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Esthetic Rehabilitation Of Maxillary Anterior Spacing And Midline Diastema Using A Digital Smile Design Approach: A Case Report

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Abstract
Background: *Digital Smile Design (DSD) combines the evaluation of the face, dento-gingival tissues, and the virtual planning of restorations to visualize the esthetic outcome and to efficiently transfer it to the clinical workflow.*
Case presentation: *Clinically, a 40-year-old woman was seen who had a midline diastema, generalized spacing between the maxillary canines and mild anterior tooth proclination. An orthodontic treatment was advised, but the patient refused this treatment. A standardized extraoral and intraoral photographs along with a 3D intraoral scan were used to virtually construct a 2D smile design and 3D virtual mock-up using the 3Shape software. The preparation of the teeth and provisional restoration were guided using three-dimensional printed models and silicone index. CAD/CAM fabricated monolithic zirconia crowns were made for teeth 13–23 and cemented after confirmation of the endodontic therapy of tooth 21 and intentional endodontic therapy of tooth 11. Digital impressions allowed communication with the dental lab and after thorough clinical checking, the definitive restorations were adhesively luted.*
Conclusion: *The DSD-assisted workflow allowed the systematic diagnosis, patient-specific visualization, controlled transfer of the virtual treatment plan and coordinated fabrication of the definitive prosthesis. If there is a decision not to do orthodontics, it is important to clearly explain the increased biological consequences for restorative correction, and to prepare teeth with an additive restorative plan in mind.*
Keywords: *CAD/CAM; Case report; Digital Smile Designing; Maxillary diastema; Monolithic zirconia*

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I. Introduction

Smile is an important facial expression and esthetic perception depends on the interplay of face, lips, gingiva and teeth and how they move. A maxillary midline diastema can be a normal appearance in certain facial and cultural situations, but often the patient requests treatment because the space and/or the inclination of the teeth and/or the asymmetry in the distribution of the spaces has an undesirable impact on the self-perceived appearance. Correcting a central gap thus involves more than just closing the gap, it involves analyzing facial midline, occlusal plane, position of the incisal edges, tooth proportions, gingival architecture, phonetics and functional envelope. [1-4] Digital Smile Design offers a systematic way to transfer reference lines and suggested tooth forms to standardized photographs, and correlates the 2D plan with the 3D scan information. This process may enhance diagnostic imaging, enhance communication between the patient, clinician and lab personnel, enable an additive mock-up to be tested prior to irreversible treatment. [1,2,6-10] The virtual design can also be printed in models, silicone indices or be used to fabricate provisional restorations to guide the clinical implementation and control the amount and distribution of the tooth reduction. [7,10,12] In general, orthodontic alignment is the most conservative approach with anterior spacing with proclination, allowing the spaces to be redistributed and anterior axial inclination to be corrected prior to restorative work. However, some patients refuse to get orthodontic treatments due to the length of time it takes, the device that is used during treatment, or personal preference. In these situations, a restorative approach should be designed carefully considering the risk to the pulp, remaining tooth structure, emergence profile, occlusion and limitations of apparent alteration of the position of the tooth

with restoration. The following is a description of a DSD-guided, mostly digital workflow for prosthodontic rehabilitation of a maxillary anterior diastema from canine to canine using CAD/CAM monolithic zirconia crowns. The report is structured following the CARE framework of reporting cases. [5]

II. Case Presentation

Patient information and clinical findings

A 40-year-old female patient presented to the Department of Prosthodontics and Crown & Bridge with the chief complaint of spacing between the maxillary anterior teeth, including a prominent midline diastema and mild proclination of the maxillary anterior teeth, resulting in an unaesthetic smile. The patient expressed a desire to have the spaces closed and to improve the aesthetics of her smile. Extraoral examination was performed using frontal, smiling, and profile views. Intraoral examination revealed a prominent midline diastema between teeth 11 and 21, generalized spacing in the maxillary anterior segment, and mild proclination of the maxillary anterior teeth (Fig 1). No clinical signs of disease in the periodontal tissues and no oral pathology were found. The tooth #21 had been previously treated with root canal treatment and the anterior teeth were clinically sound.

