

Digital Smile Design-Guided Esthetic Rehabilitation of Maxillary Anterior Teeth: A Clinical Case Series

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Abstract

Background: Digital Smile Design (DSD) is a multidisciplinary planning tool that improves diagnostic accuracy, interdisciplinary communication and treatment predictability in esthetic dentistry.

Case presentation: A 20-year-old male presented with missing maxillary left central and lateral incisors, an Ellis Class I fracture of the maxillary right central incisor and anterior spacing following a road traffic accident. Standardized extraoral and intraoral photographs, intraoral scans and diagnostic casts were integrated in exocad DentalCAD to establish facial and dental reference lines and to design a patient-specific smile. The approved design was 3D-printed as a diagnostic wax-up, from which silicone indices were fabricated for an intraoral mock-up and for preparation guidance. Following endodontic treatment of tooth 11, a lithium disilicate fixed dental prosthesis (11–23) and laminate veneers (12, 13) were fabricated through a CAD/CAM workflow and adhesively cemented.

Results: The digitally planned smile was reproduced clinically, and the patient remained satisfied at the 1.5-year follow-up.

Conclusion: A DSD-guided digital workflow combined with lithium disilicate restorations allowed conservative and predictable esthetic rehabilitation of traumatized maxillary anterior teeth.

Keywords: Digital smile design; Esthetic dentistry; Lithium disilicate; Laminate veneers; CAD/CAM; Fixed dental prosthesis

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Introduction

A beautiful confident smile is desired by all [1]. Media-driven esthetic awareness has significantly increased patient demand for brighter, ideal dentition, with a preference for minimally invasive and less time-consuming treatment modalities [2–4]. The perception of facial esthetics significantly influences psychological well-being, social perception, and perceived success [5].

Esthetic dentistry has become one of the most sought-after disciplines dedicated to enhancing smile esthetics and facial appearance [6]. To meet these esthetic demands and minimize treatment time procedures, various Digital Smile Design (DSD) software programs have been introduced into clinical practice [2,7,8]. 3 Smile Design Pro, Planmeca Romexis Smile Design, Nemo Digital Smile Design 3D system (DSD), exocad and Guided Positioning System (GPS) are some examples of such DSD systems [2].

Digital Smile Design (DSD) is a multidisciplinary planning tool that enhances diagnostic accuracy, interdisciplinary communication, and treatment predictability through comprehensive dentofacial analysis [2]. DSD enables comprehensive dentofacial analysis by combining standardized extraoral and intraoral photographs with facial reference lines to establish optimal gingival contour, tooth morphology, and dental alignment [9–11]. DSD software allows virtual closure of interdental spaces, modification of tooth morphology, adjustment of the

smile line, and shade enhancement using digital photographs or scanned models. Virtual tooth templates from digital libraries can be modified in terms of position, rotation, and morphology to establish the desired smile design. The finalized digital plan is subsequently translated into a conventional or virtual diagnostic wax-up to facilitate restorative procedures [2].

Meticulous treatment planning is fundamental to achieving conservative, predictable, and durable esthetic rehabilitation. Restorative intervention is indicated when modifications in tooth colour, morphology, contour, size, volume, or position are necessary [9].

Advances in minimally invasive esthetic dentistry have established ceramic laminate veneers as a predictable restorative option. Among the available glass-ceramic materials, lithium disilicate demonstrates superior mechanical strength, excellent optical properties, and well-documented long-term clinical performance [5]. The use of a diagnostic wax-up supports conservative tooth preparation, while adhesive bonding of ceramic veneers to enamel with resin cement provides predictable retention and increased resistance to fracture [9].

This clinical case series presents the clinical application of a Digital Smile Design-guided digital workflow for the minimally invasive esthetic rehabilitation of traumatized maxillary anterior teeth using lithium disilicate restorations, emphasizing predictable treatment planning and favorable esthetic outcomes [5].

Case Series

Case 1 – DSD-Guided Esthetic Rehabilitation

A 20-year-old male patient presenting dissatisfaction with his smile, sought dental treatment at the Department of Prosthodontics of ACPM Dental College and Hospital, with the chief goal of improving his smile and making it "brighter" and "more attractive" than currently. A written informed consent has been provided by the patient to have the case details and any accompanying images published. He was concerned regarding missing and fractured maxillary anterior teeth, due to road traffic accident and unaesthetic spacing, which were negatively affecting his self-confidence (Figure 1). The patient had high esthetic expectations. His medical history was non-contributory, with no systemic diseases, known drug allergies, or medical conditions that could compromise dental treatment or wound healing [12]. He was a non-smoker and denied alcohol consumption. There was no history of bruxism, temporomandibular disorders, or previous restorative treatment failures [13]. Dental history included routine check-ups, prophylaxis, and extraction with the remaining tooth fragment following accidental trauma [14].



