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ORIGINAL ARTICLE

A Comprehensive Survey of Natural Smile Perception

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ABSTRACT

Objective: To comprehensively analyze smile perception by examining various smile parameters and identifying potential group differences. **Material and Methods:** A cross-sectional study was conducted utilizing a photographic-based electronic survey. Participants' demographic data were collected, and their perception of smile photos, altered across 12 parameters, was assessed using a Likert scale. The study included laypersons, dental students at different academic levels, and dental professionals. Statistical analyses were performed to analyze ratings and determine group differences. The significance level was set at 0.05. **Results:** A total of 435 participants completed the survey. Neither ordinal regression nor linear regression yielded any significant associations between individual photos and perception across groups ($p>0.05$). However, chi-square analysis revealed six events with statistically significant differences among groups, with laypersons exhibiting significant differences in four of them ($p=0.009$, $p=0.012$, and $p=0.017$). **Conclusion:** The limited statistically significant differences in perception between the study groups could be a consequence of the naturally-looking photo edits that may have posed challenges in recognizing subtle alterations and eye fatigue from viewing numerous duplicate photos. Future research should address such limitations to enhance our understanding of smile perception across diverse groups.

Keywords: Surveys and Questionnaires; Dentistry; Face; Beauty.

Introduction

A smile is a very important part of one's persona and appearance and is crucial in determining a person's attractiveness and relationships [1]. Upon searching the literature, what constitutes a perfect smile vastly differs from one person to another [2]. Nevertheless, is there truly a perfect or ideal smile? The depiction of perfection in this scenario assumes altering one's natural characteristics to satisfy a plethora of static and dynamic prosthodontic and esthetic parameters, which have been an area of debate over the previous decades [3-5]. While pursuing such a conceptual smile has gained immense popularity recently, it is important to recognize that the conventional notion of beauty may not always align with natural features. Over the past few years, many patients have undergone unwarranted aesthetic dental treatment in pursuit of a "perfect smile". This results in a smile that appears unrealistic and features a replicated geometry or balance not tailored to different types of patients [2,6].

"Beauty is in the eye of the beholder" entails that the eye for beauty is influenced by perception, which is how a person chooses, categorizes, and interprets input from sensory receptors. Facial beauty is largely influenced by smile architecture, and laymen's perception of a smile is influenced by social and cultural beliefs and norms that differ globally [7]. The natural human smile consists of several soft tissue (lips and gingiva) and hard tissue (the teeth) components, the coalescence of which gives birth to additional in-between ones, such as black triangles and buccal corridor space [8]. Consequently, aesthetic dentistry comprising smile design and analysis has relied on somewhat historically accepted scientific concepts that have been presented in a very static manner with specific measurements for form, color, and position of various smile elements. However, aesthetics might not be a finite point but rather a broad zone or range of values. Therefore, smile perception is a very dynamic concept that is subjected to changes over time. One example is diastemas, which were once considered a sign of beauty, but nowadays, many people seek dental treatment to close them [9]. Furthermore, the exponential surge in idealized smiles showcased on social media prompts us to consider the status of natural smiles in this digital age. The manner in which individuals perceive alterations to their natural smiles, whether as enhancements or shortcomings, is a subject of interest. Similarly important is the difference in such perception between laypersons and individuals with a background in dentistry, whether students or practitioners. Moreover, the level of dental education and dental experience could influence how dental students and dental specialists assess and perceive smiles.

By observing the literature, one method to assess smile perception is done using a digital photo of a smile and altering it across multiple smile parameters, often one parameter at a time, followed by asking different groups of people to rate the altered photos using a Likert-, or Visual Analogue Scale [10-13]. Very often in such studies, the baseline or unaltered smile is labeled "ideal" and defined before alterations are done [10,11,13-15]. To our knowledge, the term "natural" has not been previously adopted in smile perception studies.

Several studies have looked into smile perception and the level of agreement between different study groups, such as laypersons, dental students and dental practitioners, with varying levels of agreement [16-19]. To date, each of these studies has primarily concentrated on only a limited set of parameters, typically no more than four or five parameters at most per study, such as the buccal corridor, gingival exposure, gingival marginal level, crown lengths, maxillary midline, diastema, midline shift, smile arc, and the vertical position of canines and incisors. In addition, no studies have looked at dental students at different academic levels of their education and how that could affect their perception of smiles. Thus, the present study aimed to comprehensively analyze smile perception in laypersons, dental students, and dental professionals by examining various smile parameters and identifying potential group differences.