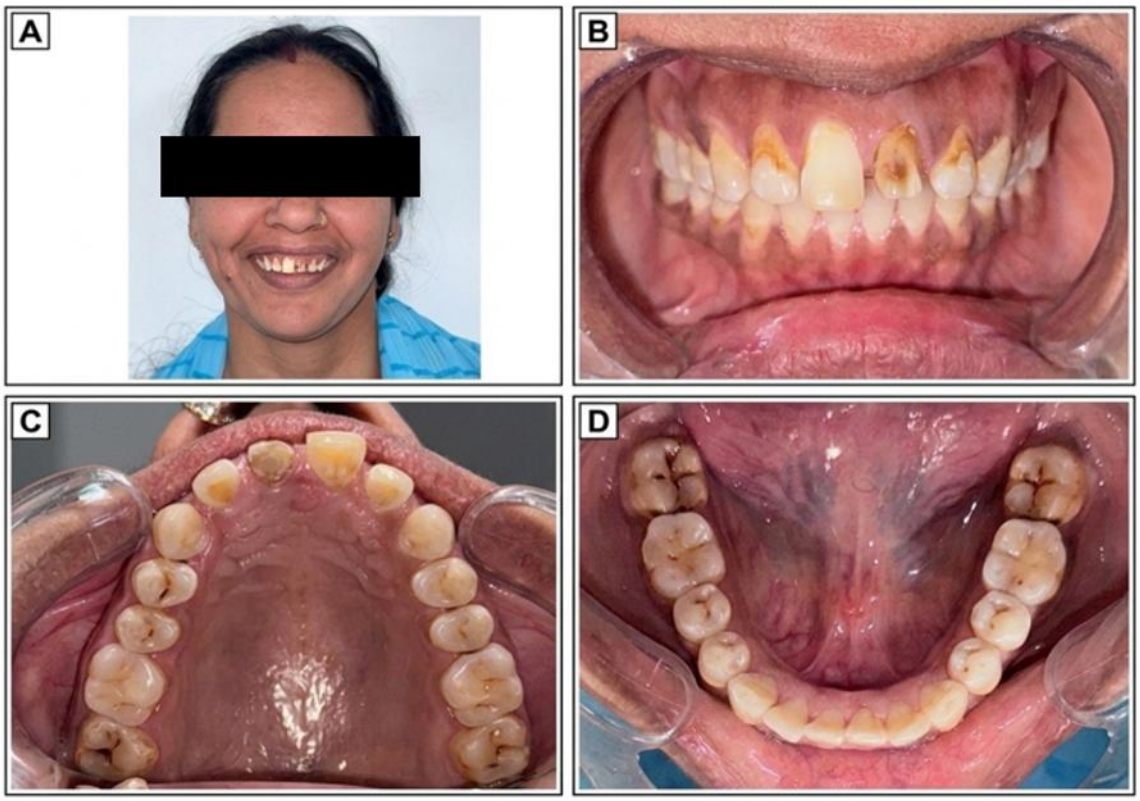

Figure 1. Preoperative assessment. (A) Frontal facial photograph; (B) Frontal intraoral view demonstrating the maxillary midline diastema and anterior spacing; (C-D) Maxillary and Mandibular occlusal views.

Diagnostic assessment and treatment planning

The treatment objective was to achieve esthetic closure of the anterior diastemas while establishing optimal dentofacial harmony, physiologic anterior guidance, cleansable emergence profiles, and appropriate tooth proportions and symmetry. Orthodontic treatment was recommended to correct the mild proclination of the maxillary anterior teeth, optimize space distribution, and minimize the extent of tooth preparation required for definitive restorations. However, after a detailed discussion of the benefits, limitations, treatment duration, and restorative implications of the available treatment options, the patient declined orthodontic therapy and elected to undergo prosthodontic rehabilitation. Standardized extraoral photographs and digital intraoral scans were acquired using an intraoral scanner (SHINING 3D, Hangzhou, China) (Fig 2A-C). The photographic and digital scan datasets were imported into the 3Shape Unite platform (3Shape, Copenhagen, Denmark) for digital smile analysis, virtual treatment planning, and workflow integration. The relationship between the dental midline and the face, width/length ratios and gingival levels of the teeth, and distribution of anterior spaces were determined using facial and dental reference lines (Fig 2D-F). A two-dimensional smile design was first designed and discussed with the patient. The treatment plan was then incorporated with the intraoral scan to create a 3D virtual wax-up from tooth 13 to tooth 23.

