The esthetically guided and occlusally protected (EGOP) technique

Case report of fully digital adhesive rehabilitation in patients with dental structure loss

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Abstract

Aim: To describe a technique for performing an adhesive oral rehabilitation based on a digital workflow and focused on the integration between esthetic and occlusal aspects in a young patient with a worn dentition.
Materials and methods: An adhesive oral rehabilitation with severe loss of dental structure in a 40-year-old male patient is described. The treatment was based on a fully digital workflow (including facial scanning), esthetic and occlusal virtual planning, guided implant surgeries, an adhesive resin prototype, and ceramic restorations. The technique integrates both esthetic and occlusal factors, splitting the dental arches into four sectors and following a stepped sequence with specific objectives for each one. The loss of dental structure was initially rebuilt by an adhesive composite resin full-mouth prototype rehabilitation. This step also helped to confirm the esthetic and occlusal digital planning. After 4 months, lithium disilicate restorations were delivered following the same order, sector by sector, to reduce possible errors when transferring the previously approved anatomy to the final ceramic oral rehabilitation. Lastly, an acrylic nightguard was installed and a 6-month recall program established.
Results: An accurate integration between esthetic and occlusal aspects was achieved during digital planning, which was also corroborated by the adhesive resin prototype. The final ceramic restorations fulfilled the patient's esthetic expectations and recovered the occlusal anatomy.
Conclusions: The proposed esthetically guided and occlusally protected (EGOP) technique seems to be a reliable approach to treat patients with worn dentition. Further clinical research and additional proposals are necessary to assess the possible benefits associated with these procedures.

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Introduction

Important changes have occurred in the field of prosthetic dentistry over the past 20 years. Developments in adhesive materials, implantology, and, most recently, digital dental technologies have impacted positively on daily practice. New software programs allow fluent facially driven planning, which has become a fundamental clinical step to improve the communication among the patient, dental team, and dental technician. Therefore, the predictability of the treatment objectives can be improved from the beginning.[1-6]

Conventional analog semi-adjustable articulators have been a key instrument for many years.[7,8] However, the lack of integration between occlusal aspects and the patient's face can jeopardize esthetic references by adding possible errors to the desired planning. In these analog systems, in order to connect the facial structures to the maxillary casts, the use of a conventional facebow is needed.[9] However, the articulator's design does not offer information about the temporomandibular joint or the oral and facial soft tissue. These limitations may negatively affect an accurate integrated diagnosis between esthetic and occlusal features, and, consequently, the entire planning.

In the last few years, some digital proposals such as Digital Smile Design (DSD)[4] have allowed the transference of certain facial reference parameters to dental casts using standardized dental and facial photography.[10] Most publications using this technique are focused exclusively on the maxillary anterior teeth, with no full-mouth recommendations.

The evolution of current digital technologies also includes CBCT, digital models obtained through 3D printing, and, more recently, complete facial scanning. All these tools serve to improve the occlusal and esthetic integration and can ensure an optimal outcome in prosthetic treatments.[11,12]

Regarding biomechanical aspects, the literature has shown that most complications in fixed prosthodontics are associated with factors related to occlusion, and, more specifically, with parafunctional habits.[13] As the loss of tooth structure produces biologic, esthetic, and occlusal disorders, the challenge for clinicians is to establish suitable treatment planning to recover such factors. Therefore, the need for a reliable integration between esthetics and occlusion in adhesive prosthetic rehabilitations is of extreme importance for long-term success.

The esthetically guided and occlusally protected (EGOP) technique is a step-by-step treatment sequence, based on the different features and characteristics of the anterior and posterior teeth. The rationale of this four-step protocol relies on:

1. The importance of an esthetic result. Therefore, treatment planning starts with the maxillary anterior teeth.
2. A smooth integration between esthetic and occlusal aspects. This is initially established by an accurate relationship between the maxillary and mandibular anterior teeth.
3. Solid posterior tooth support for a suitable distribution between biomechanical, functional, and parafunctional forces.

The objective of the present article is to introduce a digital restorative technique that integrates esthetic and occlusal aspects during diagnosis, planning, and prosthetic treatment to rehabilitate patients with loss of tooth structure. The authors have termed this clinical systematization the EGOP technique.

Clinical report

A 40-year-old male presented to a private dental office. His main complaint was his

Fig 1 Preoperative view. (a) Patient's smile showing worn anterior tooth. (b) Intraoral view of the occlusal relations in maximum intercuspation (MI) showing edge-to-edge anterior teeth. (c and d) Intraoral occlusal views of the dental arches revealing severe enamel and dentin loss on the occlusal surfaces. (e and f) Lateral views in MI showing an unbalanced occlusal plane. (g) Panoramic radiograph.

