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Exploring the Role of Digital Dental Previsualization within the context of Rehabilitation Dentistry

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Abstract: As part of creating a beautiful smile, aesthetic dental rehabilitation plays an important role. Regarding aesthetic analy-sis in the context of oral rehabilitation and treatment predictability, Digital Smile Design (DSD), mainly through plat-forms like SmileCloud®, provides invaluable resources. Our prospective study aimed to examine the relationship be-tween the clinical experience of dental practitioners and their proficiency in using DSD (SmileCloud). Additionally, the study assessed the association between previsualization scores and the category of respondents in terms of their connec-tion to the field of dentistry (laypeople, dental students, and dentists). The study included 11 subjects for whom three different dental practitioners (a 2nd and a 6th-year dental student and a 2nd-year resident doctor in Prosthodontics) created a DSD using SmileCloud. The DSDs were evaluated in an online survey regarding tooth colour, shape, and over-all smile appearance. A number of 220 responses have been collected from 48 dentists, 86 dental students and 86 lay-people. The DSD created by the 2nd year resident doctor in Prosthodontics has received significantly higher scores for tooth shape and overall smile appearance ($p<0.05$), as well as for the design ($p<0.05$) and design*respondent ($p<0.05$) variables. The practitioner's clinical experience considerably impacted aesthetic dental rehabilitation tools, which means there is always a learning curve involved.

Keywords: dental rehabilitation, digital previsualization, DSD, aesthetic dentistry, SmileCloud software, digital dentistry, dentofacial harmony

Introduction

The desire to achieve a perfect and predictable aesthetic result has brought considerable improvements in creating a digital smile in the last two decades. Before the appearance of photo editing programs, the design of the future restoration was drawn by hand on the patient's photos as a means of communicating with the patient and previewing the final result. In 2017, Coachman divided the evolution of smile design into six generations, starting from the 1st generation, in which the analog design made on photographs had no connection with the analog model, continuing with the 3rd generation, which represented the beginning of the analog-digital connection and reaching present in the 6th generation, in which the 4D concept was introduced, which allows adding movement to the smile design [1].

The focus of aesthetic dentistry is the pleasant appearance of the smile [2]. The balanced interaction between smile components, the harmony between tooth display and lips at rest and during a smile, and the harmonious integration of the smile into the face structure determines one's ability to develop a pleasant smile [3]. Therefore, an aesthetic smile requires the perfect harmony of the constitutive elements of the dental, dentofacial and facial structures [4]. Clinical professionals face the challenge of

balancing aesthetics and functionality in an oral rehabilitation [5]. Digital smile design (DSD), photo editing programs or presentation software are practical tools used to improve aesthetic analysis and diagnosis, they simplify communication and interaction with the patient, dental technician, or other team members, and consequently improve the predictability of treatment [6]. The concept of SmileCloud allows the practitioner and the patient to preview different smiles based on realistic images due to artificial intelligence based platform [7]. SmileCloud is a DSD program co-founded by Dr. Florin Cofar in March 2019. Since then, SmileCloud has become a relevant platform, creating a collaborative environment for dentistry professionals, who can now communicate and design smiles by elaborating a structured case-based treatment plan using biometric tooth libraries with photo-realistic images [8].

The dental rehabilitation field now offers various Digital Smile Design (DSD) software options. These tools aim to facilitate optimal results by considering various factors, such as cost, clinical expertise, time investment, preview precision, and user-friendly platform interface [9]. Modern methods of smile previsualization are accessible to dentists worldwide, who do not need special training, but only the practice required during the learning curve [10].

Our study aimed to assess the correlation between the clinical experience of the dental practitioners (a 2nd and a 6th-year dental student and a 2nd-year resident doctor in Prosthodontics) and their proficiency in using digital previsualization software (SmileCloud) by conducting an online survey. Three categories of respondents filled out an online evaluation form, different in terms of their connection to dentistry (laypeople, dental students, and dentists).

Additionally, the study evaluated the relationship between previsualization scores and the category of respondents in terms of their connection to the field of dentistry (laypeople, dental students, and dentists). The second and third aims of our study were to determine whether there was a statistically significant correlation between the respondents' connection to dentistry (laypeople, dental students, and dentists) and design scores and between the dentists' experience (years of practice and experience level) or students' year of study and their perception of the design. The fourth goal of the current study was to assess how often dental students, dentists, and laypeople use or heard about digital preview software.