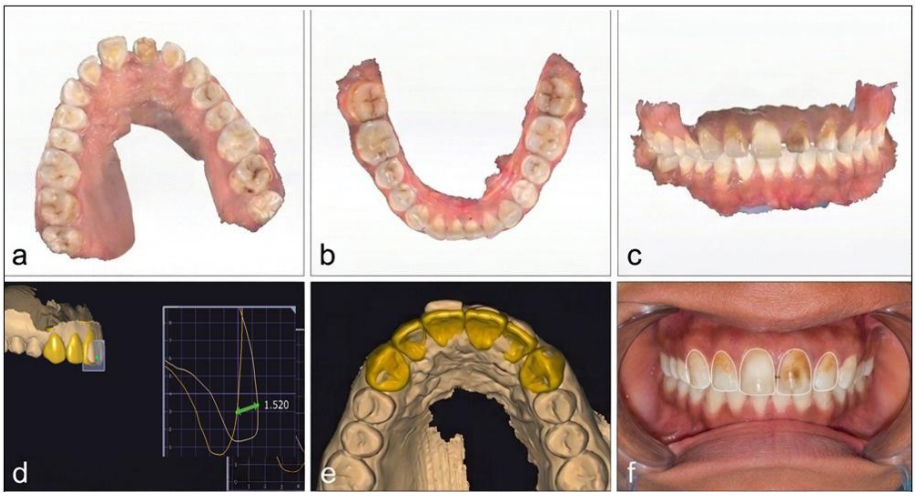

Figure 2. Digital planning sequence. (A-C) Preoperative intraoral scans; (D-F) Digital smile analysis, virtual treatment planning

A pair of resin models was fabricated using additive manufacturing to produce a silicone index for the fabrication of provisional restorations (Fig 3A). Virtual treatment planning revealed inadequate restorative space for tooth 11 due to its proclination. To achieve the planned restoration without compromising pulpal health, intentional endodontic treatment was performed on tooth 11. Tooth 21 had been previously endodontically treated. Periapical radiograph was taken to evaluate the teeth #11 and 21 and periapical areas (Fig 3B).

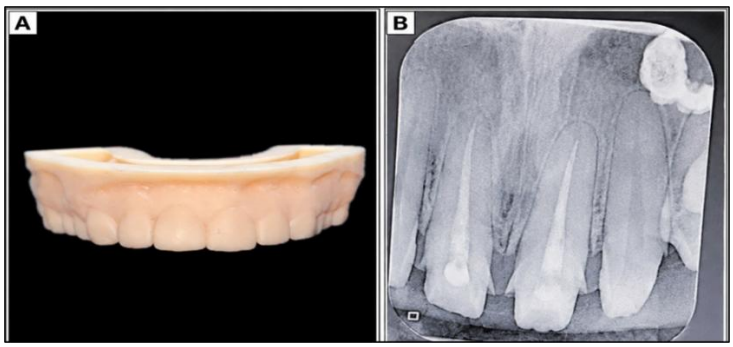

Figure 3. Mock-up **(A)** Additively manufactured resin model (**B)** Preoperative periapical radiograph

Table 1. Clinical timeline

Stage	Clinical procedures	Purpose/decision
Visit 1	History, extraoral and intraoral examination, photographs, intraoral scans, and periapical assessment.	Establish diagnosis and baseline records.
Planning	Orthodontic option discussed; patient elected prosthodontic correction. Two-dimensional DSD and three-dimensional virtual wax-up prepared.	Define facially guided restorative endpoint and obtain patient approval.
Mock-up	Two 3D-printed models fabricated; intraoral mock-up and silicone preparation index produced.	Validate esthetics, phonetics, proportions, and transferability.
Pre-restorative	Intentional endodontic treatment completed for tooth 11; tooth 21 had been treated previously.	Create restorative space while managing anticipated pulpal risk.
Preparation	Preparation of teeth 13–23; gingival displacement; digital impression.	Control reduction and record finish lines accurately.
Provisional phase	PMMA provisional crowns, and occlusal refinement.	Evaluate appearance, function, and soft-tissue response.
Definitive phase	CAD/CAM monolithic zirconia crowns try in and resin-luted; immediate postoperative records obtained.	Deliver definitive esthetic and functional rehabilitation.
Follow-up	Clinical review performed at 6 months.	Assess retention, margins, occlusion, tissues, and esthetic integration.