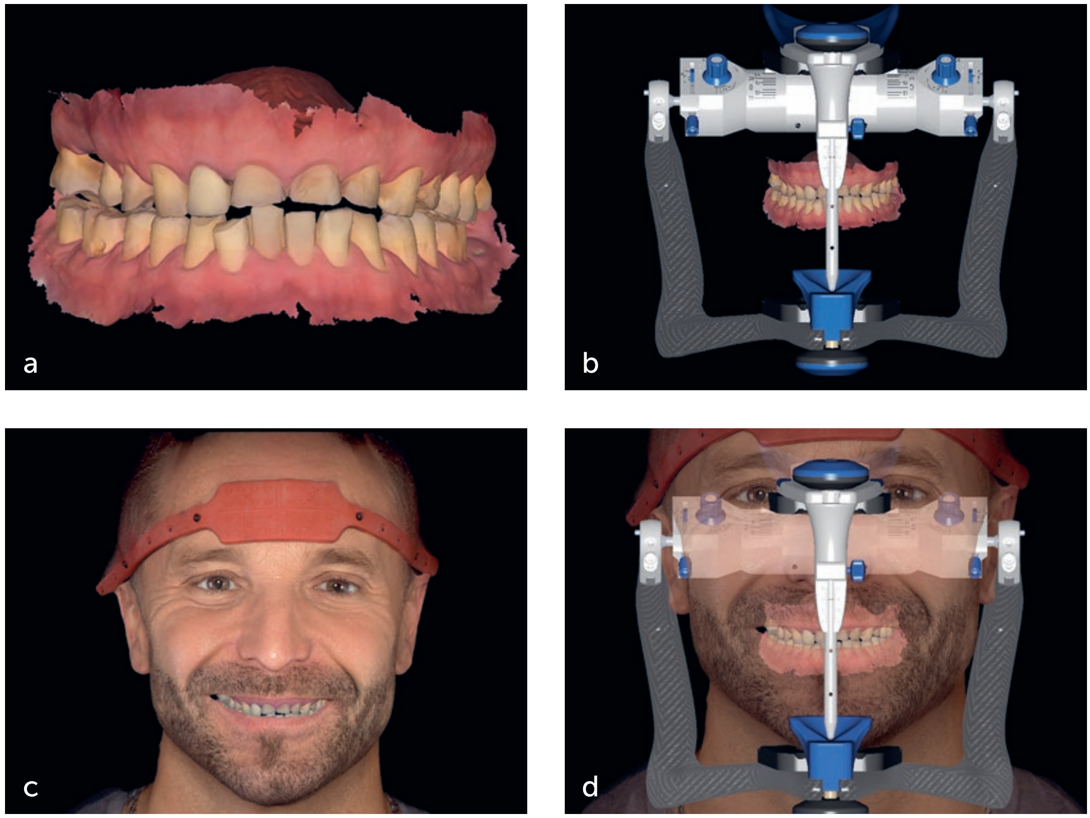


Fig 2 Files obtained through intraoral and facial scanning. (a) Occlusal relations in centric relation of occlusion (CRO) (exocad). (b) Virtual articulator with intraoral captures. (c) Merged intraoral scans (PLY files) with facial scan (OBJ files). (d) Full integration of facial, dentolabial, and intraoral aspects with the virtual articulator (exocad).

unesthetic smile, caused by the loss of tooth structure as a result of the parafunctional habit of bruxism. Intraoral and extraoral examinations were performed, and photographs and intraoral (Trios 3; 3Shape, Copenhagen, Denmark) and extraoral (Vectra H2 3D Imaging System; Canfield Scientific, NJ, USA) scans were taken with facial scan bodies (AFT Dental System, Sevilla, Spain).

Facial analysis showed an unpleasing situation during lip rest and smile, associated with the loss of dental structure. The intraoral examination revealed several cavities, cervical lesions, and the widespread loss of hard tissue, with generalized signs of erosion and attrition. The functional examination of the anterior teeth in maximum intercuspation (MI) revealed considerable surface contacts with a cusp-to-cusp relation and an Angle Class III tendency. This condition was caused by the lack of posterior support and loss of the vertical dimension of occlusion (VDO). Dynamic analysis showed a total absence of anterior guidance with a bilateral balance during excursive movements on both sides. The clinical images and panoramic radiograph are shown in Figure 1.

The obtained data were overlapped and processed through a design software program (exocad; exocad, Darmstadt, Germany). This step was performed to integrate facial esthetics, dentolabial aspects, and the patient's occlusion (Fig 2). Once the files were integrated, the digital planning was started.

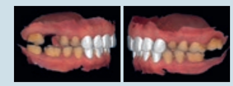
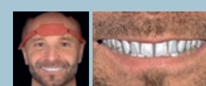
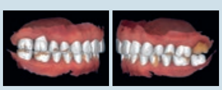
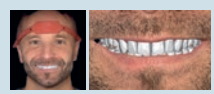
	Zone	General objectives	Esthetic parameters	Occlusal parameters
1		Esthetics Phonetics	Central incisal edge at rest Incisal edges and gingival margins during smile 	Maxillary incisal edges Palatal anatomy 
2		Centric relation of occlusion Vertical dimension of occlusion (VDO) Anterior guidance	Facial harmony 	Bilateral canine contact VDO Anterior relations 
3		Occlusal plane	Buccal corridor Full smile alalysis 	Posterior 3D alignment Curves 
4		Posterior support	Full esthetic analysis Facial report 	Interocclusal relations Posterior disocclusion 

Fig 3 Schematic representation of the steps of the EGOP technique. The dental arch areas are shown in the 'Zone' column. Then, general objectives and esthetic/occlusal parameters are related to each oral cavity sector.

The patient's dentition was split into four sectors, each with specific requirements and clinical objectives. Figure 3 describes the general objectives and esthetic/occlusal aspects.

Digital planning began with the six maxillary anterior teeth, also called Sector 1 (S1). The position of the incisal edge of the maxillary central incisors was determined by the position of the resting upper lip (ideally, 2 to 4 mm below the lip line). Once this parameter was set, the upper lip smile line was used to determine the length of the maxillary central incisors. After the incisal edge and smile line were recorded, the proportion between width and length was determined. The correct establishment of S1 is crucial for the steps that follow, since S1 is responsible for esthetics and phonetics. A bisacrylic mock-up is recommended in complex cases or in the event of doubts regarding proportion or size in order to confirm the dental design; this can also include the buccal aspect of the maxillary premolars to complete the smile analysis.

Planning continued with Sector 2 (S2), which included the mandibular anterior teeth in between the canines. The anatomical shape was established according to the proportions of the mandibular incisors and the relationship with S1. The virtual articulator module (exocad) was used to increase the closing arch and generate enough space for the anatomical reconstruction of the mandibular anterior teeth, to establish a correct overjet and overbite.

