OPEN ACCESS
Saudi Journal of Medical and Pharmaceutical Sciences
Abbreviated Key Title: Saudi J Med Pharm Sci
ISSN 2413-4929 (Print) | ISSN 2413-4910 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article **Radiology**

From Artistry to Algorithms: The Evolution of Digital Smile Design-A Comprehensive Review

Dr. Tenzin Lhadon[1], Dr. Amanpreet Kaur[2]*, Dr. Latifa Elbanna[3], Dr Ridhi Bhola[4], Dr. Amit Kumar[5], Dr. Sandeep Singh[5]

[1]BDS, MCP, The Oxford Dental College and Hospital, Bengaluru, Karnataka, India
[2]BDS, SKSS Dental College and Hospital Ludhiana, Punjab, India
[3]PhD, Prosthodontics, Faculty of Dental Medicine – Al Azhar University, Cairo, Egypt
[4]BDS, MDS, Postgraduate Institute of Dental Sciences, Rohtak, India
[5]BDS, MDS, Army College of Dental Sciences, Secunderabad, India

DOI: https://doi.org/10.36348/sjmps.2026.v12i07.001 | **Received:** 12.04.2026 | **Accepted:** 03.06.2026 | **Published:** 04.07.2026

***Corresponding author:** Dr. Amanpreet Kaur
BDS, SKSS Dental College and Hospital Ludhiana, Punjab, India

Abstract

Digital Smile Design [DSD] has transformed esthetic dentistry by integrating digital technology, facial analysis, and restorative planning to improve treatment predictability and patient satisfaction. Conventional smile design techniques often lacked precision, reproducibility, and effective communication. The development of DSD has addressed these limitations through the use of digital photography, intraoral scanning, CAD-CAM systems, virtual simulations, and artificial intelligence. This review discusses the evolution, principles, technological foundations, clinical workflow, applications, advantages, limitations, and future perspectives of DSD. The technology has enhanced interdisciplinary treatment planning in esthetic rehabilitation, orthodontics, implant dentistry, and full-mouth reconstruction while improving patient communication and diagnostic accuracy. Emerging technologies such as artificial intelligence, augmented reality, and cloud-based workflows are expected to further expand its role in personalized dentistry. Despite its advantages, challenges including high costs, technical complexity, and the need for long-term clinical validation remain. Overall, DSD represents a significant advancement toward a more precise, patient-centered, and digitally driven approach in modern esthetic dentistry.

Keywords: Digital Smile Design, Esthetic Dentistry, Artificial Intelligence, CAD-CAM Technology, Digital Workflow.

INTRODUCTION

Esthetic dentistry has become one of the most rapidly evolving fields in modern clinical practice, driven by increasing patient expectations for natural, harmonious, and individualized smiles. Beyond functional rehabilitation, contemporary dentistry places significant emphasis on facial esthetics, dental proportions, and smile symmetry, as these factors are closely linked to psychological well-being, self-confidence, and social perception. As a result, smile design has emerged as a central component of comprehensive dental treatment planning, integrating principles of biology, occlusion, and esthetics to achieve predictable and patient-centered outcomes. [1]

Traditionally, smile design was performed using conventional techniques such as diagnostic wax-ups, two-dimensional photographic analysis, and clinician-driven visual assessment. While these methods provided a foundational framework for esthetic evaluation, they were largely dependent on subjective interpretation and lacked real-time visualization for patient communication. The limitations of analog workflows, particularly in terms of predictability, reproducibility, and interdisciplinary coordination, have contributed to a progressive shift toward more advanced digital methodologies in dentistry. [2]

In response to these limitations, DSD has emerged as a transformative, multidisciplinary concept that integrates dentistry, digital technology, and facial esthetics. It utilizes digital photography, facial analysis, and virtual simulation tools to design and communicate treatment outcomes with greater accuracy and clarity. This approach not only enhances diagnostic precision but also improves collaboration among dental specialties, allowing for a more structured and predictable treatment workflow. By bridging the gap between clinician analysis and patient perception, DSD represents a significant advancement in esthetic treatment planning. [3, 4]

This comprehensive review aims to explore the evolution of digital smile design from its traditional artistic foundations to its current algorithm-driven applications.

Historical Evolution of Smile Design

The foundations of smile design originated from early esthetic principles aimed at defining ideal proportions, symmetry, and harmony within the dentofacial complex. Concepts such as the golden proportion and geometric tooth relationships were widely used as reference frameworks for achieving an esthetically pleasing smile. In addition, tooth morphology, including shape, contour, incisal embrasures, and midline alignment, formed the basis of early clinical guidelines, offering a structured yet largely artistic approach to smile evaluation and reconstruction. [5]

With advancements in restorative and prosthodontic dentistry, conventional smile design became more systematic. Diagnostic wax-ups were commonly used to simulate treatment outcomes in three dimensions, while manual planning supported by clinical examination and two-dimensional photographic analysis enabled assessment of facial proportions, lip dynamics, and tooth display. These methods improved treatment planning and facilitated communication between clinicians, technicians, and patients, although in an indirect manner. [6]

However, analog systems had notable limitations. Outcomes often varied due to subjective interpretation, and the absence of real-time visualization made it difficult for patients to fully understand proposed treatments. Communication gaps frequently led to differences in expectations, and the lack of standardized protocols reduced reproducibility and predictability.