Figure 1. Pre-operative extraoral record of the patient's initial situation.

During the clinical examination, extraoral findings demonstrated facial symmetry with a slightly convex profile and normal smile line extended bilaterally to the mesial side of the second premolar (Figure 1). Intraoral examination pointed out a disharmonious smile with disproportionate maxillary anterior teeth and irregular distribution of interdental spaces. Missing maxillary left central (21) and lateral incisors (22) and an Ellis Class I fracture involving the maxillary right central incisor were also observed. Minor diastemata were present between the maxillary right central and lateral incisors, canines, and first premolar. The edentulous ridge demonstrated favorable soft tissue contours, adequate mesiodistal space and appeared as a Seibert Class I defect (horizontal loss of tissue with normal vertical height) showing sufficient interarch space for prosthetic replacement [15]. Occlusal evaluation revealed a normal overjet and a mild deep overbite, with slight labial proclination of the maxillary incisors.

Occlusal evaluation revealed a Class I molar relationship with compromised anterior guidance due to the missing and fractured maxillary anterior teeth. Periodontal examination demonstrated healthy periodontal tissues, with probing depths of 1--2 mm and no bleeding on probing (Figure 2).

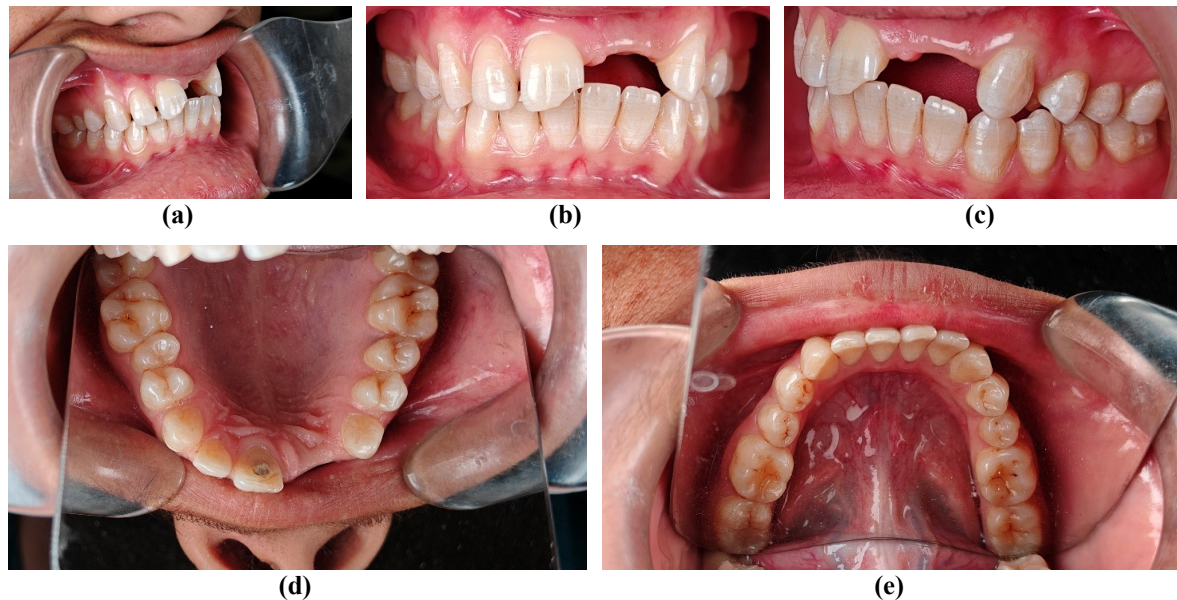


Figure 2. Pre-operative intraoral views of the patient's initial situation. (a) Right lateral view; (b) frontal view; (c) left lateral view; (d) maxillary occlusal view; (e) mandibular occlusal view.

Smile esthetics were comprehensively evaluated by assessing the initial tooth shade, facial and dental midline relationship, buccal corridor, incisal edge position relative to the lips at rest and during smiling, and phonetic assessment using the F and V sounds. The cervical margins of the maxillary anterior teeth exhibited harmonious alignment, with minimal buccal corridor display.