Material and Methods

Study Design and Ethical Clearance

This cross-sectional study received ethical approval from an Ethical Board Committee at a major institution and was conducted at a hospital within the same institution (Ethical approval number: #4254825).

Data Collection

The study was designed as a photographic-based electronic survey disseminated via e-mails and WhatsApp and took 5 minutes to be filled. The questionnaire consisted of two main parts: part 1 to collect demographic data of the participants, including gender, age in years, highest education level, social status, employment, dental year (when the participant was a dental student), and salary; followed by part 2 which consisted of a photographic catalog including different groups of photos that were rated by the participants using a general stem question "How natural does the smile look?", following a Likert scale (completely natural, somewhat natural, neutral, somewhat unnatural, and completely unnatural).

Female and male volunteers with natural smiles were recruited to be photographed with the following exclusion criteria taken into consideration during model selection: previous orthodontic treatment, prior aesthetic gingival surgeries, presence of direct or indirect anterior dental restorations (including implants), gingival tattoos, and bonded aesthetic dental jewels such as diamonds.

Photos of the smiles of three volunteers who consented to participate, one male and two females, were recorded using a professional camera (Nikon D3200 with SIGMA EM-140 DG Macro Ring Flash, SIGMA Macro lens 105 mm, exposure mode: automatic, sensitivity: ISO 100, shutter speed: 1/125, aperture: f/32, white balance: on). The colored photos were then edited digitally using Adobe Photoshop 22.1 (Adobe Inc., California, USA). Photo editing included cropping, including the teeth and both lips, strictly to eliminate any other facial factors that could interfere with the participant's ratings. After this, the colored photos were duplicated and gradually altered across 12 different parameters, creating a total of 45 photos of original and altered photos. All photos, both natural and altered, remained colored as they were taken initially, and the colors were not manipulated nor altered in any way, except for the tooth shade parameter, where only the shade of the teeth was modified. For each of the 12 parameters, a total of 4 photos were displayed (photo 1: the original/unaltered photo, and photos 2-4: altered photos ranging from mild to moderate to major alterations) except parameters marked with * having three photos, and ** having two photos in total as following in Figures 1 and 2:

1. Gingival display: original, minor, moderate, and excessive gingival display
2. Smile arc: original, flat, and inverted
3. Lip thickness: original and excessive lip thickness
4. Teeth shade: original, slightly yellowish, moderately yellowish, and extremely white shade
5. Canine characterization: original prominence/tip, minor, moderate, and excessive prominence
6. Spacing: original (no spacing), minor, moderate, and excessive spacing
7. Teeth morphonology: original/existing, triangular, and rectangular
8. Black triangles: original (none present), small, moderate, and large black triangles
9. Diastema: original (no diastema), minor, moderate, and large diastema
10. Incisal anatomy: original, mamelons, straight with minimal attrition, and canted with considerable attrition
11. Buccal corridor: original (existing), minor, moderate, and excessive corridor
12. Midline shift: original/no deviation, minimal, moderate, and excessive shift.

Figure 1. Digital photos and their altered duplicates for the first 8 parameters in order from original (photo 1) on the left with gradual increase in alteration to the right (photos 2-4, except for lip thickness which has only 1 altered photo).

Participants from the visitors and dental staff of the aforementioned dental hospital [dental specialists, students at multiple stages of education (undergraduates and interns), and laypersons including patients and other staff] were randomly invited to participate in the study (data collection period: February to April 2021). Children under the age of 12 years were excluded. The study sample was stratified into six groups: laypersons, undergraduates in their preclinical academic year (3rd-year students), undergraduates in their clinical academic years (4th, 5th, and 6th-year students), dental interns, general dentists, and specialized dentists. Participant perception was determined by a Likert-based rating scale (5= completely natural, 4= somewhat natural, 3=

neutral, 2= somewhat unnatural, and 1= completely unnatural). Upon agreement, the electronic survey was sent to the participant via e-mail or WhatsApp.