2. Results

Out of the 220 respondents to the online survey, 48 were dentists (22%), 86 dental students (39%), and 86 people who did not fit into any of the categories above—a category labelled as laypeople (39%). There were four age categories, as follows: 64% aged between 18-25, 16% aged between 26-35, 13% aged between 36-50, and 7% over 50 years of age. By gender, 78% of the respondents were females, and 22% were males. As for the dental students' year of study, the majority were in the 6th year (24%), followed by an approximately equal percentage of students in other years of study (14% in the 1st year, 12% in the 2nd year, 18% in the 3rd year, 16% in the 4th year, and 16% in the 5th year). The dentists were categorized according to their primary area of interest (Prosthodontics, Endodontics, Oral Surgery, Periodontics, Pedodontics, Orthodontics, and General Dentistry) as well as according to the years of clinical experience (less than three years, between three and six years, more than six years). Prosthodontics, Endodontics, Oral Surgery, and General Dentistry were the main areas of activity, each representing 16%, followed by a smaller percentage of 12% for each of the following specialities: Periodontics, Pedodontics, and Orthodontics. Out of 48 dentists, an equal number of 14 dentists had clinical experience between three and six years and over six years, respectively, and 11 dentists had less than three years of experience.

A total of 219 respondents believed that a smile was an important self-esteem booster, while only one answered that it was irrelevant. 68% of the respondents (68

laypeople, 46 dental students, and 5 dentists) had yet to gain experience with or knowledge of digital previsualization software.

In terms of tooth colour in digital previsualization, design A, created by a second-year dental student, obtained the highest score from 28% of the respondents, while design C, created by a second-year resident doctor in Prosthodontics, received the highest score from 18% of the respondents, regardless of the latter's connection or lack of connection to the field of dentistry (laypeople, dental students, and dentists).

	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
Dentists						
Image A	33	45	119	118	90	123
Image B	18	110	160	114	79	47
Image C	15	45	119	137	116	96
Students						
Image A	24	70	155	198	235	264
Image B	30	113	214	252	215	122
Image C	10	50	164	205	282	235
Laypeople						
Image A	56	28	142	227	147	346
Image B	58	195	224	189	147	133
Image C	32	83	170	207	201	253

Table 1. Assessment of tooth color by the three categories of respondents (dentists, dental students, and laypeople)

As for tooth shape, respondents across all categories found that design A, which received the lowest scores of 1 and 2 from 18% of the respondents, was the least pleasing, followed by design B, which received the lowest scores from 16% of the respondents. The highest scores of 5 and 6 were assigned to design C (46%), irrespective of which category in terms of their connection to the field of dentistry. Design C received the highest scores from dentists (54%) and dental students (44%).

	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6
Dentists						
Image A	38	90	137	111	69	83
Image B	14	75	145	120	108	66
Image C	19	60	130	131	110	78
Students						
Image A	71	143	193	202	208	129
Image B	22	79	170	214	273	188
Image C	28	78	173	200	256	211
Laypeople						
Image A	63	76	170	231	163	243
Image B	43	126	205	232	162	178
Image C	38	84	177	219	194	234

Table 2. Assessment of tooth shape by the three categories of respondents (dentists, dental students, and laypeople)

Following the analysis of the overall smile appearance, the dentist respondents gave the highest score to design C (2nd-year resident doctor in Prosthodontics) and the lowest score to design A (2nd-year dental student) as follows: 18% of the dentists gave the highest score to design C by, 16% to design A, and 12% to design B. Design A received the lowest scores of 1 and 2 from 22% of the dentist respondents, followed by design C (15%) and

design B (14%). Design C was the dental students' favourite design, with 24% of them giving it the maximum score of 6, 28% with a score of 5, 22% with a score of 4, and 3% with the lowest score of 1. The average score dental students gave to design C was the highest among 6th-year students (4.63) and the lowest among 5th-year students (3.81). The average score for 1st, 2nd and 3rd-year students was 4.39. Laypeople gave different answers, with design A receiving the highest score, while all designs equally obtained the lowest. 31% gave 6 to design A, 28% to design C, and 21% to design B.

The connection between the respondent's association with the field of dentistry and the experience of the practitioner who created the design in terms of scores obtained for tooth colour are shown in Table 3. The statistically significant value of p<=0.05 was obtained for the design variable (p<0.001). In the other two cases, a statistically significant value was not obtained (p=0.096, namely p=0.104).