Following diagnosis and case analysis, the treatment options were discussed with the patient, focusing on esthetic rehabilitation of the maxillary anterior teeth. Restorative options included either conventional direct composite veneers or indirect ceramic veneers for esthetic recontouring of the right lateral incisor, canines, a full-veneer crown for the right central incisor and implant placement with left central and lateral incisors [16].

After reviewing each approach, the patient declined any surgical intervention. Later, minimally invasive esthetic rehabilitation plan with DSD-guided lithium disilicate (LDS) veneers and bridge was selected.

A Digital Smile Design (DSD)-guided treatment plan was proposed and accepted by the patient. The treatment was selected based on the patient's preference for a shorter treatment duration, the predictable visualization of the final outcome provided by the digital mock-up, enhanced clinician–patient communication, and the favorable esthetic and mechanical properties of lithium disilicate restorations, which allowed conservative tooth preparation. The digital workflow commenced with comprehensive data acquisition to facilitate diagnosis, smile analysis, and treatment planning. To improve predictability of the proposed treatment and to enhance communication among the interdisciplinary dental team, in addition to the manufacture of diagnostic casts, this phase utilized advanced technologies, including digital photographs, intraoral scanners and smile design software [17].

During the initial appointment, intraoral scans (DEXIS IS 3800W, Brea, California, USA) of the upper and lower arches were acquired, primary impression casts were made and complete photograph documentation (extra and intraoral) was conducted using appropriate lighting provided by a ring flash (Figure 3).

The below photographic views were taken:

- Forced smile
- Spontaneous smile
- Right side and left side view of smile
- Full face with a wide smile and the teeth apart
- Full face at rest
- Retracted view of the maxillary teeth slightly apart