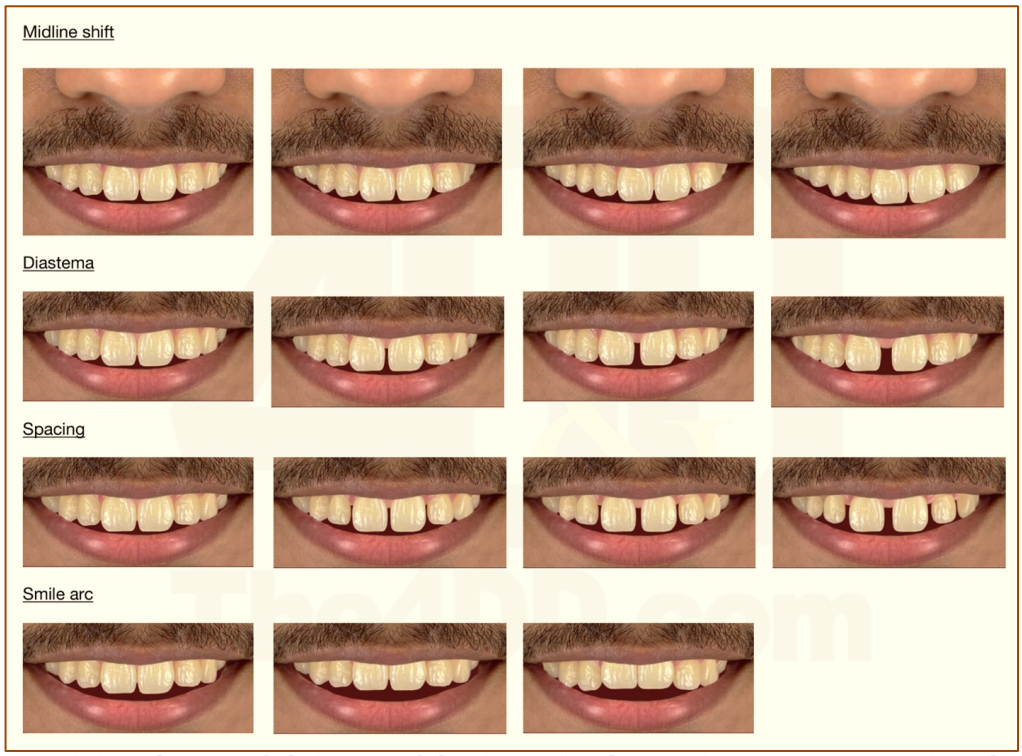

Figure 2. Digital photos and their altered duplicates for the remaining 4 parameters in order from original (photo 1) on the left with gradual increase in alteration to the right (photos 2-4, except for smile arc which has only 2 altered photo).

SurveyMonkey® (SurveyMonkey, Momentive, CA, USA) was used to generate the questionnaire in an electronic format, which commenced with a consent statement, assuring the participants of the confidentiality of their responses and of their total anonymity by not collecting any identifying information. Additionally, all participants were informed of their right to withdraw from the study at any point without any adverse repercussions or penalties. The consent statement was followed by parts 1 and 2, as discussed previously. The following measures were taken into consideration to avoid eye fatigue and any misleading ratings by the participants: (1) the photographic display was set to allow for alternation between male and female photos, and (2) the photos for each parameter were programmed to appear randomly not following any specific order form natural to altered.

Statistical Analysis

IBM SPSS, version 29 (IBM Corp., Armonk, NY, USA) was used to perform all statistical analyses. The significance level was set at 0.05. The following statistical analyses were performed: Descriptive statistics of the demographic data were calculated and presented as frequencies and percentages. Descriptive statistics of the ratings for every photo were calculated in frequencies, and an ordinal regression was used to test if, within every group of photos, a certain photo demonstrated a cutoff between natural and unnatural ratings, where the rating was considered the dependent variable for every photo. A separate regression model was used for every photo. Multivariate regression was used to test for any linear relationships between the study groups and ratings across the photos and the set of photos for each parameter. The ratings were set as outcomes and the types of

participants as predictors. A separate regression model was used for every group of photos. Finally, Chi-square was used to test the correlation between the different study groups and their photographic perception. When the Chi-square was significant, adjusted Pearson's residuals were calculated and used to determine deviation from expectancy. In addition, a Bonferroni correction was used to determine the Z critical value. The Z critical value was then calculated where all residuals greater than 3.55 or lesser than -3.55 would be considered to have a statistically significant deviation.

Results

In this cross-sectional, survey-based study, a total of 435 individuals consented to participation and completed the survey. Demographics with related descriptive statistics are shown in Table 1.

Table 1. Descriptive statistics of participants' demographics.