Variable	ANOVA (p)
Respondent	0.096 (Huynh – Feldt correction)
Design	<*0.001* (Greenhouse-Geisser correction)
Respondent* Design	0.104 (sphericity respected)

Table 3. Statistical analysis of the difference between teeth color scores according to two variables (respondent: dentist, layperson, student and design: A, B, C)

The line chart (Fig. 1) illustrates how marginal averages are modified by design and respondent. On average, design B obtained lower total scores than design A (6.8) and design C (6.7).

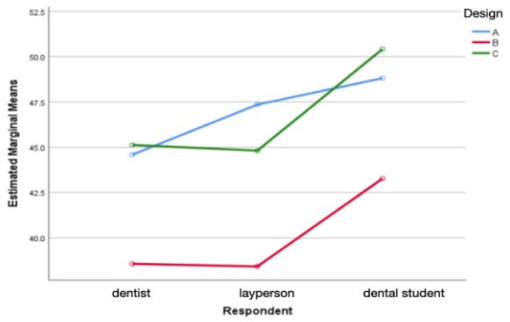

Fig. 1 Modified marginal averages in color assessment

In terms of tooth shape (Table 4), there was a statistically significant difference between the scores obtained according to the experience of the practitioner who created the design (p=*0.001*) and according to respondent*design interaction (p<*0.001*).

Variable	ANOVA (p)
Respondent	0.2 (sphericity respected)
Design	*0.001 (*Huynh – Feldt correction)
Respondent* Design	<*0.001* (Huynh – Feldt correction)

Table 4. Statistical analysis of the difference between the scores obtained for dental shape according to two variables (respondent: dentist, layperson, student and design: A, B, C)

On average, design B received lower scores, with 5.021 from dentists than dental students. The scores obtained by design C were, on average, lower, with 4.646 from dentists than for dental students. On average, design C had 2.6 higher total scores than design A and 1.6 higher than design B (Fig. 2).

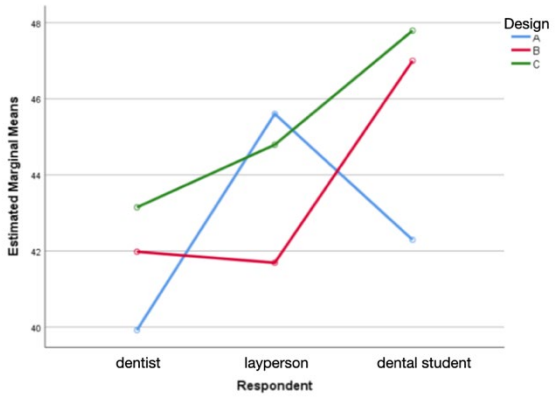

Fig. 2 Modified marginal averages in shape assessment

For the overall smile appearance, statistically significant results were obtained for the design (p=*0.05*) and respondent*design (p<*0.001*) variables (Table 5).

Variable	ANOVA (p)
Respondent	0.144 (sphericity respected)
Design	*0.005* (Huynh – Feldt correction)
Respondent* Design	<*0.001* (sphericity respected)

Table 5. Statistical analysis of the difference between smile scores according to two variables (respondent: dentist, layperson, student and design: A, B, C)

On average, picture C obtained total scores of 2.3 higher than picture A and 1.6 higher than picture B (Fig. 3).

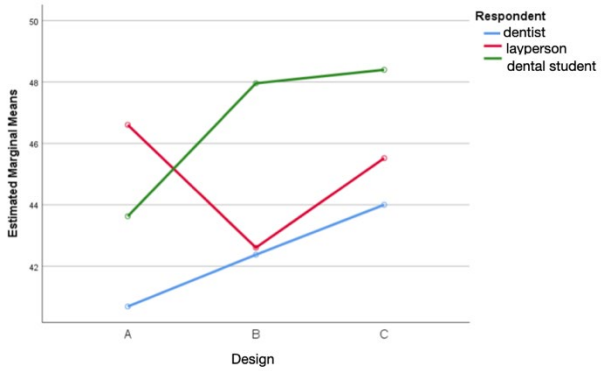

Fig. 3 Modified marginal averages in overall smile assessment

Table 6 shows the results of the statistical analysis conducted to evaluate the influence of the respondents' experience (in the case of dentist respondents) and the experience of the practitioner who created the design on the assessment of the overall smile appearance. Neither variable had a statistically significant result ($p>0.05$).