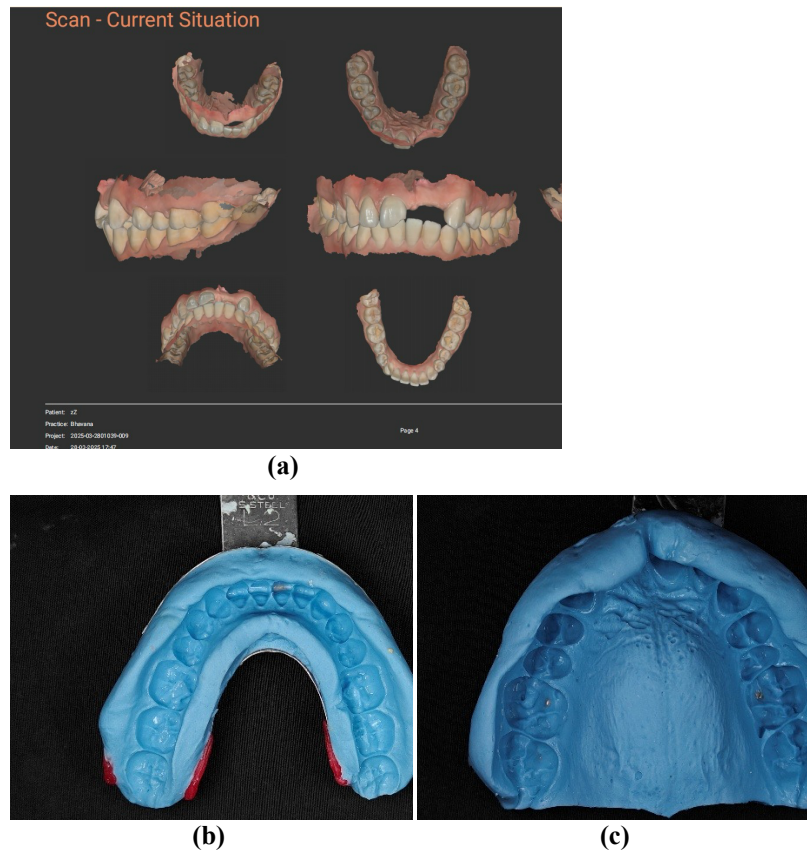


Figure 3. Initial diagnostic records. (a) Pre-operative intraoral scans; (b, c) diagnostic primary impressions. In the diagnostic cast, width-height ratio of the teeth was measured in order to calibrate the digital ruler, based on the measurements obtained. Subsequently, the acquired images were imported into software (exocad DentalCAD-Version 3.0), facial and dental reference lines were established to analyze orofacial harmonization and superimposed to assess dentofacial relationships and facilitate the creation of a harmonious digital smile design, which served as a blueprint for the diagnostic wax-up. In the full-face smile photograph, horizontal and vertical reference lines were established to form a facial cross. The interpupillary line served as the primary reference for determining the horizontal plane, while the facial midline was established using anatomical landmarks, including the glabella, nose, and chin. The full-face photograph with a wide smile and separated teeth was then aligned with these reference lines to determine the ideal horizontal plane and facial midline (Figure 4a). The dental midline and occlusal plane were identified, and their relationship with the facial reference lines was evaluated. Following facial analysis, dental analysis was performed by establishing three intraoral reference parameters: a horizontal line along the incisal edges of the central incisors, lines connecting the gingival zeniths of the maxillary canines, and a vertical line corresponding to the dental midline. These parameters enabled the transfer of the horizontal and vertical components of the facial cross to the intraoral view (Figure 4b).

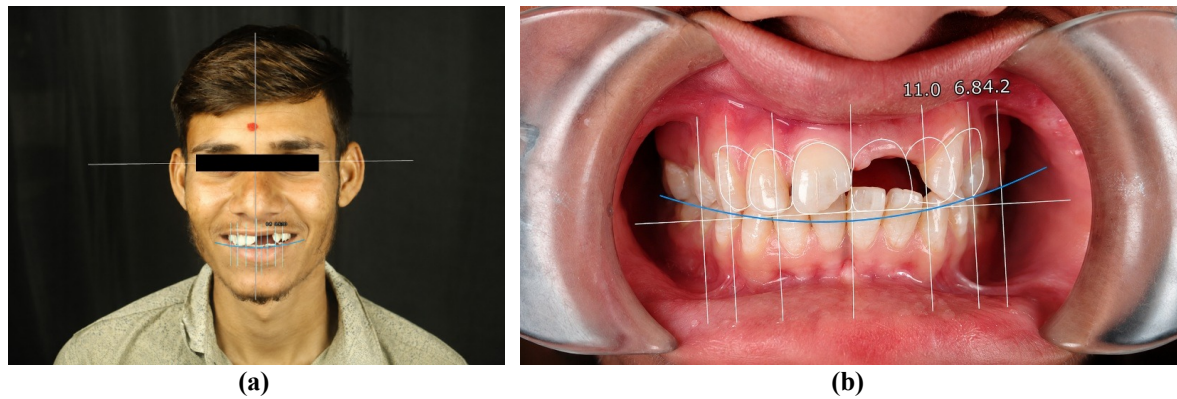


Figure 4. Orofacial harmonization lines. (a) Determination of the ideal horizontal plane and vertical midline on the facial photograph; (b) the three intraoral reference lines used to analyze the relationship among the facial lines, lips, teeth and gingiva.

Rectangular reference frames and digital tooth outlines were established to evaluate the morphology and width-to-height proportions of the pretreatment maxillary anterior teeth (Figure 5a). Based on the digital smile analysis, patient-specific ideal tooth proportions were determined (Figure 5b). Linear measurements obtained from the study model were used to calibrate the digital ruler, following which the virtual tooth dimensions were modified to achieve the planned esthetic proportions. The final tooth outlines and gingival contours were then digitally refined (Figure 5c). The finalized design was exported as a Standard Tessellation Language (STL) file and transferred to a 3D printer to fabricate the definitive digital model. This printed model served as the basis for the diagnostic wax-up.