These shortcomings highlighted the need for more precise and interactive planning methods. [6]

Collectively, these challenges led to a gradual shift toward digital dentistry. The introduction of advanced imaging technologies, computer-aided design [CAD] systems, and virtual simulation tools transformed smile design into a more accurate, reproducible, and patient centered process. This transition laid the foundation for modern digital smile design, characterized by enhanced visualization, improved interdisciplinary collaboration, and increased patient engagement. [7]

Concept and Philosophy of DSD

Definition and Origin of DSD

DSD is a digital communication and planning protocol that integrates esthetic dentistry with facial analysis, digital photography, and computer-based simulation to design predictable and individualized smile outcomes. It was introduced as a concept to enhance diagnostic precision and improve communication between clinicians, dental technicians, and patients. Rather than being a single software or technique, DSD represents a structured workflow that translates clinical data into a visual and interactive treatment plan, enabling a more systematic approach to esthetic rehabilitation. [8]

Core Principles: Facial-Driven, Patient-Centered, and Interdisciplinary Planning

The philosophy of DSD is based on three fundamental principles. The first is a facial-driven approach, where dental esthetics are planned in harmony with facial proportions, expressions, and dynamic smile analysis rather than isolated tooth positioning. The second is a patient centered model, which emphasizes patient involvement in treatment planning through visualization and shared decision-making, thereby improving understanding and treatment acceptance. The third principle is interdisciplinary planning, where prosthodontists, orthodontists, periodontists, and laboratory technicians collaborate within a unified digital framework to achieve comprehensive and predictable outcomes. [9]

Role of Visual Communication in Treatment Planning

A key strength of DSD lies in its ability to enhance visual communication. By converting clinical information into digital visual representations, DSD allows clinicians to clearly demonstrate proposed esthetic changes to patients. This improves comprehension of treatment objectives, reduces miscommunication, and aligns patient expectations with clinical possibilities. Visual tools also facilitate better collaboration among dental professionals by providing a common reference for diagnosis and planning. [10]

Digital Mock-Ups and Smile Simulation as Diagnostic Tools

Digital mock-ups and smile simulations are central components of DSD, serving as both diagnostic and educational tools. These virtual representations allow clinicians to preview proposed restorative changes before any physical intervention is performed. Mock-ups can be transferred intraorally to evaluate esthetics, phonetics, and function in real time, enabling reversible trial evaluations. This process enhances diagnostic accuracy, supports treatment validation, and reduces clinical errors by allowing modifications at an early stage of planning. [11] [Figure 1]