Variable	ANOVA (p)
Responder's experience	0.382 (sphericity respected)
Design	0.204 (sphericity respected)
Responder's experience * Design	0.846 (sphericity respected)

Table 6. Statistical analysis of the difference in smile scores according to two variables (the experience of the dentist as respondent and design: A, B, C)

The results of the statistical analysis conducted to assess the impact of the respondents' experience (in the case of dental student respondents) and the experience of the practitioner who created the design in scoring the overall smile appearance are shown in Table 7. Statistically significant results were obtained for the design variable ($p<0.001$).

Variable	ANOVA (p)
Students' year of study	0.679 (sphericity respected)
Design	<*0.001* (sphericity respected)
Students' year of study * Design	0.963 (sphericity respected)

Table 7. Statistical analysis of the difference between the scores obtained for smile according to two variables (students' year of study, respectively design: A, B, C).

3. Discussion

The results of our study emphasize how aesthetic dental rehabilitation is essential to achieving a beautiful smile. Digital Smile Design (DSD), especially with the SmileCloud® application, became a valuable tool from the oral and dental rehabilitation perspective, providing essential resources for treatment predictability and aesthetic analysis. Our results highlighted how crucial clinical experience is to dental professionals' ability to use DSD technologies effectively. Furthermore, we identified robust findings regarding the relationship between previsualization scores and the experience of the practitioner in the dental area. Notably, the exceptional results of the DSD developed by a prosthodontics resident physician in his second year highlighted the significance of competence in attaining the best possible results regarding tooth shape, overall smile appearance, and design elements. These results highlight the need for ongoing education and skill-building to properly use cosmetic dental rehabilitation methods.

In the present study, 78% of the respondents were women, which could be explained by the fact that they place greater value on appearance in general and on smiles and aesthetics in particular.

In the professional category, 39% were dental students, 39% laypeople, and 22% dentists. The lower number of dentist respondents could be explained by the fact that dentists are generally less available online.

Regarding the colour of the aesthetic dental rehabilitation, design A (2nd-year dental student) obtained the highest score from 28% of the respondents. In comparison, design C (2nd-year resident doctor in Prosthodontics) received the highest score from 18% of the respondents, irrespective of their connection to the dentistry field (laypeople, dental students, and dentists). The relationship between the respondent's connection to the field of dentistry and the experience of the practitioner who created the design in terms of scores obtained for tooth colour was revealed by the statistically significant value of the design variable ($p<0.001$). Design A received the highest ratings from respondents in all three categories, with design C ranking second. The two dental professionals, the 2nd year dental student and the 2nd year resident doctor in Prosthodontics, had quite different clinical experience and expertise.

Several studies in the field reached opposite conclusions [11, 12], demonstrating that tooth colour was perceived differently by dental specialists and laypersons. A particular study [13] revealed that non-professionals tended to have more difficulty noticing chromatic differences and being attracted to lighter colours. Other studies supported our assumption that there were no differences in colour perception according to the profession but instead according to the aesthetic, artistic sense, and subjectivity of the observer and the practitioner [14].

In terms of tooth shape, the highest scores of 5 and 6 were given to design C regardless of the respondents' connection to the dentistry field. Design C received the highest scores from dentists, followed by dental students. Design C had 2.6 higher scores than design A and 1.6 higher than design B on average. Dentists and dental students agreed on the scores assigned according to the experience level of the practitioner who created the design (design A<design B<design C). Design C (created by the 2nd year resident doctor in Prosthodontics) was the most appreciated. As for the relationship between the respondent's connection to the field of dentistry and the experience of the practitioner who created the design in terms of scores obtained for tooth shape, both the design and the design*respondent variables yielded statistically significant results, emphasizing the importance of the practitioner's experience in creating an adequate design in terms of tooth shape.

According to Gürel *et al*. [15], there are available systems (e.g., Rebel System) that can assist and guide the unexperienced dental team in using artificial intelligence to design a personalised smile design for every individual. This kind of software can provide real-time assistance and corrections for less experienced designers and may improve the learning curve.

Regarding the overall smile appearance, a statistically significant preference for design C was noticed among dentists and dental students (a score of 6 from 18% of the dentists and 24% of the dental students). In comparison, laypeople (31%) gave design A a maximum possible score of 6, followed by design C (28%) and design B (21%). The level of experience of the practitioner who created the design (design A<design B<design C) was acknowledged by both dentists and dental students. However, laypeople disagreed on ranking design A above design C. The explanation for laypeople giving design A the highest score when assessing the overall smile appearance could lie in their preference for colour. The relationship between the respondent's connection to the field of dentistry and the experience of the practitioner who created the design in terms of scores obtained for overall smile appearance was reflected in the statistically significant results obtained for both design and design*respondent variables, highlighting the importance of the practitioner's experience in designing a pleasant overall smile appearance. Several studies showed

that teeth shade was the most crucial evaluation factor in dental aesthetics assessment [16, 17].