Tooth preparation and provisional phase

A silicone reduction index, fabricated from the additively manufactured diagnostic cast, was sectioned and used as a chairside preparation guide to assess and ensure adequate three-dimensional tooth reduction. Teeth 13–23 were prepared for full-coverage zirconia crowns with uniform axial reduction of 0.8–1.0 mm and incisal reduction of 1.5–2.0 mm to achieve sufficient restorative space. A continuous circumferential deep chamfer finish line of 0.8–1.0 mm was established (Fig 4A-B).

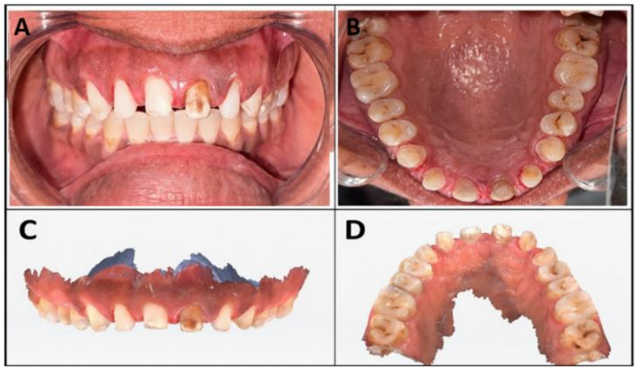

Figure 4. Preparation stages. (A-B) Tooth preparation of the maxillary anterior teeth; (C-D) Post-preparation digital scans

Provisional crowns were made using PMMA resin (DPI, Dental Product, Mumbai, India) from the accepted design and a HY-Bond Temporary Cement (Shofu Inc., Kyoto, Japan) was used to cement the provisional crowns. Occlusion, proximal contacts, incisal display, phonetics, anterior guidance, and patient acceptance of the aesthetic outcome were evaluated (Fig 5).

Figure 5. Provisional phase- PMMA provisional restorations

Digital impression and Definitive restoration

Size 000 retraction cords were placed atraumatically in the gingival sulci for 6–7 minutes to achieve adequate exposure of the cervical finish lines before digital impression. Following atraumatic cord removal and moisture control, the prepared teeth were digitally scanned with precise IOS (Fig 4C-D). The digital scan data were exported as STL files and transferred to the dental laboratory for CAD/CAM fabrication of the definitive restorations. During try-in, marginal adaptation, proximal contacts, contour, shade matching, and occlusion were evaluated. The restorations were conditioned and luted with resin cement (3M RelyX; 3M, St. Paul, MN, USA) (Fig6A-D). At the 6-month recall, the restorations demonstrated satisfactory retention, marginal adaptation, occlusal stability, periodontal health, and aesthetic integration, with no requirement for corrective intervention.

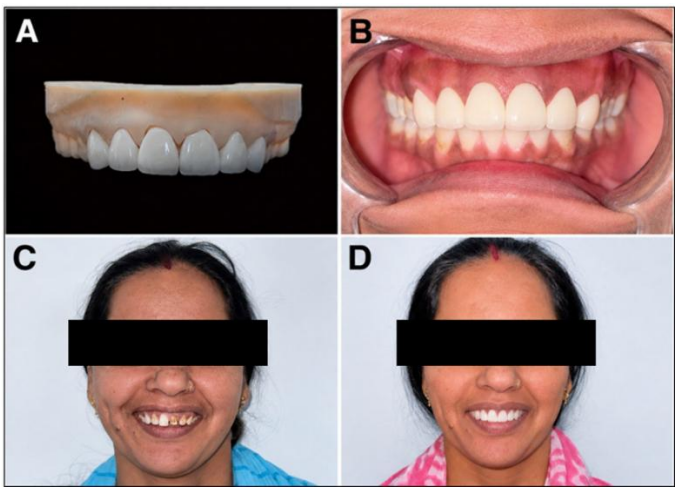

Figure 6. Definitive Phase (A) Definitive anterior restorations on the model; (B) Intraoral view of the CAD/CAM monolithic zirconia restorations from tooth 13 to 23; (C) Preoperative frontal facial view; (D) Postoperative frontal facial view;