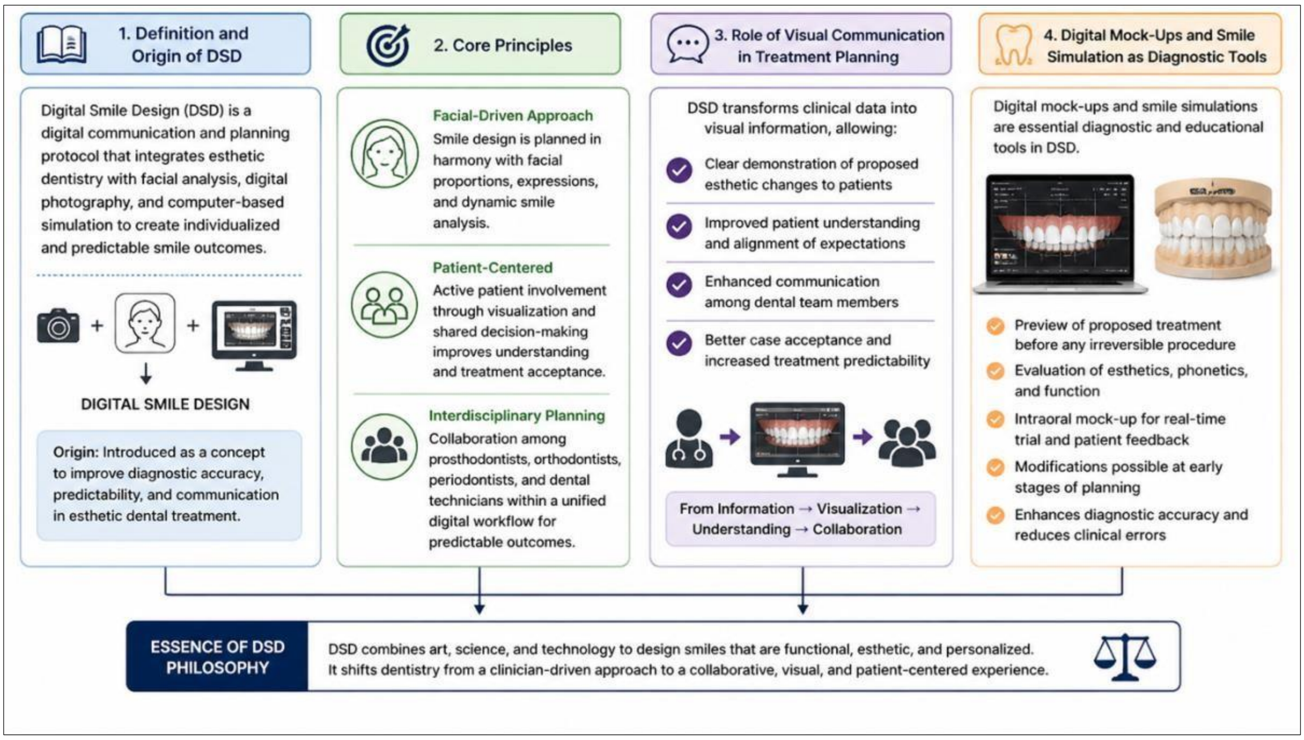

Figure 1: Concept and philosophy of DSD

Technological Foundations of DSD

Digital Imaging and Facial Analysis

Digital imaging forms the diagnostic foundation of DSD. Standardized extraoral and intraoral photography allows the clinician to assess facial symmetry, smile line, lip mobility, gingival display, tooth proportions, and dentofacial harmony. In DSD protocols, full-face frontal, profile, retracted intraoral, occlusal, and dynamic smile photographs are commonly used to transfer facial reference lines into the dental planning process. Coachman and Calamita described DSD as a tool that improves diagnostic vision, treatment communication, and predictability by analyzing facial and dental characteristics through digital documentation. [12]

Facial reference systems are essential for aligning the dental design with the patient's face rather than treating teeth as isolated units. Common reference parameters include the interpupillary line, facial midline, commissural line, occlusal plane, incisal edge position, gingival zeniths, and tooth axis. These references help determine whether the proposed smile is balanced with facial proportions and dynamic expressions. Studies on facial reference determination emphasize that vertical and horizontal facial axis are important for esthetic restorative planning, especially when correcting midline deviations, occlusal canting, and asymmetry. [12]

Intraoral Scanning and 3D Data Acquisition

Intraoral scanners have become central to digital smile workflows by replacing or supplementing conventional elastomeric impressions. Digital impressions provide three dimensional datasets that can be directly imported into smile design, CAD-CAM, orthodontic, and prosthodontic software. Compared with conventional impressions, intraoral scanning offers advantages such as improved patient comfort, faster digital transfer, reduced material distortion, and easier storage of clinical data. [13] The integration of intraoral scans with facial scans, CBCT data, and digital photographs enables the creation of a virtual patient. This three dimensional approach allows clinicians to evaluate tooth position, gingival architecture, occlusal relationships, facial esthetics, and prosthetic requirements in a unified digital environment. Such integration improves interdisciplinary planning, particularly in complex esthetic rehabilitation, orthodontic treatment, implant planning, and full-mouth reconstruction. [14]

CAD-CAM Technology

Computer-aided design and computer-aided manufacturing [CAD-CAM] technology provides the link between virtual smile planning and clinical execution. In DSD, digital wax-ups can be designed using CAD software and then converted into diagnostic mock-ups, provisional restorations, veneers, crowns, surgical guides, or definitive prostheses. This allows the proposed smile design to be tested clinically before final restoration. CAD-CAM also improves communication between clinician and laboratory by replacing subjective verbal instructions with precise digital files.

Subtractive manufacturing, or milling, remains widely used for high-strength ceramic restorations such as zirconia and lithium disilicate because of its accuracy, material reliability, and established clinical performance.

Additive manufacturing, or 3D printing, is increasingly used for diagnostic models, mock-ups, surgical guides, temporary restorations, dentures, and resin-based prosthetic components. Recent reviews suggest that CAD-CAM milling remains highly predictable, while advances in 3D printing are expanding its role in restorative and prosthetic dentistry. However, 3D printing outcomes remain influenced by resin type, printer technology, post-curing protocol, layer thickness, and long-term material stability. [15]

Artificial Intelligence in Smile Design

AI is an emerging component of DSD, particularly in automated smile analysis, tooth segmentation, facial landmark detection, and esthetic prediction. AI-based systems can analyze facial and dental images, identify reference points, suggest tooth proportions, and generate proposed smile designs based on trained datasets. In esthetic dentistry, these tools may improve workflow efficiency by reducing manual design time and assisting clinicians in objective analysis.

Machine learning models are also being explored for predicting esthetic outcomes and improving personalization of smile design. Recent literature indicates that AI-generated smile designs may show esthetic acceptability comparable to manually created designs in certain settings, while three-dimensional AI-assisted workflows may offer advantages over two dimensional planning. However, the available evidence remains limited, and many studies are preliminary, heterogeneous, or software-specific. Despite its promise, AI in smile design has important limitations. Current systems depend heavily on dataset quality, image standardization, algorithm transparency, and clinician supervision. Bias in training data may affect esthetic recommendations across different ethnicities, facial forms, and cultural perceptions of beauty. Furthermore, AI-generated designs may not fully account for biological limitations, periodontal conditions, occlusion, phonetics, material constraints, or patient expectations. Therefore, AI should be considered an adjunctive tool rather than a replacement for clinical judgment. [16, 17]

Clinical Workflow of Digital Smile Design

The clinical workflow of DSD is a structured, stepwise process that integrates diagnostic data, digital planning, and clinical execution to achieve predictable esthetic outcomes. This workflow emphasizes precision, interdisciplinary collaboration, and active patient involvement at every stage, thereby enhancing both clinical effectiveness and treatment acceptance.