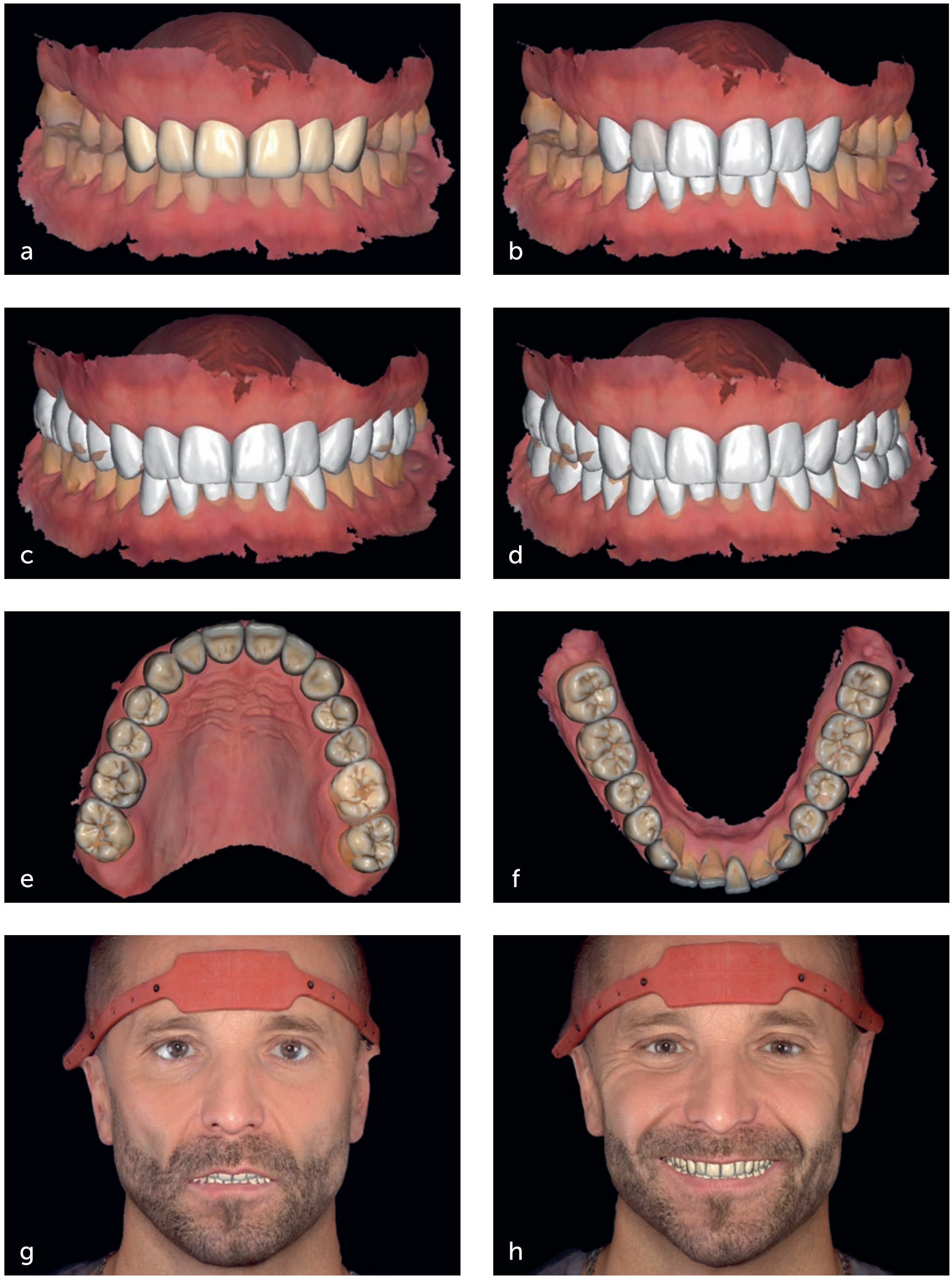


Fig 4 Digital planning. (a) Sector 1 (S1): Maxillary anterior tooth digital design. (b) Sector 2 (S2): Mandibular anterior tooth digital design, establishing an increase in the vertical dimension of occlusion (VDO), based on the bilateral contact of the canines in CRO. (c) Sector 3 (S3): Maxillary posterior tooth digital design, according to 3D alignment and avoiding occlusal contacts for the future reconstruction of the opposite teeth. (d) Sector 4 (S4): Mandibular posterior tooth digital design, determining the occlusal plane, posterior support, and occlusal stabilization in CRO. (e and f) Occlusal views of the final digital design on the structure of both dental arches. (g and h) Control of the dental exposure during lip rest and smile positions with extraoral meshes, based on digital planning reconstruction.

The aims of this step are:

1. To obtain the bilateral contact of the canines.
2. To determine a new VDO.
3. To obtain the centric relation of occlusion (CRO).

These three goals are vital for the correct integration between esthetic and occlusal parameters, and the clinician should not move forward without achieving them.

Clearly, this new VDO and CRO cannot be maintained over time with only bilateral contact of the canines; therefore, the following steps focus on the reconstruction of the posterior teeth.

Sector 3 (S3) includes the digital design of the maxillary posterior teeth, which complements the esthetic aspects when defining the smile corridor. The occlusal plane was set by the anatomical alignment of the curves of Spee and Wilson as well as the sagittal curves. A sufficient prosthetic space for the remaining posterior-inferior tooth morphology must be controlled, while maintaining the contact between the canines.

Finally, Sector 4 (S4) was designed. This sector corresponds to the digital restitution of the mandibular posterior tooth morphology. The 3D alignment and interocclusal relationship with the opposite jaw are the factors that should be taken into account to determine this anatomy. In this way, stable mandibular closure was set by multiple occlusal contacts provided by the posterior support. To ensure a functional anterior guidance, canine disocclusion of the posterior sectors during mandibular eccentric movements should be visualized, with uniform spaces between the arches.

