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Original Article

Dentistry Section

Aesthetic Evaluation of AI-generated Digital Smile Designs among Dental Students: A Cross-sectional Study

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ABSTRACT

Introduction: Smile design integrates art, science and technology to enhance facial aesthetics. Digital tools, including Artificial Intelligence (AI), have advanced personalised smile design.

Aim: To evaluate the aesthetic perception of digitally altered smile designs among dental students and assess their preferences for specific smile parameters such as smile arc, smile line, incisor shape, anterior tooth proportion and incisal edge form.

Materials and Methods: A cross-sectional study was conducted at the Department of Prosthodontics, Malla Reddy Dental College for Women, Hyderabad, Telangana, India, from January 2025 to March 2025, among 257 dental students using a structured Google Form survey containing AI-generated and Photoshop-modified images illustrating five aesthetic smile parameters. Participants rated the aesthetic appeal of each variant. The collected data were analysed using IBM Statistical Package for Social Sciences (SPSS) Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarised responses and the Chi-square test assessed associations between categorical variables.

Results: The parallel smile arc was the most preferred across all smile line categories (64.6-72.0%), while the reverse arc was the least favoured. Square incisors were the most preferred shape, with significant variation in ovoid preferences based on smile line (p=0.001). The golden proportion was favoured overall, especially by those with average and low smile lines, while the Recurring Aesthetic Dental (RED) proportion was more preferred among participants with high smile lines (p<0.001). Rounded incisal edges were generally preferred, but without a significant association with smile line (p=0.331).

Conclusion: Dental students showed significant preferences for specific smile design elements, with notable associations between smile line and both anterior tooth proportions and incisor shape. These insights reflect an individualised aesthetic approach that combines clinical principles with personal perception.

Keywords: Aesthetic dentistry, Artificial intelligence, Image-based survey

INTRODUCTION

Smile design is a multidisciplinary approach that combines art, science and technology to create a personalised, aesthetically pleasing smile [1]. The goal of smile design is to enhance the overall appearance of the smile, taking into account the patient's facial morphology, personality and lifestyle [2]. It involves a thorough analysis of the patient's dental and facial anatomy, including the shape and size of the teeth, gums and lips [3].

The concept of digital smile design emerged in the late 1990s, with the introduction of Computer-Aided Design (CAD) software and digital imaging techniques [4]. In the early 2000s, digital smile design software began to incorporate 2D and 3D imaging capabilities, allowing for more accurate and detailed smile simulations [5]. The development of intraoral scanners and 3D printing technology in the 2010s further revolutionised digital smile design, enabling the creation of highly accurate and personalised smile models [6]. Today, digital smile design software incorporates advanced algorithms and Artificial Intelligence (AI) to analyse facial morphology and create customised smile designs [7].

The recent advent of smile design applications has revolutionised the field of dentistry, enabling clinicians to create personalised, aesthetically pleasing smiles with unprecedented ease and accuracy [1]. Applications like Dental Wings, Smile Designer Pro and Digital Smile Design utilise advanced algorithms and AI to analyse facial morphology and develop tailored smile designs. These applications also facilitate communication between clinicians and patients, allowing for real-time feedback and modifications [7]. Furthermore, applications like SmileSim and Smile Designer offer Augmented Reality (AR) and 3D printing capabilities, enabling clinicians to visualise and fabricate precise smile models. These smile design applications have not only streamlined the treatment planning process but have also enhanced patient satisfaction and outcomes [4].

The seamless integration of AI in dentistry is poised to redefine the boundaries of oral healthcare. By harnessing the power of machine learning algorithms and computer vision, AI can help dentists decipher complex diagnostic patterns, predict treatment outcomes and tailor personalised care plans that cater to the unique needs of each patient. As AI continues to evolve, it is likely to play an increasingly vital role in streamlining clinical workflows, enhancing patient engagement and driving innovation in the development of novel dental materials and technologies [8]. Ultimately, the synergy between human expertise and AI-driven insights holds the promise of transforming the dental profession, leading to better patient outcomes, improved treatment efficiency and a more satisfying experience for both patients and clinicians.

The advent of AI-based design tools and image generators, such as Microsoft Bing, along with advanced editing platforms like Adobe Photoshop, allows clinicians to modify smile parameters, such as arc curvature, incisal edge shape and tooth proportions for personalised simulations. Although studies on digital tools and AI in smile design highlight advancements and patient outcomes [7,8], limited research has examined professional perspectives, particularly how dental students perceive aesthetic variations in digitally altered smiles [9,10]. Therefore, the present study was conducted to analyse the aesthetic appeal of digitally modified smile designs among dental students and assess their perceptions of specific smile parameters.