Data Acquisition Phase

The initial phase involves comprehensive collection of patient-specific data, which forms the foundation for digital planning. This includes standardized extraoral and intraoral photographs, intraoral scans, and, when required, CBCT imaging. High-quality photographic records capture facial expressions, smile dynamics, lip mobility, and dental display, while intraoral scans provide accurate three-dimensional representations of the dentition and occlusion. The integration of these datasets allows for the creation of a virtual patient, enabling clinicians to analyze both static and dynamic relationships between teeth, gingiva, and facial structures. [18]

Digital Planning and Simulation

Following data acquisition, the collected information is transferred into DSD software for analysis and planning. Facial reference lines and esthetic parameters are superimposed onto patient images to guide tooth positioning, proportions, and alignment. Virtual simulations are then generated to visualize proposed treatment outcomes. This phase allows clinicians to evaluate esthetic, functional, and phonetic aspects before initiating treatment. Importantly, digital simulations facilitate communication with patients, enabling them to understand and approve the proposed design, thereby improving treatment acceptance and expectation management. [19]

Mock-Up Fabrication and Trial Smile Evaluation

Once the digital design is finalized, it is translated into a physical or intraoral mock-up. This can be achieved through CAD-CAM milling or 3D printing of diagnostic models, followed by fabrication of provisional restorations or direct mock-ups using composite materials. Trial smile evaluation allows real-time assessment of esthetics, phonetics, occlusion, and patient comfort. It also provides an opportunity for modifications before irreversible procedures are performed. This reversible phase is critical in minimizing clinical errors and ensuring alignment between the planned and final outcomes. [20]

Final Treatment Execution Across Specialties

Prosthodontics

In prosthodontic applications, the finalized digital design guides the fabrication of definitive restorations such as veneers, crowns, bridges, or implant-supported prostheses. CAD-CAM systems enable precise manufacturing of restorations that closely replicate the approved mockup, ensuring high esthetic accuracy and marginal integrity. [21]

Orthodontics

In orthodontics, DSD assists in treatment planning by visualizing tooth movement in relation to facial esthetics. Digital setups and aligner systems can be designed based on the desired final smile, allowing orthodontic correction to be aligned with prosthetic and esthetic goals. [22]

Restorative Dentistry

In restorative procedures, DSD guides minimally invasive interventions such as direct composite bonding, enamel reshaping, and tooth contouring. The digital plan ensures that restorative treatments are harmonized with overall facial esthetics while preserving natural tooth structure. Overall, the DSD workflow provides a seamless transition from diagnosis to execution, improving accuracy, reducing chairside adjustments, and enhancing interdisciplinary coordination. By combining digital precision with clinical expertise, it represents a significant advancement in modern esthetic dentistry. [23] [Figure 2]