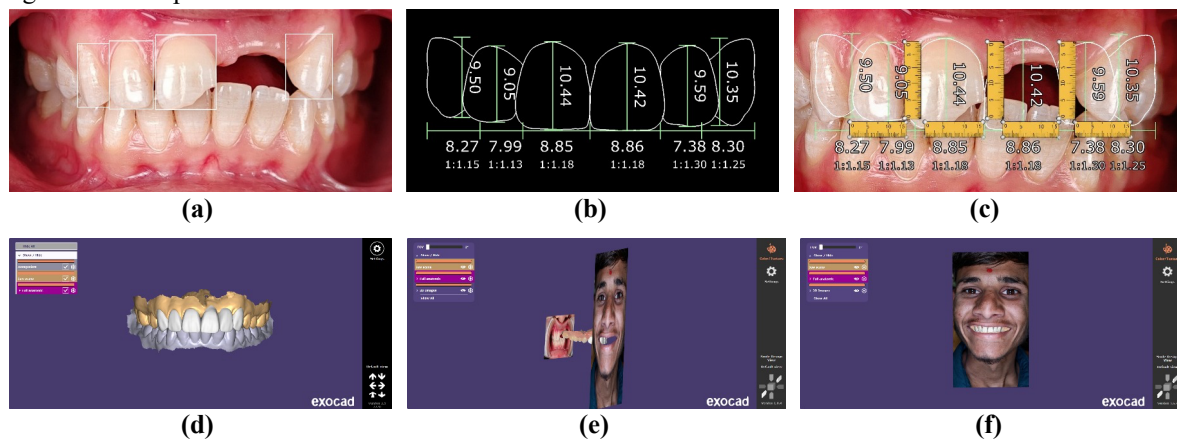


Figure 5. Digital Smile Design (DSD) protocol. (a) Rectangles placed over the maxillary anterior teeth, with tooth outlines defining the shape and proportions of the pretreatment teeth; (b) tool determining ideal proportions; (c) calibrated digital ruler with final tooth outlines and gingival contours, showing the relationship between the pre-operative situation and the final design; (d–f) Standard Tessellation Language (STL) design files.

The definitive treatment plan comprised intentional root canal therapy of the maxillary right central incisor (11), followed by prosthetic rehabilitation with a lithium disilicate fixed dental prosthesis extending from teeth 11 to 23 to replace the missing left central and lateral incisors. Lithium disilicate veneers were planned for teeth 12 and 13. To begin the clinical procedures, root canal therapy was the first step [18].

Following completion of endodontic treatment, the patient underwent oral prophylaxis [19]. After two weeks, tooth preparation was performed using the digital mock-up as a preparation guide. The three-dimensional printed diagnostic wax-up was used to fabricate two silicone indices using Zhermack SpA (Badia Polesine, Rovigo, Italy). One index was loaded with a bis-acrylic provisional material (Oratemp C&B, Prevest Denpro Limited, Bari Brahmanna, Jammu) and transferred intraorally to create a diagnostic mock-up, enabling evaluation of the proposed esthetic and functional outcome. Minor modifications were incorporated based on the patient's feedback. The second silicone index was used as a preparation guide to verify the extent of horizontal and vertical tooth reduction throughout the preparation procedure.

Before tooth preparation, shade selection was performed using the VITA 3D-MASTER shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) (Figure 6).



Figure 6. Pre-operative shade assessment with the VITA 3D-MASTER shade guide.

A size 000 knitted gingival retraction cord (Sure - cord, Sure Dent Corporation, Gyeonggi-do, Korea) was gently placed within the gingival sulcus to achieve soft tissue displacement and improve visualization of the cervical finish lines [20,21]. A silicone index fabricated from the diagnostic wax-up was used throughout the procedure to guide and verify the amount of tooth reduction (Figure 7a,b). Minimally invasive veneer preparations were performed on teeth 12 and 13 using a ceramic laminate veneer preparation kit, with enamel reduction limited to 0.3--0.5 mm in the middle third and approximately 0.2 mm in the cervical third. Full-coverage tooth preparations were subsequently completed for teeth 11 and 23 to serve as abutments for the fixed dental prosthesis. The prepared surfaces were finished and polished using diamond finishing burs and polishing discs to obtain smooth and well-defined surfaces for optimal bonding of the lithium disilicate restorations (IPS e.max Press, Ivoclar, Schaan, Liechtenstein) (Figure 7c,d).