MATERIALS AND METHODS

A cross-sectional study was conducted at the Department of Prosthodontics, Malla Reddy Dental College for Women, Hyderabad, Telangana, India, from January 2025 to March 2025, to assess aesthetic perceptions of digital smile designs among dental students. Ethical clearance for the study was obtained from the Institutional Ethics Committee (Approval No: MRDCW/IEC/AP/27/2024).

Inclusion and Exclusion criteria: The study included undergraduate dental students who had completed at least one year of dental education and provided informed consent. Exclusion criteria included students with known visual impairments or prior experience with digital smile design projects.

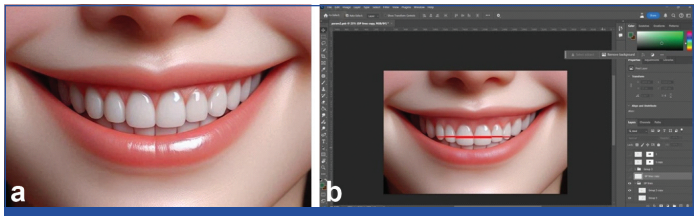
Sample size calculation: The sample size was calculated assuming equal response proportions (33%) [11] for high, medium and low smile lines, using the formula:

$$n=(Z^2 \times P \times Q)/d^2$$

Where Z=1.96 for 95% confidence interval, P=33%, Q=67% and margin of error=5.75%.The required sample size was 237, which was rounded to 257 participants to accommodate potential non responses. Convenience sampling was used to recruit participants.

Study Procedure

Development of image stimuli: A standardised smile image was generated using the Microsoft Bing AI Image Creator tool (https://www.bing.com/images/create) with the prompt "female with beautiful smile" [Table/Fig-1a]. This base image was modified in Adobe Photoshop Beta version 26.2.0 (Adobe Inc., San Jose, CA, USA) to create 30 variants by systematically altering specific aesthetic parameters while maintaining all other features constant [Table/Fig-1b]. Editing was performed using the Rectangular Marquee, Paint Bucket, Scale, Warp, Move and New Layer tools to adjust anterior tooth width, incisor shape, gingival display and incisal edge form, in accordance with established aesthetic principles by Morley J and Eubank J [4].



[Table/Fig-1]: a) An online AI-generated smile image; b) Application of all parameters in Photoshop (Beta version 26.2.0).

Smile aesthetic parameters: In this study design, the smile line (high, average and low) was maintained as the constant reference parameter to ensure uniform comparison across participants. Four aesthetic variables were systematically manipulated:

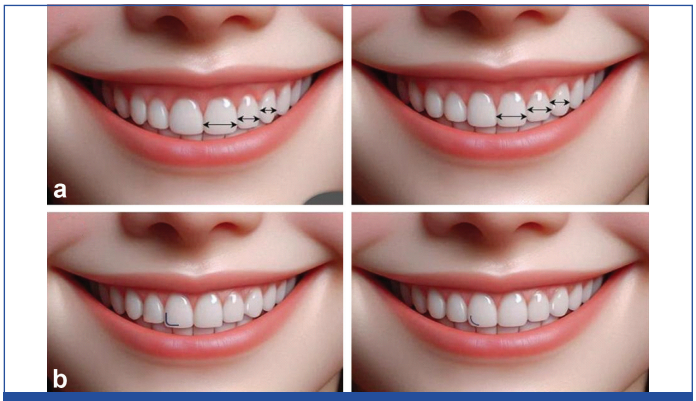
1. Smile arc (parallel, straight, reverse),
2. Central incisor shape (square, ovoid, tapered),
3. Anterior tooth proportion (Golden proportion by Lombardi RE and Levin [12] and RED proportion by Ward DH [13]),
4. Incisal edge form (sharp, rounded).

These combinations yielded 30 images arranged into sets. For each smile line, four questions were designed, resulting in a total of 12 questions, each offering two or three image-based options [Table/Fig-2,3].

Questionnaire development and validation: The questionnaire was designed by the authors based on established aesthetic parameters from the literature [4,12,13]. It was structured as a pictorial survey created in Google Forms and contained 12 aesthetic questions along with basic demographic details (name, age, academic level). To ensure standardisation, participants were provided with a PowerPoint presentation explaining the parameters.



[Table/Fig-2]: a) Smile lines: high, average, low (left to right); b) Smile arc: parallel, straight, reverse (left to right); c) Incisor shapes: square, ovoid, taper.



[Table/Fig-3]: a) Anterior teeth proportions: Golden Proportion, RED Proportion; b) Incisor edges: sharp, rounded.

A pilot study with 30 students was conducted to test clarity, image quality and sequence randomisation. The tool demonstrated good internal consistency, with a Cronbach's alpha of 0.89.

STATISTICAL ANALYSIS

Participants were asked to choose the most aesthetically pleasing image for each question. Responses were automatically recorded in Google Sheets and exported to Microsoft Excel for analysis. Descriptive statistics (means and standard deviations) were calculated for each parameter. Chi-square tests were performed to assess the students' responses, with significance set at ($p<0.05$). The image order was randomised to prevent sequence bias.

