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Review Article

Revolutionizing cosmetic dentistry through digital smile design: A narrative review

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ABSTRACT

Objective: Esthetic considerations have become central to modern dentistry, with smile design playing a pivotal role in enhancing facial appearance and self-esteem. Traditional techniques, while effective, often fall short in delivering personalized and highly accurate results. This narrative review explores the advent and evolution of digital smile design (DSD), focusing on its role in enhancing esthetic outcomes through technology-driven customization. The review aims to assess the clinical efficacy of various DSD software platforms and their impact on both clinicians and patients.

Methods: A comprehensive literature review was conducted across databases including PubMed, Medline, Embase, and Google Scholar. Relevant studies published between 2013 and 2024 were selected based on their focus on DSD parameters, esthetic analysis, and clinical applications. Emphasis was placed on human studies published in English.

Results: DSD integrates digital photography, intraoral scanning, three-dimensional modeling, and computer-aided design/computer-aided manufacturing systems to streamline esthetic dental planning. Software platforms such as Photoshop, Keynote, esthetic DSD, and Smile Designer Pro offer varying levels of esthetic and functional analysis. While these tools enhance visualization, communication, and treatment planning, they also present limitations related to dynamic assessment, cost, and functional specificity.

Conclusion: DSD represents a paradigm shift in cosmetic dentistry, offering greater precision and patient involvement. However, its limitations highlight the need for clinician expertise, careful patient education, and ongoing development to integrate both esthetic and functional components in smile rehabilitation.

Keywords: Dentistry, Esthetics, Imaging, Software, Technology

INTRODUCTION

Dental professionals and technicians consistently strive to enhance the connection between the patient's facial structure and the working model. This improvement enables technicians to create esthetically pleasing designs that necessitate fewer intraoral adjustments.

Digital smile design (DSD) is founded on the principles of facial analysis and esthetic dentistry.[1] DSD employs digital technologies, including three-dimensional (3D) imaging, computer-aided design (CAD), and augmented reality (AR), to create precise and consistent treatment plans.[2,3] A fundamental technology utilized in DSD is digital photography and videography. High-resolution images and videos capturing the patient's face and smile are obtained from various perspectives. This visual information serves as the foundation for the digital design process,

Table 1: Evolution of smile design.[10]

Generation	Details
1st	Smile design began with analogue hand drawings directly over printed photographs, offering a rudimentary, time-consuming visualisation of outcomes without any link to mock-ups or digital workflow.
2nd	The advent of digital tools like PowerPoint enabled basic 2D digital drawings, which, while aesthetically relevant to study models, lacked depth, specificity, and true correlation with mock-ups.
3rd	Digital-analogue integration started with the introduction of the first dental-specific DSD software, linking 2D drawings to physical mock-ups and incorporating facial analysis, though still disconnected from full 3D digital modeling.
4th	Digital dentistry evolved to allow 2D smile designs to be digitally connected with 3D mock-ups, enabling more precise aesthetic planning through facially integrated 3D digital models.
5th	This era introduced a fully digital 3D workflow, where all aspects of smile design—from imaging to modeling—were conducted digitally with integrated facial analysis and aesthetic parameters.
6th	The concept of 4D smile design emerged, incorporating dynamic movements like speech and expression into the digital workflow, enabling more realistic and functional aesthetic planning.

allowing dentists to thoroughly analyze the patient's facial dynamics and dental proportions.[4] In addition, intraoral scanners play a crucial role in DSD by producing accurate 3D models of the patient's teeth and gums, thereby eliminating the necessity for traditional dental impressions, which can frequently be uncomfortable and less precise.[5] CAD plays a vital role in DSD by allowing dentists to alter digital representations of a patient's teeth. This technology facilitates adjustments to the shape, size, and positioning of the teeth to attain the desired esthetic outcomes. The process is highly interactive and frequently includes collaboration with the patient to ensure that their preferences and expectations are taken into account.[6] Emerging technologies such as AR and virtual simulation are increasingly becoming significant in DSD. AR enables the creation of real-time virtual overlays of the intended smile design, facilitating visualization of the anticipated results for both the dentist and the patient.[7] Virtual simulations provide comprehensive animations of the treatment process, showcasing the sequential changes that will take place, thereby serving as valuable tools for patient education and facilitating informed consent.[8] The clinical applications of DSD are varied, particularly in procedures such as veneers and crowns, where it assists in crafting restorations that closely resemble the patient's natural teeth in color, shape, and size. The incorporation of DSD has resulted in notable enhancements in treatment outcomes and increased levels of patient satisfaction.[9]

The esthetic features of various DSD software differ; however, the fundamental approach to smile design remains consistent. Table 1 shows the evolution of digital smile design.[10,11] Each program enables users to create a personalized smile by delineating reference lines and structures on both intraoral and extraoral images.[11-13] Once all preliminary tasks have been finalized, a digital ruler is employed to implement the required adjustments. These modifications can be tailored to align with the patient's esthetic desires and individual needs.[14,15] Upon completion of all adjustments, a new smile is presented to the patient. This digital representation can be utilized to create a final model that allows for visual evaluation within the patient's oral cavity. The model facilitates the visualization of gingival structure, lip contours, and facial shape, as well as speech during the try-in phase before any permanent changes being made.[16] This study aims to review the various smile design software, their efficacy, and impact on the clinician and patients.