Another aim of our study was to determine whether the perception of the overall smile appearance was influenced by the respondents' experience (in the case of dentists) and the experience of the practitioner who created the design. Neither the dentists' experience nor the design or interaction of the two variables impacted scores ($p>0.05$). The dentists evaluated all three designs similarly, irrespective of their years of experience in practice or speciality. The explanation could lie in the fact that dental care professionals had most likely received equally good training in dental aesthetics regardless of their speciality or level of clinical experience because there is a close relationship between soft and hard tissue aesthetics in every dental procedure [18].

A third goal of the present study was to assess the connection between the responders' experience (in the case of dental students) and the experience of the practitioner who created the design on the perception of the overall smile appearance. The only statistically significant variable was design ($p<0.05$). Scores were different only concerning the practitioner who created the design; neither the year of study variable nor the interaction of the two variables had any statistically significant relevance in evaluating the design. Several studies in the field of literature [19] found a significant difference in the perception of dental aesthetics according to the year of study, with perception considerably improving with clinical years of training. However, the results of the present study contradicted the assumption. One possible reason could be the absence of clinical practice for the 5th and 6th-year students during the pandemic, favouring the acquisition of new, chiefly digital skills, which levelled the distinction between clinical and preclinical years.

A fourth aim of the present work was to assess the frequency of digital aesthetic dental rehabilitation methods among students, clinicians, and laypeople. Only a small number of clinicians used such programs regularly, one reason being most likely their preference for conventional methods.

Partial or complete digital aesthetic dental rehabilitation is still a novelty in dentistry, so adaptability, skills, and willingness to adopt such methods are key factors in determining clinicians' choices. Research in the field [20,21] shows similarities between traditional and digital methods, suggesting that the best option is to use both methods concurrently because the advantages and disadvantages of each approach are not enough to tip the scales in favour of either. DSD uses photographic information to create aesthetic previsualization; the intra-oral mock-up is a validation procedure for the final restorations. The combination of DSD and mock-up for diagnosis and treatment planning has positive results in the aesthetic rehabilitation of the anterior teeth. These techniques provide predictable and highly satisfactory results [22,23].

Utilizing digital images of patients for DSD in dentistry raises several ethical considerations, particularly regarding privacy, data protection, and informed consent.

1. Privacy: Patients' digital images, especially those involving intraoral and extraoral photos, cone beam computed tomography (CBCT), and facial and intraoral scanning, contain sensitive personal information. These images may reveal dental conditions, facial features, and structures. Ensuring the privacy of such data is crucial to prevent unauthorized access that could lead to identity theft or other privacy violations.

2. Data Protection: Using digital images in DSD requires robust data protection measures to safeguard against unauthorized access. This includes implementing secure storage systems and encryption protocols to ensure compliance with data protection regulations such as GDPR (The General Data Protection Regulation). SmileCloud'sData Processing Agreement (DPA) in compliance with GDPR is essential in this regard, as it outlines the responsibilities of both the data controller (SmileCloud) and data processor (dentist) in handling patient data securely.

3. Informed Consent: Informed consent is fundamental in ethical dental practice. Patients must be fully informed about the purpose of collecting their digital

images, how they were will be used in DSD, who will access them, and any potential risks or benefits involved. Additionally, patients should have the right to refuse or withdraw consent at any time without facing any repercussions. Obtaining informed consent ensures that patients have autonomy over their data and understand the implications of its use in DSD.

In summary, ethical considerations are crucial in using digital images of patients for DSD in dentistry. Upholding privacy principles, data protection, and informed consent are essential to ensure patient autonomy and trust. Balancing the potential benefits of DSD with the risks to patient privacy and data security is crucial to practicing beneficence and non-maleficence. By integrating these ethical considerations into digital dentistry research and clinical practice, dentists can promote patient well-being while advancing the field responsibly.

Our study also revealed that a considerable percentage of laypeople were not familiar with the term digital smile design, which could be explained by the fact that neither the dentists enrolled in the study were familiar with digital aesthetic dental rehabilitation.