RESULTS

The study included 257 female dental students with a mean age of 21.6±2.1 years. Since the study was conducted in a women's dental college, only female participants were included. In terms of academic level, 48 (18.7%) were second-year students, 63 (24.5%) were third-year students, 72 (28.0%) were final-year students and 74 (28.8%) were interns.

The association between the type of smile line (high, average, low) and the corresponding preferences for smile arc (parallel, reverse, straight) among the participants is shown in [Table/Fig-4]. The majority of respondents across all smile line categories preferred the parallel smile arc. Specifically, 185 (72.0%) participants with a high smile line, 166 (64.6%) with an average smile line and 166 (64.6%) with a low smile line preferred the parallel arc. The reverse smile arc was the least favoured across all groups, with only 12 (4.7%),

Smile line	Smile arc			p-value
	Parallel n (%)	Reverse n (%)	Straight n (%)	
High	185 (72.0%)	12 (4.7%)	60 (23.3%)	0.240
Average	166 (64.6%)	11 (4.3%)	80 (31.1%)	
Low	166 (64.6%)	16 (6.2%)	75 (29.2%)	

[Table/Fig-4]: Association of smile line with smile arc preferences among participants.

11 (4.3%) and 16 (6.2%) of participants choosing it in the high, average and low smile line categories, respectively. The differences in distribution across smile line types were not statistically significant (p=0.240), suggesting that the type of smile line did not significantly influence the preference for a particular smile arc in this sample.

Across all smile line categories, the square incisor shape was the most preferred, chosen by 181 (70.4%) participants with a high smile line, 195 (75.9%) with an average smile line and 155 (60.3%) with a low smile line. However, a notable difference was observed in the preference for ovoid-shaped incisors, which was significantly higher among 75 (29.2%) participants with a low smile line compared to 46 (17.9%) with a high smile line and 41 (16.0%) with an average smile line. The preference for tapered incisors remained relatively low across all smile line types. The statistical analysis yielded a p-value of 0.001, indicating a statistically significant association between smile line and incisor shape preferences. This suggests that the aesthetic perception of incisor shape is influenced by the type of smile line [Table/Fig-5].

Smile line	Smile arc			p-value
	Ovoid n (%)	Square n (%)	Tapered n (%)	
High	46 (17.9%)	181 (70.4%)	30 (11.7%)	0.001
Average	41 (16.0%)	195 (75.9%)	21 (8.2%)	
Low	75 (29.2%)	155 (60.3%)	27 (10.5%)	

[Table/Fig-5]: Association between smile line types (high, average and low) and the preferred shape of maxillary central incisors (ovoid, square and tapered) among the participants.

Participants with average 184 (71.6%) and low 179 (69.6%) smile lines showed a stronger preference for the golden proportion, whereas those with a high smile line demonstrated a comparatively higher preference for the RED proportion 113 (44.0%). The association was statistically significant (p<0.001), indicating that the type of smile line influences anterior teeth proportion preference [Table/Fig-6].

Smile line	Anterior teeth proportion		p-value
	Golden n (%)	Red n (%)	
High	144 (56.0%)	113 (44.0%)	<0.001
Average	184 (71.6%)	73 (28.4%)	
Low	179 (69.6%)	78 (30.4%)	

[Table/Fig-6]: Association of smile line with anterior teeth proportion preferences among participants.

Across all smile line categories, participants consistently favoured a rounded incisal edge over a sharp one. The preference was highest among those with a low smile line 174 (67.7%). However, the difference was not statistically significant (p=0.331), indicating no meaningful association between smile line and incisal edge preference [Table/Fig-7].

Smile line	Incisal edge		p-value
	Round n (%)	Sharp n (%)	
High	160 (62.3%)	97 (37.7%)	0.331
Average	160 (62.3%)	97 (37.7%)	
Low	174 (67.7%)	83 (32.3%)	

[Table/Fig-7]: Association of smile line with incisal edge preference. Percentages with frequencies in parentheses.

DISCUSSION

A smile is a vital aspect of an individual's facial aesthetics, serving as a powerful medium of non verbal communication that conveys emotions, confidence and overall psychological well-being. In prosthodontics, smile design is not merely an artistic endeavor but a structured clinical process that integrates aesthetic and functional principles to restore or enhance dental harmony. Several studies underscore the importance of smile aesthetics in shaping perceptions of attractiveness and social competence [14,15].

Smile design incorporates macroaesthetic, microaesthetic and functional parameters. Macroaesthetic elements—such as smile curve, buccal corridor display and smile symmetry—define the overall harmony of the smile with the face [2]. Microaesthetic elements focus on details like incisal embrasures, tooth shape and proportion and gingival zeniths [16]. Functional considerations ensure the biomechanical integration of prosthetics with occlusal harmony, including bite force, speech and mandibular movement.