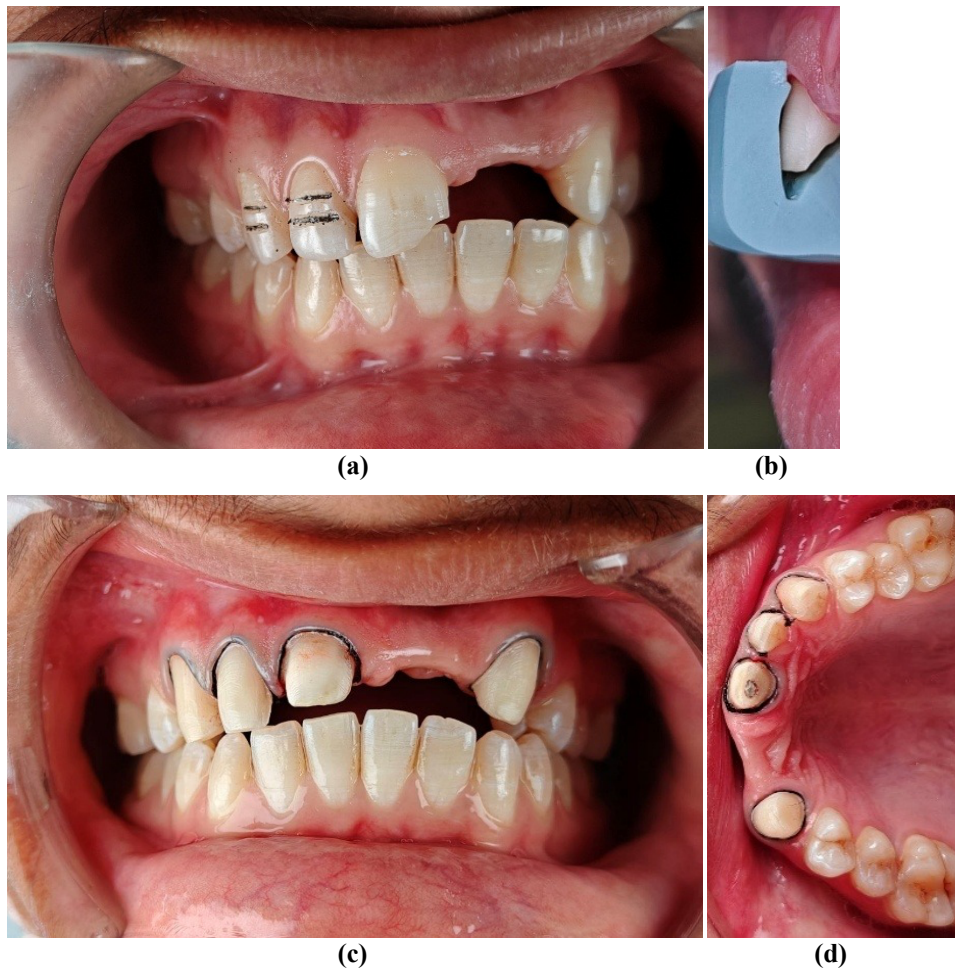


Figure 7. Minimally invasive tooth preparation. (a) Conservative preparation depth; (b) silicone index used to guide tooth reduction; (c) prepared teeth with retraction cords in place, frontal view; (d) occlusal view. No provisionalization was needed due to the minimal nature of the veneer preparations located in the enamel. Digital scans of the maxillary arch, mandibular arch, and occlusion were subsequently obtained using an intraoral scanner (Figure 8).

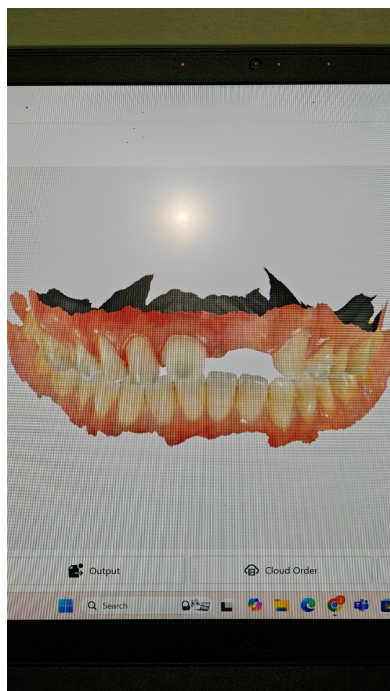


Figure 8. Intraoral scan of the prepared teeth.

The STL files from the intraoral scans were imported into DentalCAD (exocad GmbH, Darmstadt, Germany) to create a unified virtual model of the patient's dentition. The definitive restorations were digitally designed and subsequently fabricated from lithium disilicate using a CAD/CAM workflow.

A clinical try-in was performed to verify the fit, marginal adaptation, and esthetic outcome of the restorations before definitive cementation (Figure 9a,b). The appropriate resin cement shade was selected using try-in pastes, and a translucent shade was chosen. Following confirmation of the fit and esthetics, adhesive cementation was performed under rubber dam isolation. The intaglio surfaces of the lithium disilicate restorations were etched with 5% hydrofluoric acid for 20 seconds, thoroughly rinsed, air-dried, cleaned with phosphoric acid, and treated with a silane coupling agent for 60 seconds (Figure 9). The prepared teeth were etched with 37% phosphoric acid for 15 seconds, followed by application of a universal adhesive, which was gently air-thinned. The restorations were luted using a light-cure resin cement (Fusion Ultra D/C, Prevest DenPro Limited, Jammu, India), seated with firm digital pressure, and excess cement was removed using a microbrush and dental floss. Each restoration received an initial tack cure of 5 seconds, followed by final polymerization for 60 seconds from all aspects. Residual cement was removed, and the restorations were finished and polished using polishing burs and discs (Figure 9c,d).