Variables	N	%
Gender		
Male	189	43.0
Female	246	57.0
Age (in Years)		
12-24	137	32.0
25 to 39	157	36.0
40 and above	141	32.0
Education		
Primary education	49	11.0
Bachelor's degree	260	60.0
Higher education degree	126	29.0
Social Status		
Single	175	40.0
Married	227	52.0
Divorced/Widowed	33	8.0
Employment		
Unable to work/unemployed	18	4.0
Private	28	6.0
Governmental	209	48.0
Student	128	30.0
Retired	25	6.0
Housewife	27	6.0
Study Groups		
Dental student	139	32.0
Dentist	136	31.0
General practitioners	39	9.0
Specialists	97	22.0
Layperson	160	37.0
Academic Year (for Dental Students)		
Preclinical	12	9.0
Clinical	53	38.0
Internship	74	53.0
Salary (Saudi Riyals)		
No income	87	20.0
<5000	80	18.0
5000-10,999	93	21.0
11,000-20,999	106	25.0
>30,000	69	16.0

Based on the descriptive statistics of all the photos, the combined percentages of completely natural and somewhat natural perceptions were always higher than the combined percentages of completely unnatural and

somewhat unnatural perceptions in photo 1 (original/unaltered photo) in every set of photos. However, ordinal regression did not show any photo that could act as a statistically significant cutoff between the natural and unnatural ratings for every type of participant across all photographic sets ($p>0.05$). In addition, linear regression did not demonstrate any statistically significant linear relationships between the study groups and their photographic perception ($p>0.05$).

Chi-square results with all residual values for the statistically significant findings are shown in Table 2. There was a significant association between gingival display photo 1 (GD1) and study group, in which undergraduates in their clinical years (CU) were found to select "neutral" significantly more than the other groups ($p<0.05$); teeth shade photo 3 (TS3) and study group, in which interns (INT) were found to rate the photo as completely unnatural significantly more than the other groups ($p<0.05$); spacing photo 3 (S3) and study group, in which laypersons were found to rate the photo as completely natural significantly more than the other groups ($p<0.05$); spacing photo 4 (S4) and study group, in which laypersons were found to rate the photo as completely natural significantly more than the other groups ($p<0.05$); incisal anatomy photo 4 (IA4) and study group, in which laypersons were found to rate the photo as somewhat natural significantly more than the other groups ($p<0.05$); and midline shift photo 4 (MS4) and study group, in which laypersons were found to rate the photo as somewhat natural significantly more than the other groups ($p<0.05$).

Table 2. Bonferronicorrected Pearson's Chi-square and adjusted the z value as a post-hoc, showing only significant chi-squares and groups with at least one significant post-hoc.

Parameter Photo	Study Group	Pearson's Chi-square	Completely Unnatural	Somewhat Unnatural	Neutral	Somewhat Natural	Completely Natural
GD1	CU	0.002*	-0.9	-0.4	4.2**	-1.5	-0.7
TS3	INT	0.002*	3.9**	0.2	-1.3	-2.3	-1.4
S3	L	0.009*	-1.9	-1.3	0.4	1.9	3.7**
S4	L	0.012*	-2.8	-0.4	1.8	0.5	4.2**
IA4	L	0.009*	-1.2	-1.6	-0.1	3.6**	-1.4
MS4	L	0.017*	-2.8	0.4	-0.3	3.9**	1.2

*Statistically Significant at $p<0.05$, **Significant at $z \geq 3.55$ or $z \leq -3.55$.

Discussion

The aim of the current paper is to comprehensively analyze smile perception in laypersons, dental students, and dental professionals by examining various smile parameters and identifying potential group differences. Smile perception was assessed using a commonly accepted method, which is conducted by obtaining a set of pictures, which are then altered and shown to participants to test how they would perceive the altered photos compared to the original ones. However, in the current paper, instead of using a set of "ideal smile" photos selected based on predefined aesthetic parameters as our baseline, models were recruited to take photos of their existing smiles, something that to date has not been done in any of the recent publications studying smile perception. However, such photos were cropped to include the perioral area to provide laypersons and students an experience that would mimic, to an extent, how dental professionals concentrate on macro- and micro-aesthetic features of smiles. The current study was not designed to assess face perception, attractiveness or how the brain perceives smiles with background facial features. Our method aligns with the majority of studies that have employed cropped images [10-22], although it differs from some prior research that used photos in which the face remained constant and other smile-related variables were changed [23-26].