The step-by-step approach of each sector, the occlusal view of both arches, and the facial impact of digital planning in this four-step technique are shown in Figure 4.

Once the digital design was primarily approved, final CAD files were exported and 3D printed (Asiga; Dental Axess, Sydney, Australia). A full-mouth mock-up with bis-acrylic resin (Protemp 4; 3M ESPE, Seefeld, Germany) was performed using silicone indexes obtained from the printed model. This step transfers the information from the digital design to the patient's mouth with the aim of assessing the esthetic and occlusal parameters. This full-mouth mock-up must be carefully evaluated and approved by both the clinician and the patient. The aims of this step are to preview the final result before the start of treatment, to confirm the planned reconstruction, to plan the position of the implants, and to evaluate possible orthodontic treatment in S2.

Clinically, the treatment started with oral hygiene therapy (periodontal treatment and plaque control). The following step is a biologic and structural reconstruction. Tooth decay, previous failed restorations, cervical enamel loss, unsupported cusps, and other issues should be replaced, reinforced or restored with direct composite resin restorations (Beautifil II; Shofu, Kyoto, Japan). Tooth 37 was extracted due to an endo-periodontal compromise. An old porcelain-fused-to-metal crown on tooth 12 was replaced by an acrylic provisional. No further occlusal or major esthetic modifications were undertaken in this step.

Based on the prosthetic planning, guided surgery planning (CoDiagnostiX; Dental Wings, Montreal, Canada) was performed to place two wide-neck implants (4.8 x 10 mm; Straumann, Basel, Switzerland) in regions 16 and 37. After 6 weeks, 5.5-mm abutments (Solid Abutments; Straumann) were installed, and provisional chairside restorations (Caulk Acrylic Resin; Dentsply, Milford, USA) were placed, following the patient's usual occlusion.

To perform a resin-based adhesive prototype, segmented and complete 3D models were printed (Asiga) with the aim of preparing translucent polyvinylsiloxane

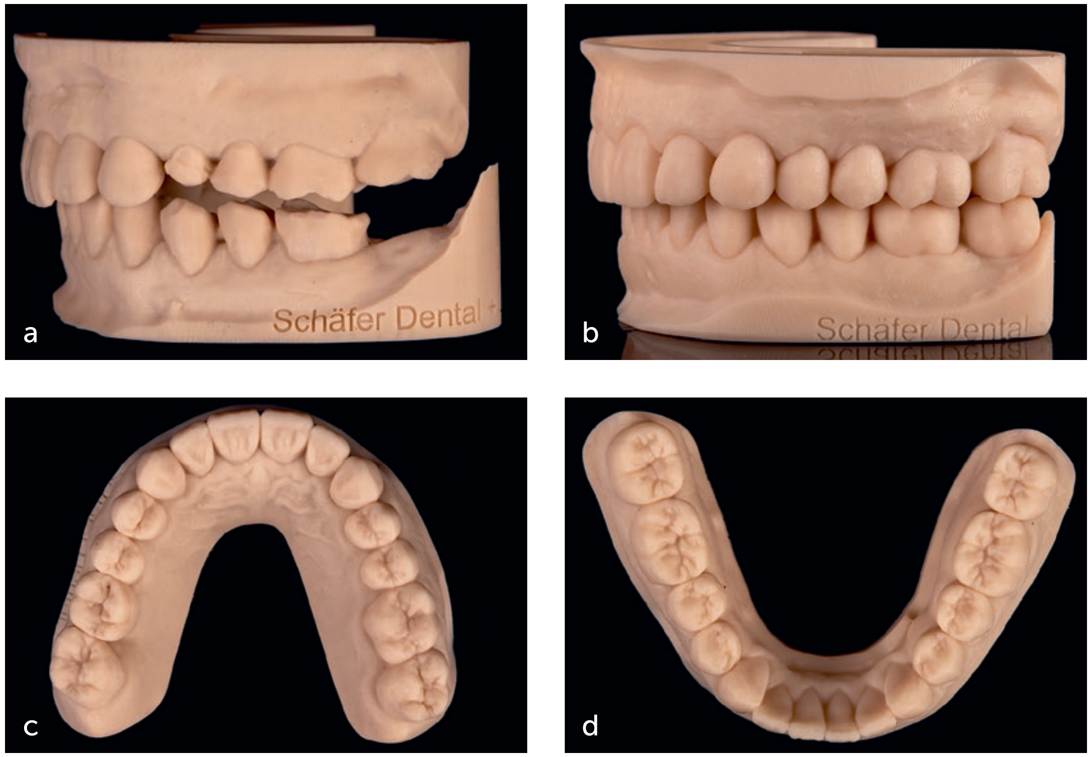


Fig 5 Printed models for future composite resin prototype reconstructions. (a) Lateral view of the partial models of S1 and S2. (b) Lateral view of the fully designed maxillary and mandibular models with occlusal contacts. (c and d) Occlusal view of the maxillary and mandibular printed models showing the fully designed dental anatomy.