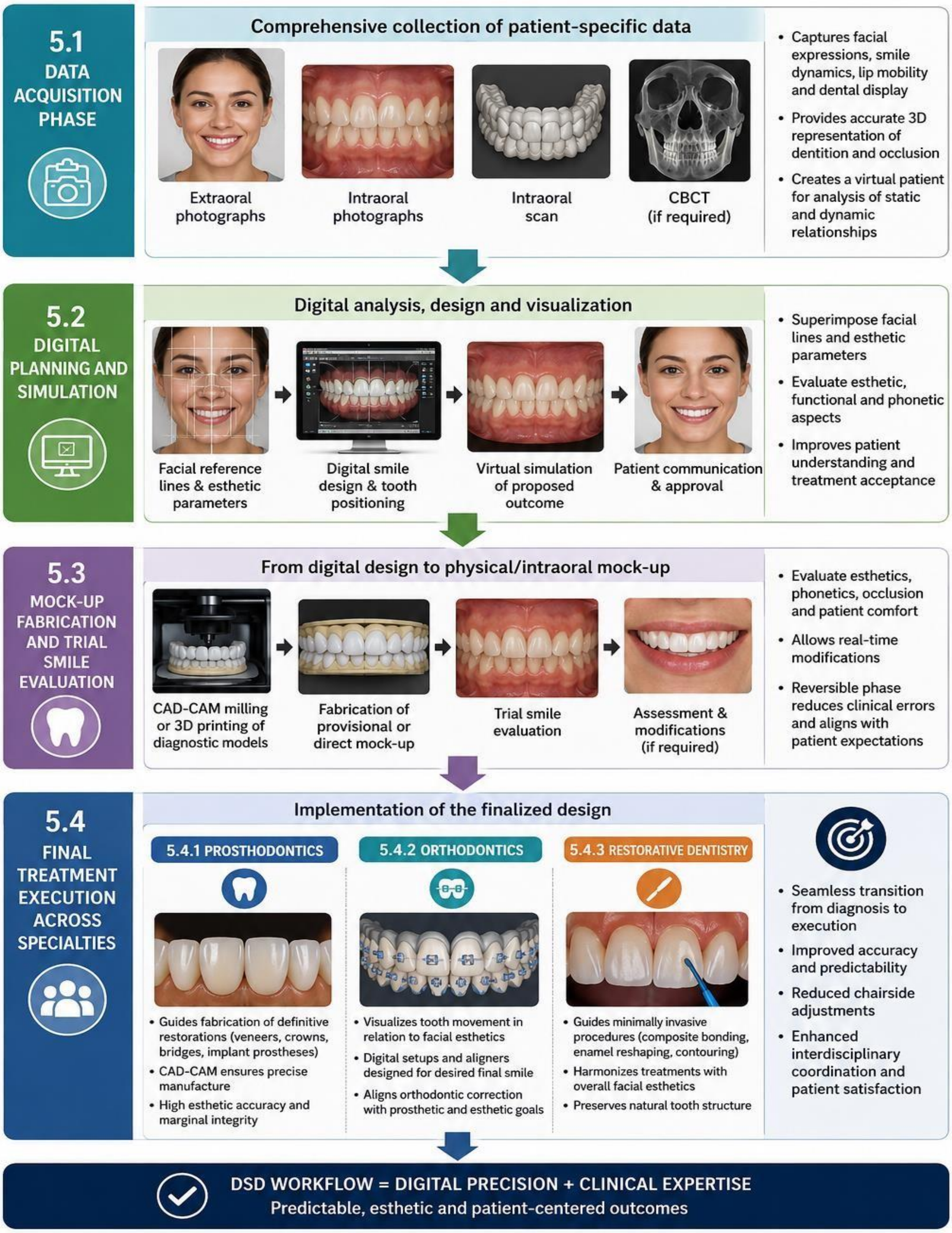

Figure 2: Clinical workflow of DSD

Clinical Applications of DSD

DSD has significantly expanded the scope of esthetic and restorative dentistry by improving diagnostic accuracy, treatment predictability, and interdisciplinary communication. Its applications extend across multiple specialties, enabling clinicians to integrate facial analysis, digital simulation, and restorative planning into a unified workflow. [24]

Esthetic Rehabilitation Cases

DSD is widely utilized in esthetic rehabilitation procedures involving veneers, crowns, composite bonding, and gingival recontouring. By combining facial reference analysis with digital simulations, clinicians can visualize proposed outcomes before treatment initiation. This allows improved customization of tooth proportions, smile line, and gingival architecture according to patient-specific esthetic requirements. Studies have shown that DSD enhances treatment predictability and patient acceptance by allowing patients to preview expected outcomes through mock-ups and virtual simulations. [25]

Full-Mouth Rehabilitation

In complex full-mouth rehabilitation cases, DSD facilitates comprehensive treatment planning by integrating occlusal, functional, and esthetic considerations within a digital workflow. The technology enables clinicians to evaluate vertical dimension, tooth wear, facial support, and prosthetic design simultaneously, thereby reducing cumulative clinical errors. Digital workflows combined with CAD-CAM systems have demonstrated improved efficiency and reproducibility in full-mouth rehabilitation, especially in cases involving severe tooth wear or extensive esthetic rehabilitation. [26]

Orthodontic Treatment Planning

In orthodontics, DSD assists in aligning tooth movement with facial esthetics and smile dynamics. Digital simulations allow orthodontists to visualize the final esthetic outcome before treatment, improving treatment sequencing and interdisciplinary coordination. Integration with aligner systems and cephalometric analysis further enhances planning accuracy. Recent literature highlights that digital smile preview techniques improve communication between orthodontists, prosthodontists, and patients, particularly in multidisciplinary esthetic cases. [27]

Implant-Supported Prosthetic Planning

DSD has become increasingly important in implant dentistry by enabling prosthetically driven implant placement. The integration of intraoral scans, CBCT imaging, and facial analysis allows clinicians to determine optimal implant positioning according to esthetic and functional requirements. Digital workflows also facilitate the fabrication of surgical guides, provisional restorations, and definitive implant-supported prostheses with greater precision. Studies indicate that digitally guided implant planning improves surgical accuracy, prosthetic predictability, and patient-centered outcomes compared with conventional approaches. [28]

Interdisciplinary Treatment Coordination

One of the most significant advantages of DSD is its ability to enhance interdisciplinary collaboration. By creating a shared digital platform, clinicians from prosthodontics, orthodontics, periodontics, implantology, and laboratory technology can coordinate treatment objectives more effectively. Digital planning files, virtual mock-ups, and smile simulations improve communication among team members and minimize discrepancies between planned and executed outcomes. This collaborative workflow is particularly valuable in complex esthetic rehabilitation cases requiring sequential multidisciplinary procedures. [29]

Advantages and Disadvantages of DSD

DSD has transformed esthetic dentistry by improving visualization, communication, and treatment predictability. However, despite its numerous clinical advantages, certain technical, financial, and practical limitations continue to influence its widespread implementation. A balanced understanding of both benefits and challenges is essential for effective integration of DSD into routine clinical practice. [30-34]