In the present study, the perioral area was the constant part of the image and different details related primarily to the teeth were changed. As a result, the current study design was characterized by four aspects: 1) A wide set of smile parameters was included in order to fully investigate how various factors influence the way

a smile is perceived, contrary to other similar studies which have factored either one parameter or a limited number of parameters in their analyses; 2) Both female and male smiles were included; 3) The study photos were not only acquired by a trained dentist, but all photo edits and alterations were performed by an expert in the field of photo editing who also happened to be a dentist. This resulted in a set of edited photos that appeared very natural in comparison with the original baseline photos; 4) Instead of considering dental students as one study category, they were split into three categories based on their undergraduate academic level, which has not been adopted in previous research designs; and 5) The study participants were asked to rate whether the photos looked "natural" not "ideal".

In this study, the baseline photo for every parameter was always voted natural more than the rest of the photos in the same parameters per every group. Despite using the same baseline in all parameters, the amount of natural to unnatural ratings varied from one parameter to another. Moreover, the study group's results do not show any significant effect on the smile perception ratings of all 45 study photos. The statistical tests did not establish a significant correlation between the study groups and the ratings of the baseline photo as natural. The reason behind this could be the finding that around 89% of the study participants had an advanced level of education (Bachelor's, Master's, and/or PhD).

The parameters investigated in this study can be split into three main categories: hard tissue, soft tissue, and other parameters. Hard tissue parameters included teeth shade, canine characterization, spacing, teeth morphology, diastema, incisal anatomy, and midline shift. With the exception of gingival display in the soft tissue parameter group, all statistically significant findings regarding differences between groups occurred in the hard tissue parameters (Table 2).

Regarding teeth shade, it was found that for photo 3, which had the most yellowish teeth, interns perceived it as "completely natural" significantly more than the other study groups. This result does not concur with those of Schwefer et al. [22], who found no significant differences between the study groups when it came to TS. This may be due to the inclusion of laypersons and inexperienced dental students in one group in their study, which might have caused the dental students to tip the weight of the overall outcome. Contrary to the present study's findings are those reported by Krajangta et al. [14], in which laypersons and non-dental students had a significant preference for the brightest teeth shade as compared to dentists and dental students. This could be because teeth shade was tested simultaneously in their study, along with lip thickness and multiple lipstick colors. This, in return, could have influenced the smile perception due to the contrast between lipstick colors, such as red, pink, and orange, and teeth shade. The present results may also be masked by the fact that there were fewer students than interns in the study sample, not to mention that many of the laypersons in this study had at least a bachelor's degree, reflecting a high educational level comparable to the other study groups. Additionally, the current study population may have a true preference for brighter teeth shades, which could reflect socially or culturally driven perceptions.

Regarding canine characterization, no statistically significant differences were found between the groups in any of the photos. Such results come in line with those reported by Schwefer et al. [22], who tested five different canine lengths deviating increasingly and decreasingly from ideal and found their set of groups to have no statistically significant differences.

In relation to spacing, it was observed that for both photos 3 and 4, laypersons rated the picture as "completely natural" significantly more than everyone else. Interestingly, this difference grew significantly more in photo 4 compared to 3, indicating that laypersons may be less critical to spacing, consequently not altering their perception of a smile as natural. The present results concur with those reported by Khalaf et al. [13], who

found laypersons to rate mild and moderate spacing as natural more than dental specialists. This is despite their use of clinical photos of smiles from different patients with varying degrees of spacing, as opposed to an original baseline photo and digitally altered duplicates, as this study did [13].

Regarding teeth morphology, the current study did not find any statistically significant differences between the study groups, which is similar to the findings reported by Machado et al. [25]. However, they found laypersons to have an overall different pattern of perception, which could be because teeth shape was tested simultaneously with gingival display, as opposed to testing each separately [25]. In addition, the photos used included excessive parts of facial skin and wrinkles, which have been previously shown to negatively influence smile perception [7].

In relation to diastema, no statistically significant differences were detected between the study groups. This is contrary to what was reported by Geevarghese et al. [12], who found dentists to be significantly more perceptive to midline diastema compared to laypersons. Although both studies were conducted on a Saudi population, the opposite findings could be because a large portion of their study sample were laypersons as opposed to 37% in this study.

Regarding incisal anatomy, the findings of this study indicated that laypersons perceived inverse incisal edges to be "somewhat natural" statistically significantly more than dentists and dental students. This could be a true perception of a natural smile in the current studied population or possibly be a consequence of some sort of eye fatigue or confusion from rating a large number of nearly identical photos in a couple of minutes.

As for the midline shift, laypersons perceived photo 4 as "somewhat natural" statistically significantly more than dentists and dental students. This indicates that laypersons might view severe midline shift as a natural variation, as opposed to dentists and dental students, who may recognize it as an abnormality. These findings fall close to those reported by Geevarghese et al. [12], who found that as midline shift increased, dentists became more perceptive of it. Moreover, these findings are like those reported by Martins et al. [21], who also found dentists to be more rigorous in rating smiles with midline shifts than laypersons.