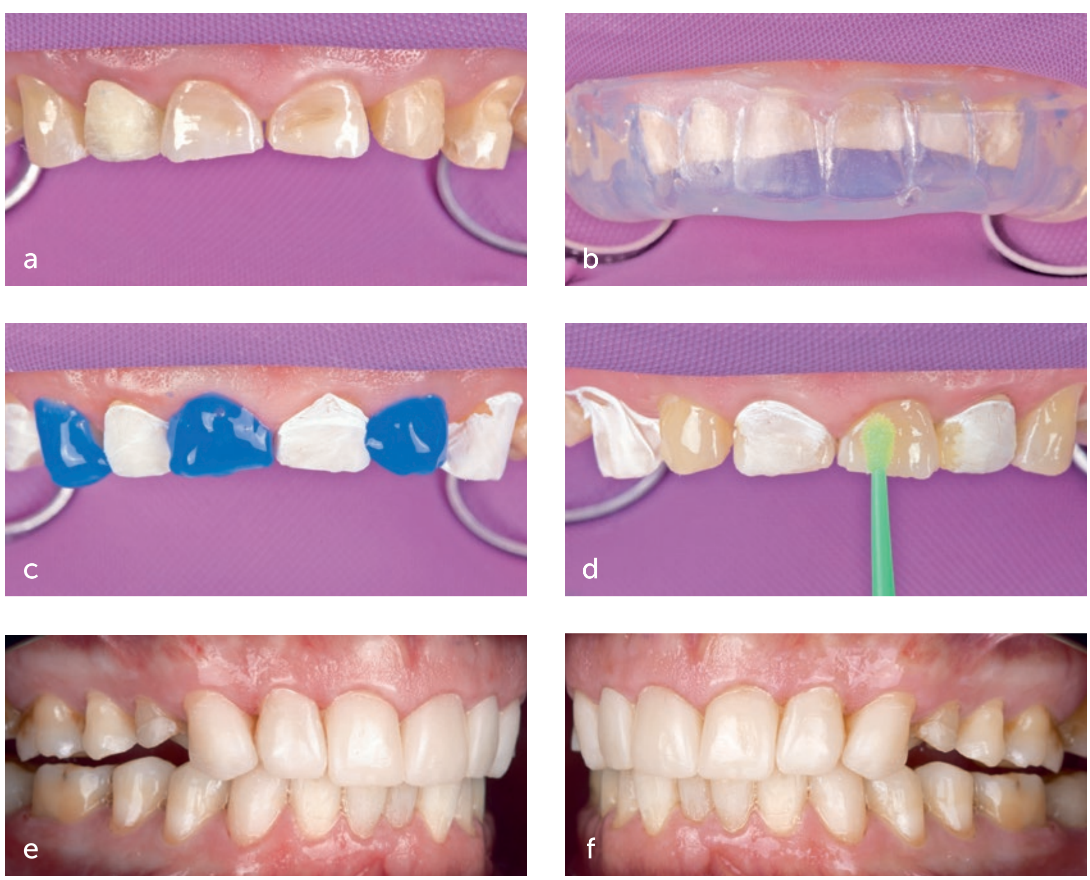


Fig 6 Clinical temporary adhesive systematization with flowable composite resin. (a) Maxillary anterior tooth (S1) isolation. (b) Try-in of the translucent silicone index. (c and d) Adhesive treatment of the enamel and dentin surfaces of S1. (e and f) S1 and S2 adhesively reconstructed, establishing the new VDO.

