reached similar findings, they revealed a notable and significant level of agreement between the perspectives of orthodontists and laypeople. Parekh et al also found both orthodontists and laypersons tend to exhibit similar judgment regarding the perceived acceptability of smile arcs [19,29,4].

Beyond identifying the most aesthetically pleasing smile according to laypersons, defining the threshold for acceptable smile characteristics is critical to preventing unnecessary interventions. Acceptability reflects the level of appeal deemed satisfactory by a given population. For this study, threshold was set at median ≥ 60 , high benchmark to ensure a decisive majority, avoiding ambiguity from marginal preferences [4].

Correcting a deviated midline often involves complex mechanics and prolonged treatment, hence identifying ideal value and acceptability threshold is valuable [30]. According to findings, no midline deviation is considered ideal and threshold extend to 3mm, this is in agreement with Ker et al and William et al results, they identified 2.9mm and 2.92 ± 1.10 mm respectively as threshold of acceptability [14,30].

Laypeople considered consonant smile arc as the ideal among the four presented forms, this is in agreement with Sarver's recommendation [31]. While the preference for consonant smile arc, study participants found smile with flat smile arc to be acceptable. This contrasts with the findings of Parekh and colleagues, who reported that flat smile arcs were considered highly undesirable [4].

Comparing the age groups, weak significant differences in perception of midline discrepancy at 5mm shift, and excessive smile arc were found. Older age group were less sensitive to changes and showed higher ratings to larger discrepancies. While Flores-Mir et al and Sriphadungporn & Chamnannidiadha found that age of smile evaluators did not consistently influence their aesthetic perceptions, this study revealed a different outcome [32,33].

Similar to the findings of Flores-Mir et al., the current study also revealed that the level of education among our layperson sample did not exert a significant influence on their perception of smile aesthetics [32]. This consistency across independent investigations strengthens the notion that, at least within lay populations, the fundamental appreciation of smile attractiveness may be largely independent of formal educational attainment.

Since the number of male lay participants (19) was significantly smaller than the number of female participants (101), a meaningful comparison of perceptions based on gender was not feasible.

This study acknowledges certain limitations. The relatively small number of orthodontist participants. Additionally, the

layperson sample was predominantly female, which could have influenced gender-based comparisons. While some research suggests that gender does not significantly affect evaluations of smile aesthetics, other studies indicate that females may be slightly more critical when assessing altered smiles [34,35,32]. The gender imbalance may also reflect broader trends in survey participation, as women are generally more likely to respond to questionnaires [36-41].

Conclusion

This study found agreement between Libyan orthodontists and laypeople in their perceptions of midline deviation and smile arc. Future studies should include larger samples with participants from various Libyan regions and examine additional smile-related variables to improve representativeness and provide a more comprehensive understanding of smile aesthetics.

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