The present study's limitations consisted of the variations occurring during design, which influenced the respondents' aesthetics evaluation. Another important aspect was the practitioner's subjective perspective on the patient's individual characteristics, which could have also been influenced by the suggestions automatically generated by the artificial intelligence of the Smile Cloud software. At the same time, because the study included a small number of subjects of similar age, it would be recommendable to expand the research by using subjects with more diverse dental characteristics and ages. Another limitation was the number of respondents, who, on the one hand, had similar socio-demographic characteristics (similar age, background, female predominance) and, on the other, were divided into unequal groups (dentists, dental students, and laypeople). Further research on a more extensive and diverse sample of people would be recommended to validate and generalize these results. Based on our findings, future research could evaluate the perception of the patients over the enhancing of their smile using DSD (Smile Cloud) and it would be interesting to make a comparison of these results with other DSD technologies. An in vivo study could also highlight the long-term stability of the results and the impact on patients.

The main advantage of DSD is represented by the possibility of visualizing the final result before starting the treatment. The patient can have an image of the final appearance and can express his opinion on the shape, color and arrangement of the teeth, and this leads to an increase in his satisfaction. Also, using DSD increases the patients' motivation and highlights the benefits of the treatment.DSD also facilitates interdisciplinary communication with the dental laboratory throughout the treatment. The data from the literature emphasized the fact that the digital design of the smile brings a plus to dental medicine, offering predictable results, good doctor-patient communication, as well as aesthetic and functional restorations, also constituting a medico-legal document [1].

Several digital smile design programs are used in dentistry. Eight different programs were compared regarding their ability to evaluate dental, dentofacial, and facial parameters. The best results were obtained by Photoshop CS6 and Keynote, even if these programs are not specific to dentistry. Most programs created specifically for dental practice focus mainly on dental and dentofacial aesthetics, with facial aesthetics omitted. One of the programs evaluated in the study (Visagismile) considers the patient's personality, while the program analyzed by us (Smile Cloud) does not have this function. However, Smile Cloud is a unique design program due to the fact that it uses dental libraries of natural teeth, scanned and imported into the application [24].

The advantages of using DSD software such as the SmileCloudplatform are that it enables active patient participation in treatment planning, leading to higher compliance and motivation. Patients can visualize expected outcomes through

previsualization and simulation. Customizable changes allow treatment modifications according to patient desires. Even more, SmileCloud uses natural tooth libraries, which makes it unique and realistic to give the patient a better understanding of the process. However, the initial setup costs for DSD could be considerable, and rigorous training is required to operate DSD effectively, increasing the learning curve. Despite software predictions, patients may disagree with treatment outcomes, leading to potential dissatisfaction. Intellectual property protection is crucial, securing the storage of original images to prevent unauthorized reproduction.

To the best of our knowledge, the novelty of our study lies in the fact that the digital smile design has been created by three practitioners with different backgrounds and clinical experiences and then assessed from three distinct perspectives (dentists, dental students, and laypeople). The three perceptions were compared within the context of aesthetic dental rehabilitation, under the circumstances where the project could not be approved and accepted until the dentist's vision had met the patient's perspective on the smile's color, shape, and overall appearance.

4. Materials and Methods

Eleven subjects with dental aesthetics issues were recruited in the current prospective study to create a digital smile design for each participant. The inclusion criteria were as follows: individuals between 18 and 25 years of age, regardless of gender, with intact dental arches but with dental aesthetics concerns (unpleasant tooth colour or shape, minor teeth crowding, inverted incisal line or different dental axes) belonging to all three skeletal classes. They also had to express their willingness to be included in the study and sign an informed consent to use their photographs. Subjects who did not meet the age criteria, those who refused to provide consent and those with facial changes due to dental fractures, orthodontic treatment, prosthetic rehabilitations, orthognathic surgery, facial paralysis, plastic surgery, facial asymmetry, tumour processes, and retractile scars were excluded. The patients included in the study were selected from among dental students, aged between 18-25, being a category of patients to whom we had access. We selected subjects who presented complete arches, with natural teeth who presented changes in dental aesthetics, which would allow the creation of digital smile design with the resulting effects. We excluded patients with paralysis, asymmetry, or facial scars, with changes in dento-facial and dento-labial aesthetics.

Digital previsualization using Smile Cloud was performed individually for each participant by three practitioners with different clinical experiences: a second-year dental student, a sixth-year dental student, and a second-year resident doctor in Prosthodontics.