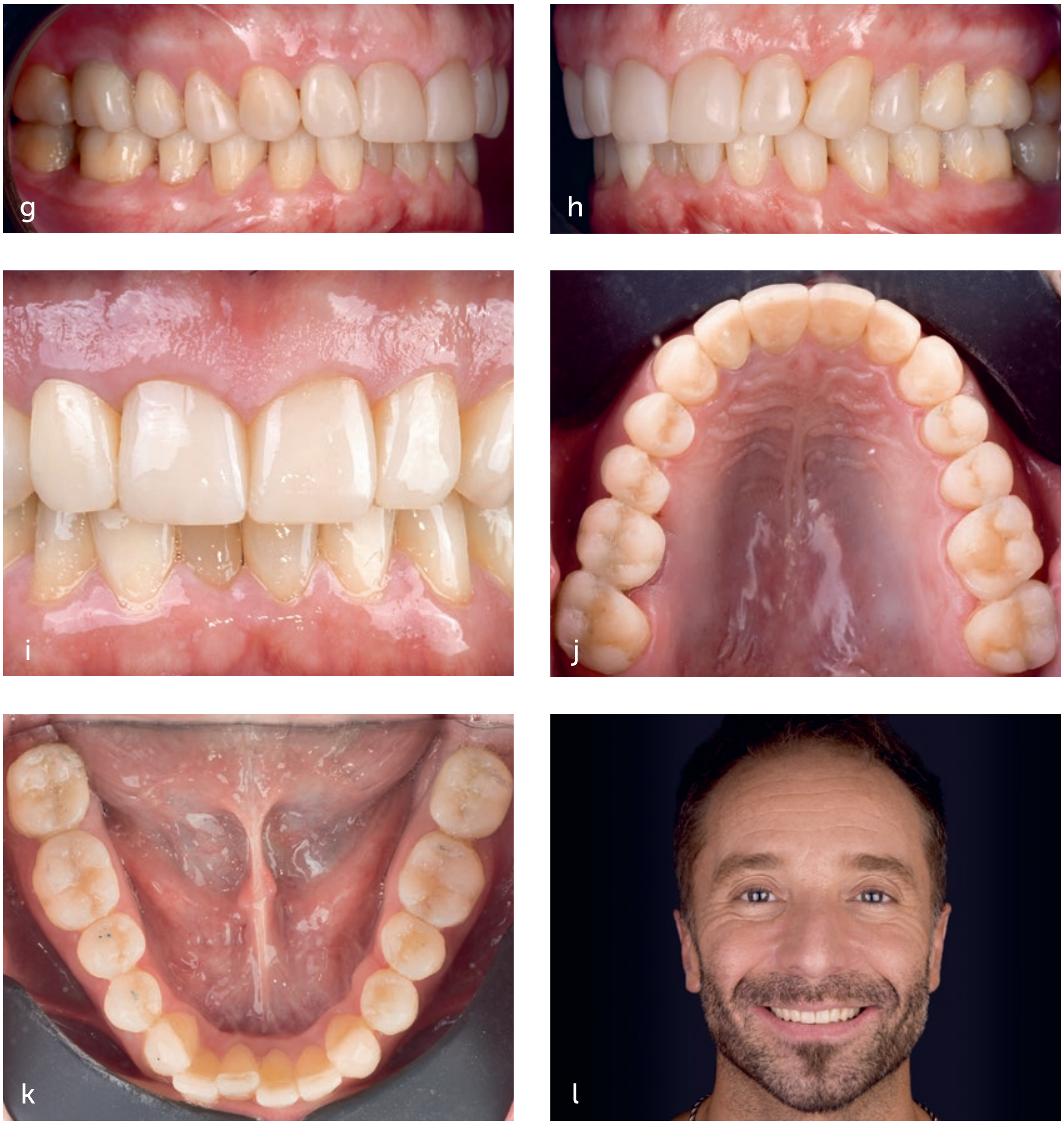


Fig 6, cont
(g and h) Lateral view of the fully rehabilitated maxillary and mandibular arches. (i) Frontal view of the full-mouth adhesive reconstruction. (j and k) Occlusal views of the anatomical reconstruction of the maxillary and mandibular arches. (l) Extraoral view during smile.

indexes (Elite Glass; Zhermack/Dentsply Sirona, Bensheim, Germany) over it (Fig 5).

Reconstructed tooth anatomy was transferred from the models to the patient's mouth through the use of flowable composite resin (Beautifil Flow Plus; Shofu). This composite resin prototype was fabricated following the same order of the above-described planning sequence. In the first session, the maxillary and mandibular anterior teeth (S1 and S2) were individually rebuilt. A new VDO and CRO were determined, and esthetic and phonetic parameters were also recovered. In the second session, the morphology of the posterior sectors (S3 and S4) was reestablished and the posterior occlusion consolidated (Fig 6). The patient was provided with a maxillary vacuum occlusal nightguard to protect the reconstructed structures.

Once the full-mouth adhesive prototype was finalized, an orthodontic treatment on S2 was performed to improve the alignment of the teeth, and, consequently, to reduce the amount of tooth-structure reduction required for the ceramic restorations. The planning of this orthodontic treatment was also part of the initial full-mouth digital design.

The following sessions were dedicated to preparing, scanning, and adhering the ceramic restorations. Tooth preparation criteria was based on the balance between the amount of remaining tooth structure, the amount of composite resin, and the indicated design of the final ceramic restoration.

As S1 showed the least amount of dental structure, and the majority of palatal structure was reconstructed by flowable composite resin, six full crowns were prepared. In S2, conservative veneers were prepared because the smaller amount of tooth wear plus the orthodontic treatment allowed better tissue preservation. Then, the preparations were intraorally scanned (Trios 3; 3Shape) and the occlusion was recorded, maintained by the composite resin in the posterior sites. The files were sent to the dental laboratory for the milling of monolithic lithium disilicate ceramic restorations (e.max CAD LT A1; Ivoclar Vivadent, Schaan, Liechtenstein). Adhesive fixation was performed under rubber dam isolation using an adhesive protocol and a light-cure composite resin cement (Variolink Esthetic LC; Ivoclar Vivadent). The ceramic rehabilitation of S1 and S2 is shown in Figure 7a to d. The final dynamics of the canine guidance with the new restorations were also corroborated (Fig 7e and f).

The final sessions were focused on the ceramic reconstruction of S3 and S4. The selected designs for the posterior tooth preparations included occlusal and buccal tooth reduction. The adhesive fixation as well as the ceramic material and techniques were the same as those developed for the previous sectors (Figs 8 and 9). Once S4 was installed, a computerized occlusal adjustment was performed to ensure the correct distribution of the occlusal forces in the posterior teeth and a suitable anterior guidance (OccluSense; Bausch, Hainspitz, Germany).

Figure 10 shows the final esthetic parameters of the digital planning. An occlusal nightguard was installed and a 6-month recall program arranged to control the effects of future parafunctional habits and to protect the ceramic restorations.

Discussion

The proposed EGOP technique adds to the techniques that have previously been published on the restoration of esthetic and functional conditions. Although all of them are valid protocols in the process of planning and executing conservative prosthetic adhesive rehabilitations,[10-12,14-16,30] there are certain differences in terms of treatment timeline, materials selection, occlusal philosophy, and other aspects that warrant discussion.

In a series of publications, Vailati et al[14-16] proposed an additive protocol for patients with dental substance loss. The VDO determination in this proposal was obtained by the posterior sectors. A potential problem with this protocol is the possibility of generating premature contacts on the posterior teeth, which can lead to mandibular instability.[17] A small error in the establishment of a VDO in the posterior teeth could be worsened in the anterior teeth due to the pantographic effect.[18] As a result, an occlusal adjustment may affect tooth morphology, ceramic structure, and/or the appearance and size of the anterior teeth. Moreover, any failure to eliminate premature contacts could lead to adaptive mandibular displacement.[19-21]

In the present proposal, beginning the diagnosis and treatment planning from the

Fig 7 Preparations and ceramic restorations of S1 and S2. (a) S1 crown preparations and S2 veneer preparations ready to be intraorally scanned. (b) S1 intraoral scan file of the crown preparations. (c) CAD/CAM monolithic lithium disilicate restorations (e.max CAD LT A1) of S1 and S2. (d) Adhesive fixation of ceramic restorations. (e and f) S1 and S2 restorations showing the canine guidance on both sides.

anterior teeth allows an accurate esthetic/occlusal integration. Once the morphology and position of the anterior teeth are obtained, the esthetic and phonetic parameters are recovered, while two essential occlusal parameters are also established: the recovery of the VDO and the CRO. This is performed using the anterior guidance as the main foundation for this systematization, avoiding the anatomical information of the posterior sectors that is lost or mostly affected. Anterior tooth contact produces less activity on the elevator muscles (the strongest masticatory muscles), thus minimizing the forces exerted during parafunction. Consistent with other studies,[22] determining the VDO from the anterior sector presents some benefits, including the achievement of esthetics and phonetics from the start as well as providing a reference for the

Fig 8 Preparations and ceramic adhesive fixation of S3 and S4. (a) Right preparations of S3 on tooth and implant 16. (b and c) Tooth 34 preparation and monolithic porcelain try-in. (d) Both left and right S3 isolation and ceramic adhesive fixation.

mandibular position through the anterior guidance. Bilateral canine contact allows the clinician to increase the VDO and generate enough space to restore the posterior sectors with accurate precision.