III. Discussion

This case proves to be a DSD diagnostic and transfer protocol and is not just being used as a presentation tool. Facial/smile references were made from the preoperative photographs and the three-dimensional dental anatomy was provided from the digital scan. Thanks to their integration, it was possible to assess the tooth proportions and space closure prior to any irreversible treatment in relation to the face. The visual preview was also a great asset to shared decision making as the patient could see what was involved in the intended outcome and visualize it against their current smile, which was often a key element of the DSD literature. [1,2,6-10] Midline diastema, adjacent spacing and anterior proclination were the three major challenges in the treatment planning. Preparing for axial correction was to be considered a conservative second choice and orthodontic alignment would have reduced it. The patient nevertheless decided to go for prosthodontic treatment. Respect of this preference was achieved by explaining clearly that the cost of biological factors for full-coverage restorations from canine to canine was much higher than those of the orthodontics, additive direct restorations and selected veneer approaches. The virtual wax-up was used in the present case to identify if it was possible to develop the desired external contours without too much over contouring. The only tooth that needed endodontic treatment had been endodontically treated prior to presentation, and only one tooth 1.e, 11, was deemed to have an expected vital preparation and required endodontic treatment as a planned outcome. Controlled execution was one of the key components to the mock-up of the additive and silicone index. A freehand preparation might be too aggressive, or, if the desired preparation is within the original boundaries of the tooth, it might not leave enough room for restoration. Digital waxing-guided protocols and indices can enhance the ability of the clinician to distribute reduction in accordance with the final design, however the accuracy of this depends on the quality of the scan, the quality of the print or models, the stability of the index, the calibration of the burs and the operator's control. [7,10,12] This reduction was used in this case for full contour zirconia crowns and not for minimally invasive veneer restorations and should not be applied to other restorative designs. Impression margins and areas where under-recorded areas could be instantly evaluated with the digital impression, and the STL data set could be sent without the distortion that is possible to occur with impression storage or transport. Studies regarding intraoral scanning have demonstrated the clinical efficacy of digital impressions in numerous fixed prosthodontic scenarios with potential variations in accuracy based on the length of the span, tissue control, scanner strategy, reflective surfaces, and operator experience. [13,14] Therefore, gingival displacement and high definition capturing of the cervical areas was important in this case. Monolithic zirconia was chosen to offer a CAD/CAM fabricated restoration that offers high fracture resistance and minimizes the risk of chipping of the veneering-ceramic. While today's zirconia materials offer better translucency than previous generations, the optical properties, minimum thickness, surface treatment, bonding, antagonist wear and long-term aging are still dependent on the material and manufacturers. [15] For this reason, the use of zirconia in a highly visible anterior segment should be determined on the basis of the colour of the substrate, the thickness that is available, the laboratory characterization and the esthetic expectations of the patient, not just on the strength. The immediate outcome revealed good closure of the diastema and integration of the restored segment. The main advantages of the workflow were that the planning was done in a facially driven manner, an approved three-dimensional endpoint was available, guided transfer was possible, digital margin capture was utilized, and provisional restorations were used to evaluate the design. The single patient design, the lack of objective esthetic pre- and postoperative scoring and the lack of calibrated periodontal and marginal fit measurements are limitations, as is the lack of follow-up detail documented. The photographs are also a static evaluation; dynamic smile and voice recordings would have been helpful to give more information. Further study is needed to determine the biological and technical life of this species.

IV. Conclusion

An additive workflow was successfully coordinated and used for the diagnosis, patient visualization, additive planning, guided preparation, provisional evaluation, digital impression and CAD/CAM fabrication for prosthodontic correction of a maxillary anterior diastema using a DSD-guided workflow. This approach was especially convenient for transfer of the desired tooth proportions and incisal relationship to the clinical restoration from the virtual restoration. However, when it is decided not to perform an orthodontic treatment, the practitioners must clearly explain that the biological expense of the axial correction to be performed is higher than the expense of non-axial correction and they should apply the digital plan to achieve minimum extra reduction.

Clinical Significance

Digital smile planning in conjunction with intraoral scanning and a printed mock-up can transform an esthetic concept to a treatment endpoint that can be clinically verified. The protocol offers a sequence of steps for communicating with the patient, preparing and provisionalizing, and transferring to the laboratory in difficult anterior spacing situations while maintaining the principles of conventional biologic, periodontal and occlusal treatments.

Declarations

Declaration	Statement
Patient consent	Written informed consent was obtained from the patient for treatment and for publication of the clinical details and identifiable images.
Ethical approval	Ethical approval was not required for this single-patient case report describing routine clinical care.
Source of support	Nil.
Conflict of interest	The author declares no conflict of interest.

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