In the present study, both macroaesthetic parameters (smile arc and smile line) and microaesthetic components (shape of incisors, incisal edges and anterior tooth proportions) were considered. Understanding how dental students, as future clinicians, perceive these variables is crucial for clinical education and treatment planning.

The data obtained from 257 dental students through a structured questionnaire revealed significant associations between smile line and both anterior tooth proportions and incisor shape, suggesting that these features are perceived in tandem to define aesthetic appeal.

The majority of students preferred the golden proportion for anterior teeth, consistent with studies by Snow SR [17] and Preston JD [18], who advocated for the aesthetic harmony achieved through this ratio. However, the present study also revealed a relatively higher preference for the RED proportion among students with a high smile line—a finding aligned with Ward DH [13], who emphasised the visual balance achieved through recurring proportions rather than strict mathematical ratios.

The preference for square-shaped teeth across most smile lines echoes the findings of Hasanreisoglu U et al., [19], who reported that square teeth are perceived as strong and dominant—traits often associated with aesthetic appeal. The significant association between incisor shape and smile line in our data reinforces the idea that tooth morphology must be individualised to smile dynamics.

Interestingly, preferences for rounded versus sharp incisal edges did not yield a statistically significant association with smile line, though rounded edges were generally favoured—supporting results by Lombardi RE [12], who associated rounded edges with youthfulness and femininity. In contrast, some studies, such as those by Rufenacht CR [20], report a preference for sharper incisal edges in male subjects or among older age groups, suggesting that gender and age may influence incisal edge aesthetic preferences—variables not explored in the current study.

The present study findings regarding the parallel smile arc as the most preferred, regardless of smile line type, align with the study by Machado AW et al., [21], which demonstrated that consonant arcs are perceived as more attractive due to their alignment with the curvature of the lower lip. However, there were also noteworthy minor preferences for straight arcs among those with average smile lines, indicating the need for individualised smile design rather than a universal template.

Emerging evidence highlights the expanding role of artificial intelligence in aesthetic smile evaluation. Buduru S et al., demonstrated that perceptions of smile design varied between laypeople and dental professionals when assessed through an AI-based platform. This indicates that training background can shape aesthetic judgments [22]. In another study, Kaushik K et al., compared AI-generated smiles with conventionally designed ones and found that AI improved uniformity, often resulting in preferences among participants [1]. Macris A et al., emphasised that not all digital smile design systems perform equally; usability differences can influence both workflow and perception of aesthetic outcomes [23]. Collectively, these findings support the authors choice of AI-generated images and highlight the potential of AI to make smile design more consistent, efficient and patient-focused.

Additional factors such as midline alignment, embrasure form, gingival display and the presence of black triangles can significantly

influence how a smile is judged by both professionals and laypersons. Even subtle midline deviations may alter facial symmetry and harmony, affecting overall aesthetic perception. Similarly, the shape and size of incisal embrasures contribute to the natural appearance of anterior teeth, while improper embrasure design may result in an artificial or disharmonious smile.

Gingival display, often described as the "smile line of the gums," plays a crucial role in defining aesthetic balance. Excessive gingival exposure (gummy smile) or inadequate display can lead to negative perceptions. The presence of black triangles, resulting from papillary loss or improper tooth proportions, is another factor that can draw attention and diminish smile attractiveness [24].

Incorporating these parameters into AI-generated images in future studies could provide a more realistic and holistic representation of smile aesthetics. This would not only allow for a more comprehensive assessment of aesthetic preferences but also strengthen dental education by training students to recognise a broader range of aesthetic variables, thus enhancing their diagnostic accuracy and treatment planning capabilities.

Limitation(s)

While the present study adds valuable insight into smile aesthetic perceptions among dental students, some limitations must be acknowledged. The use of digitally created images, while standardised, may not fully replicate real-life dynamic smiles. Furthermore, the convenience sampling and focus on a student population limit the generalisability to the wider public or clinical population.

CONCLUSION(S)

The study effectively captured dental students' aesthetic perceptions using a structured, image-based questionnaire delivered through a digital platform. This approach proved to be efficient, economical and accessible. The results provide a foundational understanding of preferred smile characteristics, which can inform future research and contribute to the refinement of aesthetic guidelines in dental practice and smile design. Understanding dental students' preferences in smile design parameters—such as incisor shape, incisal edge form, anterior tooth proportions, smile arc and smile line—offers valuable input for aesthetic treatment planning. These insights can guide clinicians in delivering restorations that align with both professional standards and patient expectations. Incorporating such preferences into clinical practice may enhance aesthetic outcomes and overall satisfaction in dental treatments.

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