Although various authors have established facially guided workflows in order to carry out predictable esthetic planning,[23-26] they have not integrated the occlusal aspects in detail. In the proposed EGOP technique, dentolabial analysis and planning is linked to facial and dental structures to establish an appropriate relationship between the maxillary and mandibular anterior teeth, which is the starting point of the entire procedure.

The introduction of digital tools in prosthetic rehabilitation has enabled the development of facially guided workflows that determine the importance of the maxillary anterior teeth in the establishment of facial esthetics.[27-29] A published digital technique, the Digital Smile Design (DSD) protocol by Coachman and Calamita,[4] was one of the first attempts at integrating digital photographic images of a patient's face with a diagnostic wax-up on a plaster cast. In this case, the integration could be visualized digitally and then confirmed when the patient received a mock-up. In the present case, the digitalization of the face through a facial scan had the significant advantage of

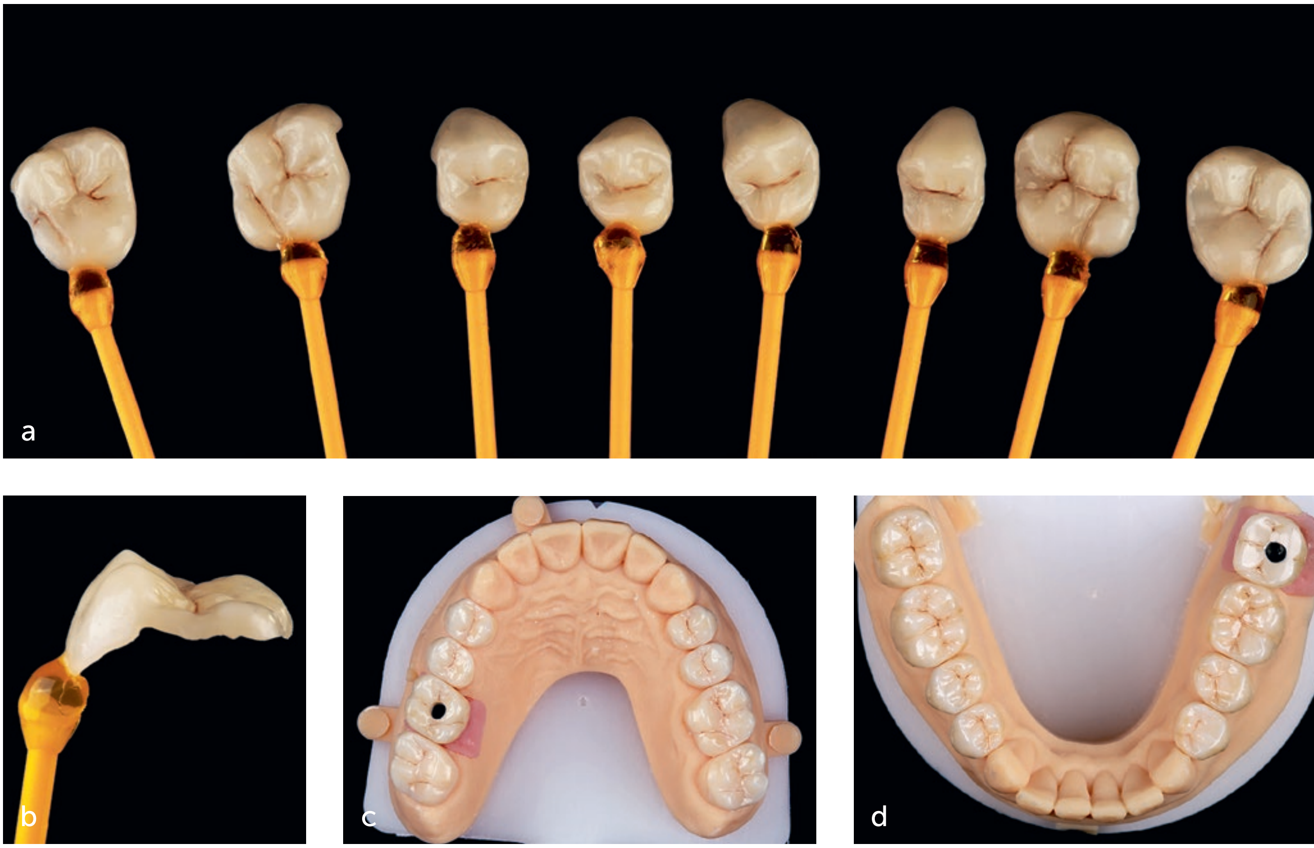


Fig 9 Ceramic restorations of S3 and S4. (a and b) Ceramic restoration designs for S3. (c) S3 monolithic lithium disilicate restorations on the printed model (except tooth 16, which was an implant-supported hybrid crown). (d) S4 monolithic lithium disilicate restorations on the printed model (except tooth 37, which was an implant-supported hybrid crown).

the virtual determination of the patient's horizontal plane and its relation to the incisal plane, which determined the 3D positioning of the maxillary anterior teeth. Furthermore, the patient could immediately preview the result through a full-mouth 'functional' mock-up that included the anterior and posterior teeth.

For full-mouth reconstructions, McLaren et al[30] proposed a bonded functional esthetic prototype to improve the interim prostheses in an oral adhesive rehabilitation. Different materials, steps, and clinical alternatives were described, but the integration between esthetic and occlusal aspects was not defined.