In order to create the design, a set of photographs was taken for each participant using the professional DSRL camera and accessories: flash, spreaders and contrastors. Four pictures were taken during the session, two intraoral and two extraoral: resting portrait extraoral photograph (Fig. 4A), smiling portrait extraoral photograph (Fig. 4B), maximum intercuspation intraoral photograph (Fig. 4C) and upper arch intraoral photograph with contrastor (Fig. 4D).

Fig. 4. (A, B, C, D) - Set of photographs taken of each subject

The photos were uploaded to the SmileCloud application. Each practitioner created digital previsualization for each of the eleven subjects by following the same protocol and the sequence of steps constituting the standard work instruction in the DSD program: the smiling portrait extraoral photograph was adjusted with a bi-pupillary line parallel to the horizontal line (Fig. 5), the automatically detected internal outline of the lip was improved for better precision (Fig. 6), the restorative space was defined according to the golden ratio by adjusting smile curvature, zeniths and dental proportions (Fig. 7). Finally, the algorithm generated natural teeth libraries within three categories of teeth shapes (Fig. 8). Libraries in the first category (marked with yellow) matched the restorative space 100%, while libraries in the second and third categories (marked with orange and grey) matched the restorative space 95% and 90%, respectively, with the danger of distorting the shapes. The practitioners were allowed to use teeth only from the yellow category. Moreover, bearing in mind the facial aesthetics and specific characteristics of each participant in the study, the practitioners customized the digital libraries according to their aesthetic sense, clinical experience, and practice, allowing colour and shape, length and width changes of each tooth as well as slight imperfections as long as the golden ratio was respected (Fig. 9).

Fig. 5. Uploading the smiling portrait extraoral photograph

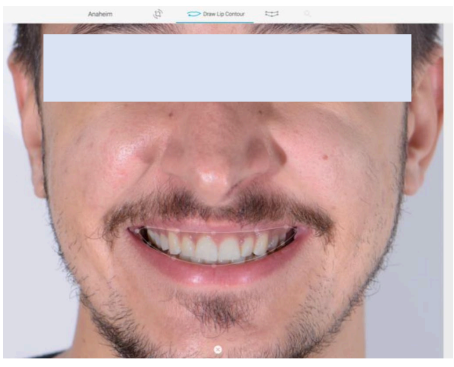

Fig.6. – Detection of the internal lip outline

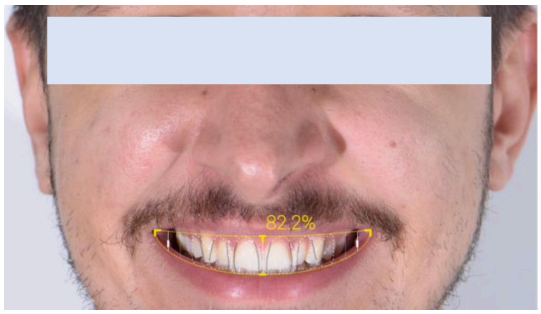

Fig.7. - Adjusting proportions and restorative space.

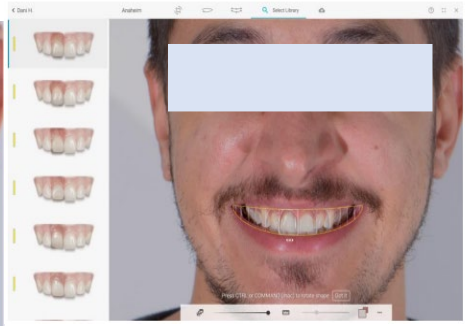

Fig.8 - Choosing teeth features from the virtual library

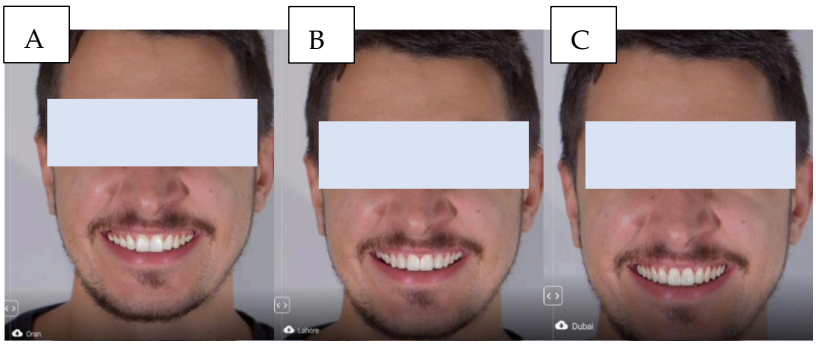

Fig.9 – DSD (digital smile design) created by three practitioners (A- 2nd year dental student, B- 6th year dental student, C- 2nd year resident doctor in Prosthetics)