Advantages	Disadvantages
Enhances diagnostic accuracy through digital visualization and facial analysis	High initial cost of software, scanners, and CAD-CAM systems
Improves communication between clinician, technician, and patient	Requires advanced technical knowledge and training
Allows patients to visualize expected treatment outcomes before procedures	Learning curve associated with digital workflow integration
Increases patient motivation, understanding, and treatment acceptance	Dependence on high-quality photographs and accurate data acquisition
Facilitates interdisciplinary treatment planning and collaboration	Software compatibility and integration issues may occur
Improves predictability and reproducibility of esthetic outcomes	Risk of over-reliance on virtual simulations
Reduces chairside modifications and remakes	Simulated results may not perfectly match final clinical outcomes
Enables minimally invasive and more conservative treatment planning	Equipment maintenance and software updates increase long-term costs
Integrates efficiently with CAD-CAM and digital manufacturing workflows	Limited accessibility in smaller or resource constrained practices
Enhances documentation and medico-legal record keeping	Ethical concerns related to AI-generated esthetic standards and patient expectations

Future Perspectives

The future of DSD is expected to be shaped by rapid advancements in artificial intelligence, immersive visualization technologies, and data-driven personalized dentistry. As digital workflows continue to evolve, DSD is gradually transitioning from a primarily visualization based system to an intelligent, predictive, and fully integrated treatment-planning ecosystem.

Fully AI-Driven Smile Design Systems

AI is anticipated to play an increasingly dominant role in smile design by automating facial analysis, tooth arrangement, esthetic prediction, and treatment planning. Future AI-driven systems may utilize deep learning algorithms trained on extensive clinical datasets to generate highly personalized smile proposals with minimal manual intervention. These systems could improve workflow efficiency, reduce operator variability, and enhance treatment predictability. However, maintaining clinician oversight will remain essential to ensure biological, functional, and ethical considerations are appropriately addressed. [35]

Integration of Augmented Reality [AR] and Virtual Reality [VR]

The incorporation of AR and VR technologies has the potential to revolutionize patient communication and treatment visualization in esthetic dentistry. AR systems may enable real time overlay of proposed restorations directly onto the patient's face during clinical consultations, while VR-based simulations could provide immersive previews of posttreatment outcomes. These technologies may improve patient understanding, treatment acceptance, and interdisciplinary collaboration by creating interactive and realistic representations of planned procedures. [36]

Digital Twins and Predictive Dentistry

The concept of digital twins, virtual replicas of a patient's oral and facial structures, is emerging as a promising advancement in digital dentistry. By integrating intraoral scans, facial scans, CBCT imaging, and patient-specific biological data, digital twins could allow continuous monitoring, simulation, and prediction of treatment outcomes over time. This predictive approach may facilitate early detection of complications, optimization of treatment protocols, and development of more individualized esthetic solutions. [37]

Cloud-Based Interdisciplinary Workflows

Cloud computing technologies are expected to further strengthen interdisciplinary collaboration within digital dentistry. Cloud-based platforms enable secure sharing of patient data, digital impressions, treatment simulations, and laboratory designs among clinicians, technicians, and specialists in real time. Such systems can improve workflow efficiency, reduce communication delays, and facilitate remote consultations and tele dentistry applications. As digital ecosystems expand, cloud integration may become central to comprehensive esthetic treatment planning. [38]

Personalized Esthetic Dentistry Using Big Data

The growing availability of large-scale digital datasets and advanced analytics may contribute to the development of highly personalized esthetic dentistry. Big data combined with AI could help identify patterns related to facial proportions, smile preferences, treatment outcomes, and patient satisfaction across different populations. This may enable clinicians to design restorations and smiles tailored not only to anatomical characteristics but also to individual esthetic preferences and cultural perceptions of beauty. [39]

CONCLUSION

DSD has transformed esthetic dentistry from a conventional artistic approach into a technology-driven and patient-centered discipline. Through the integration of digital imaging, facial analysis, CAD-CAM systems, and artificial intelligence, DSD has improved treatment visualization, communication, predictability, and interdisciplinary collaboration. It enables clinicians to deliver more precise and individualized esthetic outcomes while enhancing patient understanding and satisfaction. Despite its numerous advantages, challenges related to cost, technical expertise, standardization, and long-term clinical validation remain significant. Continued research and evidence-based protocols are necessary to establish the long-term reliability and reproducibility of digital workflows. As technologies such as AI, augmented reality, and cloud-based systems continue to evolve, DSD is expected to play an increasingly important role in the future of personalized and predictive esthetic dentistry.