The soft tissue parameters included in the present study were gingival display, lip thickness, and black triangles. For gingival display, the current study found undergraduate students in their clinical academic years to rate photo 1 as "neutral" statistically significantly more than the other study groups. A possible reason behind this could be that these students might be indecisive (neutral) when evaluating gingival display cases because of their adherence to a taught concept of ideal gingival display (predefined set of parameters when assessing gingival display). Nonetheless, no statistically significant differences were noticed between the study groups for any of the altered gingival display pictures. This is contrary to what was reported by Geevarghese et al. [12], who found dentists to rate excessive gingival display significantly lower than laypersons. On the other hand, the results of this study corroborate the findings of Aldeeri et al. [10], who did not find a statistically significant difference between professional groups when it came to gingival display.

For lip thickness, no statistically significant differences were found between any of the groups. This is in agreement with the findings of Sadrhaghighi et al. [15], who found no significant differences between dentists, students, artists, and laypersons. On the other hand, Krajangta et al. [14] found significant differences between 3 different lip thicknesses (thin, medium, thick) between dentists, dental students, other students, and laypersons. This could be attributed to the fact that in their study, lip thickness evaluation occurred simultaneously with the assessment of other parameters, such as lipstick color and teeth shade. Regarding black tringles, no statistically significant differences were seen between the groups. This comes in agreement with what was reported by Alomari et al. [27].

Lastly, for the other remaining parameters, this paper investigated the smile arc and buccal corridor. For smile arc, the results of this study showed no statistically significant differences between the groups. This is contrary to what was reported by Almanea et al. [16], who found that laypersons were less perceptive to altered smile arcs, where 27% of them found a reversed smile arc to be attractive. One explanation for this is that the generated alterations in their study were very slight, unlike the more noticeable alterations in the current study.

As for the buccal corridor, no statistically significant differences were found between the groups. These findings are similar to several published papers, such as the studies by Aldeeri et al. [10] and Geevarghese et al. [12], which were both conducted on a Saudi population. This observation can be attributed to the notion that, in contrast to other micro-esthetic factors, the buccal corridor can be considered a macro-esthetic factor influenced by the extent to which it occupies a person's smile. As such, buccal corridor might exhibit greater perceptibility compared to other parameters [8].

Despite all efforts to use a more comprehensive tool for smile perception, the research design of the study at hand has the following limitations: first, the research sample is a convenient one and lacks more representation of laypersons in general (32% of the study sample were laypersons opposed to 68% who were dentist or dental students) and laypersons with lower educational levels (only 11% of our sample had primary education). Second, the digital photo alterations were done by a trained dentist certified in Adobe Photoshop, rendering the study photos very natural, which could have impeded the ability of the study participants to recognize the alterations. Third, the inclusion of numerous altered duplicates could have resulted in some sort of eye fatigue, hindering the ability of the study participants to recognize any differences. Fourth, the generated photo alterations might have been too minimalistic or comparable, making them unperceivable to the study participants. Fifth, the choice of photo display might have additionally contributed to the eye fatigue. The display of a set of photos rather than individual ones could have facilitated the rating process and reduced fatigue. Sixth, the use of an alternative stem, such as “choose the most naturally appearing smile” instead of a Likert scale, might have facilitated the rating process and reduced eye fatigue. Seventh, the interpretation of “natural” might be very subjective and vary from one individual to another. On the one hand, it could be translated in comparison to what is the norm, most commonly seen or encountered smiles in one’s environment. On the other hand, it could be understood based on one’s own definition of a natural smile or set criteria. In addition, such interpretation is also most likely to be socially and culturally driven as well as impacted by what is portrayed by social media. Future research overcoming the above-mentioned limitations may assist in providing a thorough understanding of smile perception and how it varies among different research groups.

Conclusion

This study on smile perception between dentists and laypersons offers a novel approach by using models' existing smiles as a baseline. It comprehensively investigates various smile parameters and highlights differences in perception. The findings contribute to understanding how these factors influence smile perception, aiding clinical decision-making. Despite limitations, this study provides valuable insights into smile perception, offering implications for dental professionals in treatment planning and patient communication.

Authors’ Contributions

AIM	https://orcid.org/0000-0003-1744-7768	Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing - Original Draft and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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