METHODS

The type of study design followed in this study is a non-experimental study design. A thorough literature review was performed by exploring various electronic databases, including PubMed, Medline, Embase, and Google Scholar. The search employed specific keywords such as "facial esthetics," "esthetic parameters," "smile analysis," "digital smile design," and "smile reconstruction" to gather pertinent articles related to the standardization of esthetic parameters. A total of 32 articles were meticulously chosen based on established inclusion criteria: Publications from 2013 to 2023, studies focusing on parameters for DSD, human studies, and articles published in English. Figure 1 shows the methodology.

RESULTS

From the 32 articles, 6 were excluded due to the unavailability of full text or because they were written in languages other than English. The remaining 26 articles were analyzed to extract the parameters utilized for assessing dentofacial esthetics and to enable a comparison of different DSD

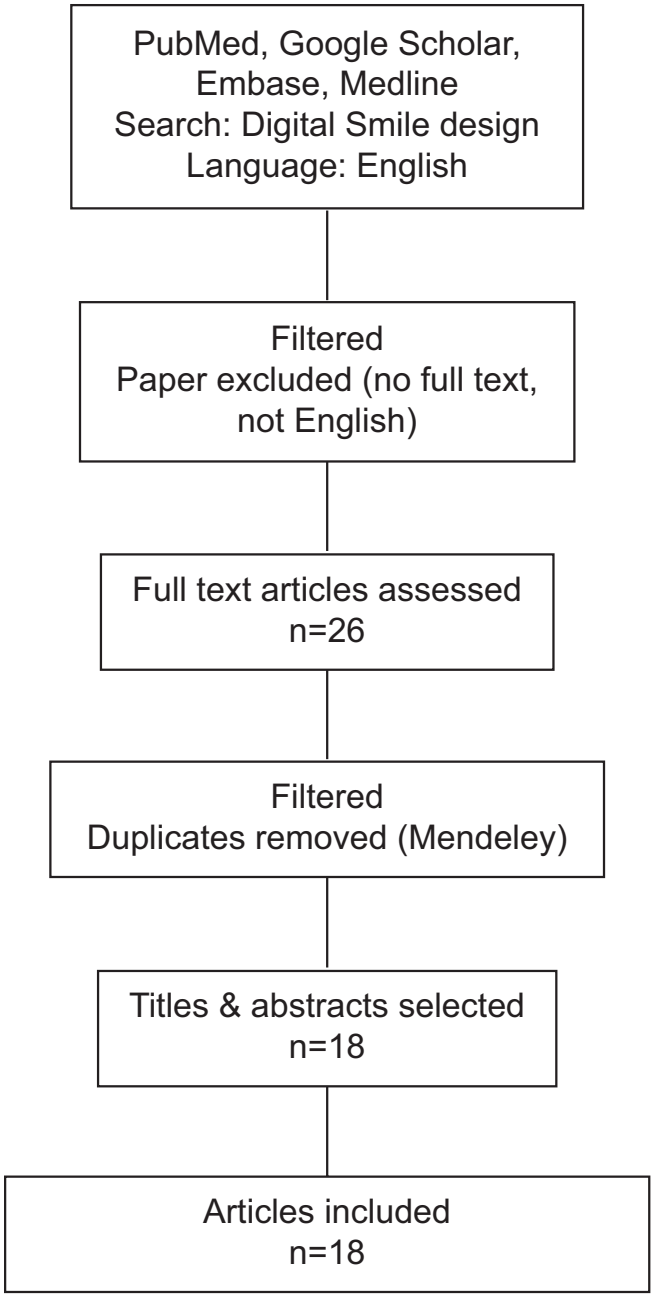

Figure 1: Methodology.

programs. For each program included in the analysis, additional articles were sourced using keywords such as "digital smile design," "DSS," "Exocad," "Photoshop," "Keynote," "Smile Designer Pro," and "esthetic digital smile design." After applying the specified inclusion criteria, 26 articles were selected: Those published between 2013 and 2024, clinical studies employing DSD programs, human studies, and articles in English. The Mendeley software was utilized to remove duplicate entries. In the end, 18 articles were incorporated into the final review. Comparing the efficiencies of different software, Omar and Duarte graded the DSD software. Photoshop achieved a perfect score of 20 out of 20, while Keynote received a score of 19 out of 20. The aesthetic DSD (ADSD) program received a score of 18 out of 20. Cerec SW 4.2, got 13 out of 20. The DSD App, SDP, and VisagiSMile programs received comparable scores, each achieving 10 out of 20.