REFERENCES

1. Alharkan HM. Integrating digital smile design into restorative dentistry: A narrative review of the applications and benefits. *Saudi Dent J.* 2024;36[4]:561–567. doi: 10.1016/j.sdentj.2023.12.014.
2. Kaushik K, Sales A, Rodrigues SJ. Comparative analysis of facial aesthetics in AIgenerated versus conventionally crafted digital smile designs: A cross-sectional study. *BDJ Open.* 2025;11[1]:79. doi:10.1038/s41405-025-00367-z.
3. Chisnoiu AM, Staicu AC, Kui A, Chisnoiu RM, Iacob S, Fluerașu M, Buduru S. Smile design and treatment planning: Conventional versus digital-A pilot study. *J Pers Med.* 2023; 13:1028. doi:10.3390/jpm13071028.
4. Jafri Z, Ahmad N, Sawai M, Sultan N, Bhardwaj A. Digital smile design: An innovative tool in aesthetic dentistry. *J Oral Biol Craniofac Res.* 2020;10[2]:194–198. doi: 10.1016/j.jobcr.2020.04.010.
5. Thomas PA, Krishnamoorthi D, Mohan J, Raju R, Rajajayam S, Venkatesan S. Digital smile design. *J*

Pharm Bioallied Sci. 2022;14[Suppl 1]: S43–S49. doi: 10.4103/jpbs.jpbs_164_22.
6. Hristozova M, Dimitrova M, Zlatev S. Bilateral symmetry in the aesthetic area achieved by digital smile design on 3D virtual patient and conventional diagnostic wax-up: A comparative study. *Dent J* [*Basel*]. 2024;12[12]:373. doi:10.3390/dj12120373.
7. Saini RS, Kaur K, Gurumurthy V, Binduhayyim RIH, Kaushik A, Kuruniyan MS, Alarcón-Sánchez MA, Heboyan A. Impact of artificial intelligence-based digital smile design on patient and clinician satisfaction and facial esthetic outcomes: A systematic review and meta-analysis. *Digit Health.* 2025; 11:20552076251388392. doi:10.1177/20552076251388392.
8. Sari A, Amanda V, Marshall D, Sani F. Digital smile design: Patient satisfaction and long-term outcomes of a novel approach to esthetic dentistry in Jakarta, Indonesia. *Crown: Journal of Dentistry and Health Research.* 2023; 1:25–37.
9. Reviansyah FH, Ristin AD, Almughni WH, Yolanda Y, Takarini V, Susilawati S, Komariah M. Eco-friendly approaches to enhance dental aesthetics and patient satisfaction using digital smile design: A systematic review. *Clin Cosmet Investig Dent.* 2025; 17:391–404. doi:10.2147/CCIDE.S535436.
10. Omar D, Duarte C. The application of parameters for comprehensive smile esthetics by digital smile design programs: A review of literature. *Saudi Dent J.* 2018;30[1]:7–12. doi: 10.1016/j.sdentj.2017.09.001.
11. Garcia PP, da Costa RG, Calgaro M, Ritter AV, Correr GM, da Cunha LF, Gonzaga CC. Digital smile design and mock-up technique for esthetic treatment planning with porcelain laminate veneers. *J Conserv Dent.* 2018;21[4]:455–458. doi: 10.4103/JCD.JCD_172_18.
12. Coachman C, Van Dooren E, Gürel G, Landsberg CJ, Calamita MA, Bichacho N. Smile design: From digital treatment planning to clinical reality. In: Cohen M, ed. *Interdisciplinary Treatment Planning.* Vol 2. Chicago: Quintessence; 2012:119–174.
13. Joensahakij N, Serichetaphongse P, Chengprapakorn W. The accuracy of conventional versus digital [intraoral scanner or photogrammetry] impression techniques in full-arch implant-supported prostheses: A systematic review. *Evid Based Dent.* 2024;25[4]:216– 217. doi:10.1038/s41432-024-01045-z.
14. Lobo S, Argolinha I, Machado V, Botelho J, Rua J, Li J, Mendes JJ. Advances in digital technologies in dental medicine: Enhancing precision in virtual articulators. *J Clin Med.* 2025;14[5]:1495. doi:10.3390/jcm14051495.
15. Cattoni F, Mastrangelo F, Gherlone EF, Gastaldi G. A new total digital smile planning technique [3D-DSP] to fabricate CAD-CAM mockups for esthetic crowns and veneers. *Int J Dent.* 2016; 2016:6282587. doi:10.1155/2016/6282587.
16. AbdelHafez M, Afia A, Shaalan O. Artificial intelligence versus conventional methods in digital smile designing: An accuracy study. *J Esthet Restor Dent.* 2026;38[4]:828– 836. doi:10.1111/jerd.70075.
17. Baaj RE, Alangari TA. Artificial intelligence applications in smile design dentistry: A scoping review. *J Prosthodont.* 2025;34[4]:341–349. doi:10.1111/jopr.14000.
18. Mannaa AI. Knowledge and attitude toward esthetic dentistry and smile perception.
19. *Cureus.* 2023;15[9]:e46043. doi:10.7759/cureus.46043.
20. Georg R. Digital smile design: Utilizing novel technologies for ultimate esthetics. *Compend Contin Educ Dent.* 2023;44[10]:567–572.
21. Farrag A, Fouda A, Kashani S, McCullagh A, Wyatt C, Nguyen C, Gebril M. Digital hybrid technique for immediate complete denture fabrication: A clinical report. *J Prosthodont.* 2025;34[9]:892–899. doi:10.1111/jopr.70023.
22. Joda T, Zarone F, Ferrari M. The complete digital workflow in fixed prosthodontics: A systematic review. *BMC Oral Health.* 2017;17[1]:124. doi:10.1186/s12903-017-0415-0.
23. Olawade DB, Leena N, Egbon E, Rai J, Mohammed APEK, Oladapo BI, Boussios S. AI-driven advancements in orthodontics for precision and patient outcomes. *Dent J* [*Basel*]. 2025;13[5]:198. doi:10.3390/dj13050198.
24. McLaren EA, Goldstein RE. The Photoshop smile design technique. *Compend Contin Educ Dent.* 2018;39[5]:e17–e20.
25. Coachman C, Calamita MA, Sesma N. Dynamic documentation of the smile and the 2D/3D digital smile design process. *Int J Periodontics Restorative Dent.* 2017;37[2]:183–193. doi:10.11607/prd.2911.
26. Meereis CT, de Souza GB, Albino LG, Ogliari FA, Piva E, Lima GS. Digital smile design for computer-assisted esthetic rehabilitation: Two-year follow-up. *Oper Dent.* 2016;41[1]:E13–E22. doi:10.2341/14-350-S.
27. Morón-Conejo B, Gil A, Bonfanti-Gris M, Salido MP, Martínez-Rus F. Esthetic and functional rehabilitation: Retreatment of anterior fixed dental prosthesis with biologically oriented preparation technique and digital workflow. *J Esthet Restor Dent.* 2025;37[3]:761–770. doi:10.1111/jerd.13393.
28. Alinda RN, Indra P, Hadinata F, Satyaputra MD, Ayub A, Alhasyimi AA. Digitally driven interdisciplinary smile redesign in a patient with midline deviation: A case report. *Eur J Dent.* 2026;20[1]:310–317. doi:10.1055/s-0045-1812109.
29. Prasher P, Tuteja A, Amin F, Sopaj R, Tuteja D, Eddin HS. Advancing precision: The role of digital workflows in modern implant dentistry. *Bioinformation.*
30. 2025;21[8]:2490–2495. doi:10.6026/973206300212490.