An online questionnaire was used to collect data for the DSD evaluation. The anonymous online 19-item questionnaire recorded the following data: age, gender, profession (dentists, dental students, laypeople), clinical experience in years and main area of interest in the dentistry field for dentists, year of study for dentistry students, frequency of use and familiarity with the DSD as well as how important smile was in the assessment of self-esteem. Questions 11-19 rated designs A, B and C (design A was created by the 2nd-year dental student, design B by the 6th-year dental student, and design C by the 2nd-year resident doctor in Prosthodontics), shown side by side in college images, awarding scores on a scale of 1 to 6, with 1 being the lowest and 6 the highest possible score. The parameters analyzed were tooth color, shape, and overall smile appearance for designs A, B, and C. The third parameter, the overall smile appearance depending on the harmony of dento-labial structure and facial aesthetics, was comprehensively evaluated from the perspective of respondent category (dentists, dental students, and laypeople), specialization and clinical experience of dentist respondents, and study year of dental students.

The two-way repeated measures ANOVA test was used to see the combined influence of the connection with the field of dental medicine of the respondents and the experience of the practitioner who made the design. Thus, there was a continuous quantitative dependent variable (score sum) and two nominal qualitative independent variables (the relation of the respondent with dental medicine and the practitioner's experience) - two way. The same subject gave three scores, the observations were not independent (repeated measures). This test needed the presence of the normal distribution of the groups, which was verified with the Shapiro Wilk test, and the presence of sphericity, verified with the Mauchly test.

Excel and IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY: IBM Corp) were used to perform a quantitative, percentage and statistical analysis of the data yielded by the three different DSD assessments. The Shapiro-Wilk test was used to check whether the continuous quantitative variables followed a normal distribution.

The Mauchly test was used to assess the validity of the sphericity assumption when performing repeated measure tests. In case of failure to comply with the sphericity condition, Greenhouse-Geisser and Huynh-Feldt corrections for p were created. A two-way repeated measures ANOVA was created, with post-hoc t-Student test to which Bonferroni corrections were applied. Partial eta squared (<0.01-negligible power; 0.01 - 0.06-low power; 0.06 - 0.14-moderate power; >0.14-high power) was used to test effect size in the ANOVA. Results were considered statistically significant for p-values <0.05.

A two-way repeated measures ANOVA test was used to assess the role played by the respondent's connection to the field of dentistry and the experience of the practitioner who created the design in terms of scores obtained for teeth colour and shape, namely overall smile. It was necessary to eliminate 38 respondents from the laypeople and dental students in order to have an equal number of respondents in each group. Accordingly, there were 48 respondents in each group. Statistically, the number was large enough for significant correlations (a minimum number of 15 in each group). Consequently, the total number was reduced from 220 to 144 respondents.

A two-way repeated-measures ANOVA test was used to determine the presence of a statistically significant difference between the scores obtained according to two variables, namely respondent (dentist, layperson, dental student) and design (A, B, C); the respondent*design variable was also tested. The null hypothesis for each variable was that there was no statistically significant difference between scores according to respondent, design, and respondent*design.

A two-way repeated measures ANOVA test was used to evaluate the impact of the relationship between the respondents' experience (only in the case of dentist and dental student respondents) and the experience of the practitioner who created the design. For that particular instance, only the smile's overall appearance was assessed. The null hypothesis was that there was no statistically significant difference between the scores of the three designs according to the dentist's experience or the student's year of study as responders and the experience of the practitioner who created the design.

5. Conclusions

A smile can be interpreted differently depending on the viewer's subjectivity. The present study emphasizes once more how important tooth colour and shape are in smile perception, an opinion held not only by patients or laypeople but also by dentists and dental students.

The practitioner's experience significantly influences the results in creating a DSD. The respondent's affiliation with the dental profession does not play any role in his assessment of smile color, shape, or overall appearance.

The importance of the practitioner's experience is emphasized by a strong relationship between the aesthetics of the digital dental rehabilitation and the vision of the practitioner who created it. This calls for constant learning curve improvement in order to achieve expertise in aesthetic dentistry, even within the context of intelligence-based digital smile design.

Because of the subjective nature of smile perception, the role of the practitioner's experience, and the influence of various factors on aesthetic evaluations, further research is required for a deeper understanding of aesthetic dental rehabilitation and its impact on smile perception.

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