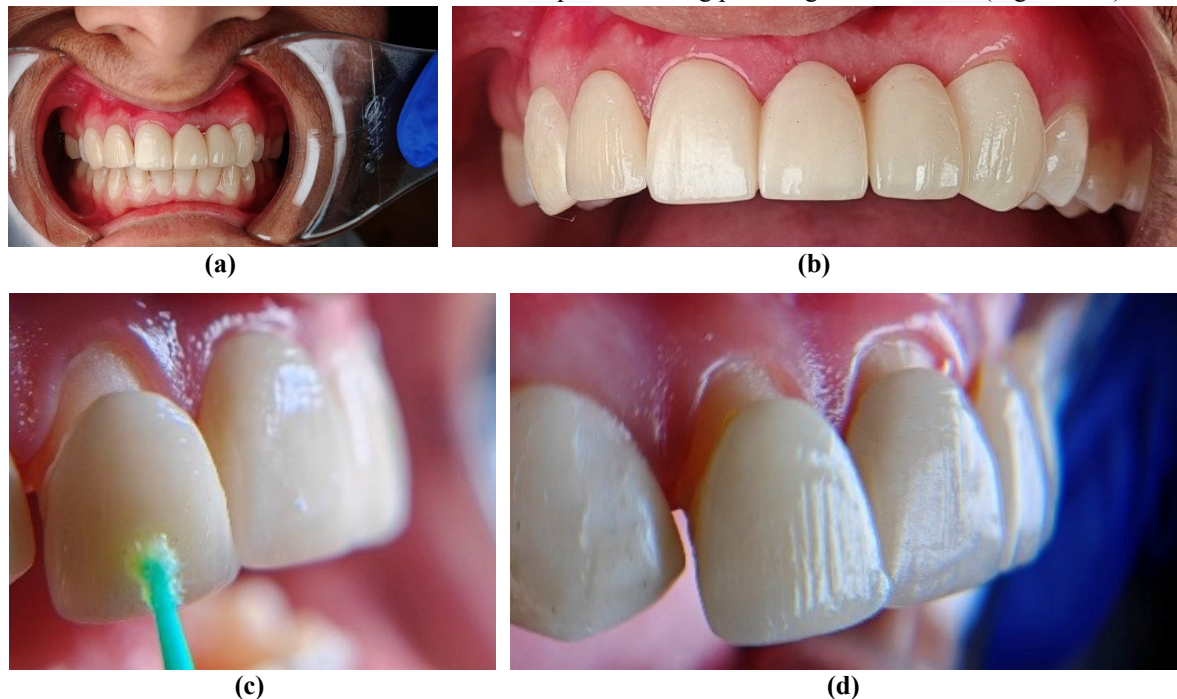


Figure 9. (a, b) Try-in of the lithium disilicate restorations; (c, d) definitive lithium disilicate restorations.

At the end of the treatment, the smile that had been proposed and designed digitally was achieved, and the patient was satisfied. The patient was scheduled for a 6-month follow-up program recall interval. After 1.5 years, he was still pleased and comfortable with his smile (Figure 10).



Figure 10. Patient's final smile at follow-up.

Case 2 – DSD-Guided Esthetic Rehabilitation

Patient-specific details to be inserted: age, sex, chief complaint, clinical findings, diagnosis, teeth involved, treatment option selected, restorative material, follow-up period, and outcome. The same standardized DSD workflow described for Case 1 may be reported for this patient where applicable. No patient-specific information has been fabricated in this template.

Case 3 – DSD-Guided Esthetic Rehabilitation

Patient-specific details to be inserted: age, sex, chief complaint, clinical findings, diagnosis, teeth involved, treatment option selected, restorative material, follow-up period, and outcome. The same standardized DSD workflow described for Case 1 may be reported for this patient where applicable. No patient-specific information has been fabricated in this template.

Case 4 – DSD-Guided Esthetic Rehabilitation (optional)

Patient-specific details to be inserted: age, sex, chief complaint, clinical findings, diagnosis, teeth involved, treatment option selected, restorative material, follow-up period, and outcome. This fourth case can be retained if complete clinical documentation is available; otherwise, it may be deleted before submission.