31. Choudhary N, Hiremath AM, PCM, Bullappa D, VKM, Rajeev A. Interdisciplinary and integrated clinical management of complex dental disorders. *Bioinformation.* 2025;21[7]:2075–2079. doi:10.6026/973206300212075.
32. Zanardi PR, Laia Rocha Zanardi R, Chaib Stegun R, Sesma N, Costa BN, Cruz Laganá D. The use of the digital smile design concept as an auxiliary tool in aesthetic rehabilitation: A case report. *Open Dent J.* 2016; 10:28–34. doi:10.2174/1874210601610010028.
33. Jain A, Bhushan P, Mahato M, Solanki BB, Dutta D, Hota S, Raut A, Mohanty AK. The recent use, patient satisfaction, and advancement in digital smile designing: A systematic review. *Cureus.* 2024;16[6]:e62459. doi:10.7759/cureus.62459.
34. Charavet C, Bernard JC, Gaillard C, Le Gall M. Benefits of digital smile design [DSD] in the conception of a complex orthodontic treatment plan: A case report-proof of concept. *Int Orthod.* 2019;17[3]:573–579. doi: 10.1016/j.ortho.2019.06.019.
35. Da Cunha LF, Fernandes ABF, Baechtold MS, Correr GM, Gonzaga CC. Cara Smile: Use of planning software to facilitate esthetic dental treatment in a case. *Indian J Dent Res.* 2019;30[6]:964–969. doi: 10.4103/ijdr.IJDR_637_17.
36. Zimmermann M, Mehl A. Virtual smile design systems: A current review. *Int J Comput Dent.* 2015;18[4]:303–317.
37. Albuhayri FS, Albshaier SJ, Dashti AI, Alrajhi JF, Alhamidy FK, Busuhail MA, Bujbarah FN, Rizq MK, Thubab NA, Takronni SA, Alharbi JI, Hakami AH, Aloufi HS, Mathar MI. The expanding role of artificial intelligence in dentistry: A cross-specialty chairside perspective. *Cureus.* 2025;17[12]:e98449. doi:10.7759/cureus.98449.
38. Iqbal AI, Aamir A, Hammad A, Hafsa H, Basit A, Oduoye MO, Anis MW, Ahmed S, Younus MI, Jabeen S. Immersive technologies in healthcare: An in-depth exploration of virtual reality and augmented reality in enhancing patient care, medical education, and training paradigms. *J Prim Care Community Health.*
39. 2024; 15:21501319241293311. doi:10.1177/21501319241293311.
40. Roy S, Richert R, Tavares JMRS, Lahoud P. Editorial: Applications of digital twin technology in dentistry. *Front Bioeng Biotechnol.* 2025; 13:1624734. doi:10.3389/fbioe.2025.1624734.
41. Bedia SV, Shapurwala MA, Kharge BP, Bedia AS, Patil A. A comprehensive guide to implement artificial intelligence cloud solutions in a dental clinic: A review. *Cureus.*
42. 2025;17[2]:e78718. doi:10.7759/cureus.78718.
43. Buduru S, Cofar F, Mesaroș A, Tăut M, Negucioiu M, Almășan O. Perceptions in digital smile design: Assessing laypeople and dental professionals' preferences using an artificial-intelligence-based application. *Dent J* [*Basel*]. 2024;12[4]:104. doi:10.3390/dj12040104.