DISCUSSION

A study conducted by Omar D and Duarte C that analyzed eight different DSD software programs, namely Photoshop CS6, Keynote, Planmeca Romexis Smile Design, Cerec SW 4.2, ÀDSD, Smile Designer Pro, DSD App, and VisagiSMile.[28] The analysis was conducted using more than 25 parameters; however, the scoring was based on 20 of these parameters. Table 2 presents 12 parameters related to facial analysis, three parameters concerning dentogingival analysis, five parameters associated with dental analysis, and five additional parameters selected from the reviewed literature.[17-27] Although the application was not specifically intended for dental purposes, it has been observed that Keynote and Photoshop CS6 offer a more extensive smile design capability compared to other professional DSD programs.[20]

Omar D and Duarte C reported that Photoshop achieved a perfect score of 20 out of 20, while Keynote received a score of 19 out of 20.[27] Photoshop possesses the ability to meet all the criteria associated with facial, dentogingival, and dental analysis.[28-30] Keynote, similar to Photoshop, has the capability to analyze a range of parameters; however, it does not possess the functionality to alter and create complex ideal modifications to the tooth structure.[31] Both Keynote and Photoshop are photo editing applications and are not specifically designed for dental purposes. They are not compatible with mobile devices and cannot be utilized in conjunction with (CAD/computer-aided manufacturing [CAM]) CAD/CAM systems. In addition, these programs were not created for patient documentation or dental applications, necessitating specialized training for effective operation. In a similar vein, the ADSD program received a score of 18 out of 20; however, it offers a limited range of facial analysis parameters.[32,33] The software has been specifically created for DSD, with a workflow tailored for dental applications. It is not compatible with CAD/CAM systems. The software can be operated effectively with minimal technical skills. Nevertheless, its functionalities are limited to those that are currently available within the software.[29] Planmeca Romexis Smile Design is a DSD software that facilitates the simulation of smiles, treatment planning, and effective communication. It is compatible with both Mac and Windows operating systems and operates independently without the need for additional software. The user-friendly interface allows for quick and efficient usage.

Table 2: Parameters of analysis.

Facial parameters	Dentogingival parameters	Dental parameter	Additional parameters
Facial midline, smile cant, lower midline, interpupillary line, dental midline shift, horizontal sections, vertical sections, profile angle, E-plane, H-plane, nasolabial angle, intercommissural line	Lower lipline, buccal corridor, and gingival line	Occlusal plane/incisal curve, teeth size, teeth structural changes, teeth characterization, teeth color	Teeth grids, 3D design, CAD/CAM, Patient interface, Mobile app

CAD/CAM: Computer-aided design/computer-aided manufacturing

Creating a smile design using a two-dimensional (2D) facial image and precise tooth selection can be accomplished in just a few minutes. The program provides the operator with the ability to meticulously adjust the position, shape, and size of each tooth to achieve optimal proportions and esthetic appeal.[31]

Cerec SW 4.2, got 13 out of 20.[34,35] This software does not demonstrate the same level of efficiency as the previously mentioned software in the analysis of facial and dentogingival parameters. It includes a limited number of frontal facial parameters and facial profile parameters. While this software is compatible with CAD/CAM systems, it is not designed for mobile application use. Furthermore, the DSD App, SDP, and VisagiSMile programs received comparable scores, each achieving 10 out of 20.[36-38] The analysis of facial components, commonly utilized for image calibration in these systems, revealed the most notable drawbacks of these programs. They lacked parameters for both frontal facial features and facial profile characteristics. In addition, some of these programs struggled to modify subtle natural traits, leading to a less authentic digital representation of the smile. In 2017, the DSD application aimed to address these limitations by incorporating comprehensive frontal and facial profile analysis, along with an extension for orofacial surgical simulation.[27,38] Photoshop, Keynote, and ADSD offer a more extensive range of esthetic analysis parameters. In contrast, other DSD software provides fewer esthetic analysis parameters but includes thorough dentogingival and dental esthetic functionalities. The PRSD, Cerec SW 4.2, and DSD App all facilitate 3D processing. In addition, both Cerec SW 4.2 and PRSD are compatible with CAD/CAM systems. Furthermore, both Smile Designer Pro and the DSD App can function as mobile applications.[27] In 2017, Santos *et al*. conducted a periodontal surgery aimed at addressing a gummy smile, utilizing DSD techniques. The outcomes of the procedure were outstanding, leading to a high level of satisfaction from the patient. The author noted that DSD application significantly facilitates the demonstration of treatment results to patients.[39] Garcia *et al*. published a study in 2018 that detailed a maxillary anterior rehabilitation utilizing the DSD system alongside a direct model technique. The findings indicated that the integration of DSD with a mock-up for diagnostic and treatment planning produced favorable outcomes in the esthetic restoration of the anterior teeth.[40] In 2018, Stanley *et al*. carried out a case study that involved the application of DSD software alongside CAD/CAM technology to create monolithic lithium disilicate ceramic veneers and crowns. This approach aimed to address issues related to vertical dimension loss, enhance esthetics, and manage temporo-mandibular joint disorders, all while employing a minimal tooth preparation technique.[41]