Discussion

Modern dentistry extends beyond the restoration of individual teeth, with increasing emphasis on achieving optimal esthetic outcomes alongside the rehabilitation of tooth structure [6]. A healthy and attractive smile plays a vital role in expressing an individual's emotions and enhancing facial appearance. Its esthetic appeal is determined by the harmonious relationship between the teeth and surrounding soft tissues. An attractive smile contributes to positive social interactions, improves self-confidence, and enhances overall personality [6,22].

In the present case, the patient desired an esthetically pleasing smile but was hesitant to undergo treatment because of the inability to visualize the anticipated outcome. Therefore, Digital Smile Design (DSD) was selected as the primary diagnostic and communication tool to facilitate treatment planning and enhance patient acceptance [1].

The integration of digital workflows into contemporary dentistry provides several advantages over conventional techniques, including enhanced communication among the dental team, improved treatment planning and coordination, fewer patient appointments, and more predictable clinical outcomes, as described by Coachman and Calamita [23]. Unlike conventional subjective assessment, Digital Smile Design (DSD) employs objective facial and dental reference parameters, including the interpupillary line, facial midline, gingival architecture, smile arc, tooth proportions, and facial symmetry, to create a patient-specific virtual smile [9]. This digital simulation serves not only as a diagnostic aid but also as a communication platform among the clinician, dental technician, and patient. Such integration minimizes discrepancies between the planned and final restorations and substantially improves treatment predictability [24].

One of the principal advantages of DSD demonstrated in the present case was its ability to convert conventional clinical information into an objective digital treatment plan. The extraoral and intraoral photographs, study models, and digital scans were integrated within exocad DentalCAD software to establish facial and dental reference lines, analyze width-to-height ratios, evaluate smile symmetry, and determine the ideal morphology of the definitive restorations [2]. This digital workflow enabled visualization of the proposed esthetic outcome before tooth preparation, allowing both the operator and the patient to assess the anticipated results [25].

An important component of the digital workflow was the fabrication of a diagnostic wax-up derived directly from the approved Digital Smile Design [5]. Unlike conventional wax-ups based primarily on stone casts, digital wax-ups incorporate facial reference parameters obtained during smile analysis, thereby providing a more realistic representation of the anticipated esthetic outcome [9]. The printed diagnostic model facilitated fabrication of silicone indices that served multiple purposes, including fabrication of the diagnostic mock-up, guidance during tooth preparation, and verification of restorative dimensions [2].

Recent studies have demonstrated that digitally generated mock-ups improve treatment predictability, facilitate communication, and increase patient acceptance of the proposed treatment [26].

This workflow promoted enamel preservation by enabling controlled tooth reduction while simultaneously allowing the patient to visualize and approve the proposed rehabilitation before definitive treatment [27]. Lithium disilicate was selected as the restorative material in the present case because it provides an optimal balance between esthetics, mechanical performance, and conservative tooth preparation [5]. Successful long-term performance of lithium disilicate restorations depends largely on an appropriate adhesive cementation protocol. Adhesive bonding improves restoration retention, marginal adaptation, fracture resistance, and stress distribution [5].

An important advantage of Digital Smile Design is the active involvement of patients during treatment planning [25].

Dang *et al.* described a minimally invasive rehabilitation using DSD-guided lithium disilicate laminate veneers following digital facial analysis and mock-up evaluation [5]. Similarly, the present case incorporated Digital Smile Design, digital mock-up, and adhesive lithium disilicate restorations to achieve predictable esthetic rehabilitation. However, unlike their case involving multiple laminate veneers, our patient required rehabilitation of traumatically missing anterior teeth using a combination of a fixed dental prosthesis and ceramic veneers [5].

Meereis *et al.* primarily reported rehabilitation using lithium disilicate laminate veneers following Digital Smile Design. The present report differs in that rehabilitation combined a lithium disilicate fixed dental prosthesis with laminate veneers to restore traumatic tooth loss while simultaneously correcting spacing and smile disharmony [9].

Ferreira *et al.* demonstrated a simplified Digital Smile Design workflow using Adobe Photoshop and Microsoft PowerPoint as cost-effective planning tools. In contrast, the present case utilized a complete digital workflow integrating exocad DentalCAD, intraoral scanning, digital wax-up, and CAD/CAM fabrication, thereby enhancing accuracy and laboratory communication [25].

The present case demonstrates incorporation of Digital Smile Design into routine prosthodontic practice may enhance treatment predictability, patient satisfaction, and long-term clinical success in anterior esthetic rehabilitation [1].

Declarations

Patient consent: Written informed consent was obtained from the patient for publication of the case details and accompanying images.

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