DSD software offers lots of advantages; it facilitates patients in visualizing anticipated results before undergoing treatment. The operator can inspire and inform the patient by digitally presenting the final outcome before any irreversible procedures are performed. Both clinicians and patients can digitally visualize and assess gingival, dental, and facial features, aiding in the determination of the final smile and overall facial esthetics. This approach enhances the personalization of smile design by actively involving patients in the design process. Before the commencement of treatment, it is feasible to compare pre-treatment and post-treatment images using a digital scale along with horizontal and vertical reference lines. Furthermore, DSD enhances communication among patients, clinicians, and other team members, including laboratory technicians.

Having talked about the advantages of DSD software, let's shed some light on its limitations. The assessment and subsequent planning rely solely on photographs and videos; any discrepancies in documentation may lead to a distortion of the reference image, consequently resulting in inaccurate diagnosis and treatment planning. The treatment utilizing DSD is costly, as it necessitates comprehensive 3D digital work, which includes updated 3D software, CAD/CAM software, an intraoral scanner, and a 3D printer. In addition, certain software programs require specialized training for operation, which further increases both the expense and the time involved. Even though DSD uses facial analysis and golden proportions, esthetic perception varies between patients and clinicians what looks ideal digitally may not always translate well intraorally. Most DSD tools cannot accurately simulate dynamic movements such as smiling, talking, or lip mobility. Soft tissue behavior (gingival display

and lip support) is not realistically visualized. There is a risk of patients expecting the exact outcome shown in the simulation. Discrepancies between digital designs and final restorations may lead to dissatisfaction if not managed properly. Most DSD software does not account for functional aspects such as occlusion, temporomandibular joint (TMJ) health, or masticatory dynamics. It is primarily an esthetic planning tool, not a comprehensive prosthodontic diagnostic system

While commercially available DSD software platforms – such as DSDApp, Smile Designer Pro, Exocad Smile Creator, and 3Shape Smile Design – offer robust visual tools for esthetic treatment planning, their accuracy and specificity are still a matter of concern.

Talking about accuracy, most software relies on 2D image-based analysis, which may not accurately represent the spatial relationships of facial and dental landmarks. Any error in photo angulation or landmark placement can lead to significant discrepancies. Advanced systems that allow integration with intraoral scans, cone beam CT, and facial scans offer higher accuracy. However, this requires a multi-step workflow and perfect alignment between datasets, which can be prone to human error. Although DSD aids in visualizing the final esthetic outcome, it does not directly control margin accuracy, occlusion, or internal fit of restorations-functions still managed by CAD software.

Talking about specificity, this software is mostly esthetically driven, not functionally specific. DSD platforms are highly specific to esthetic planning (midlines, incisal edge positions, and smile arcs), but they do not provide functional specificity, such as occlusal schemes or TMJ considerations. Some software allows limited customization of smile libraries. While they provide templates based on idealized smile forms, achieving a truly individualized design still requires clinician interpretation and adjustment. Specificity regarding lip dynamics, phonetics, and gingival display in motion is lacking in most platforms, which are typically static.

CONCLUSION

In the contemporary landscape, the significance of cosmetics and esthetics cannot be overstated, as individuals increasingly aspire to achieve an impeccable smile and overall appearance. DSD has simplified the process of smile design considerably. While DSD offers numerous advantages, it also has certain limitations. This approach is notably multidisciplinary and employs a 3D methodology, making it applicable across various dental specialties. A range of software options is available, allowing clinicians to select tools that best meet their specific requirements. In addition, some of these software solutions are accessible as mobile applications, enhancing their user-friendliness and convenience. This accessibility aids both clinicians and patients in refining treatment plans and visualizing anticipated outcomes.

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