In terms of a definitive material, there is no strong evidence regarding the stability over time of full-mouth composite resin rehabilitations. Modern adhesive ceramic-based materials (especially monolithic zirconia and lithium disilicate) have shown higher fracture resistance than conventionally cemented restorations, including situations with a thickness of < 1 mm.[31] A systematic review showed porcelain to be the best material for worn dentition reconstruction.[32] In this particular case, all teeth were restored with monolithic lithium disilicate restorations that were stained and glassed. The substrate in all cases was a mix between enamel, dentin, and composite

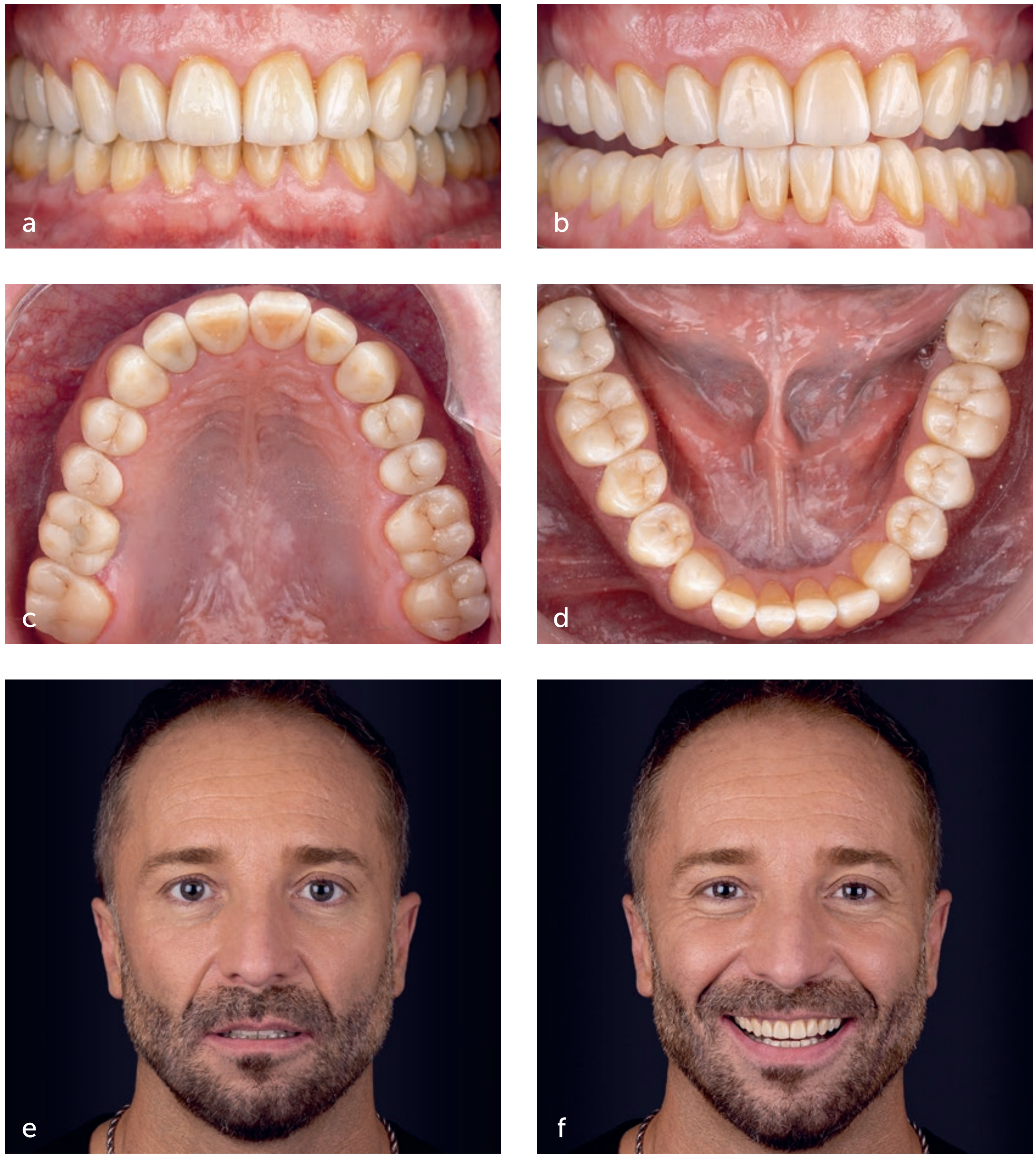


Fig 10 Final intraoral and facial images showing the results of the oral adhesive rehabilitation. (a) Frontal view of the full-mouth ceramic rehabilitation. (b) Anterior guidance in protrusive mandibular movement. (c and d) Occlusal view of the fully reconstructed maxillary and mandibular arches. (e and f) Facial aspect featuring dentolabial dynamics during lip rest and smile positions.

resin, except for teeth 16 and 37, which were replaced by two implants with a hybrid crown design over Variobase (Straumann) titanium abutments. The design of each tooth preparation was based on the amount of remnant dental structure: the less the natural tooth structure, the more the preparation involved.

On the one hand, the benefits of the present EGOP proposal can be summarized as follows:

1. The technique attempts to integrate occlusal and esthetic data in all the steps: diagnosis, planning, and execution. The consistency and repetition allow fluent networking and communication among

the patient, dental team, and different specialists.

2. A sectorized treatment, systematically repeated in all phases, increases the predictability of the outcomes, with minor adjustments and fewer time-consuming chairside procedures. It also improves the laboratory workflow by dividing it into single sectors instead of the provision of full-mouth or full-arch fabrications that demand more time, effort, and cost over a short period of time.
3. Treating four to six teeth per sector may be beneficial for less experienced prosthodontists when facing a full-mouth reconstruction; also for the patient, as this avoids long clinical sessions.

On the other hand, the disadvantages or limitations of the EGOP technique can be summarized as follows:

1. There is a need for several sessions in order to prepare and adhere each sector.
2. The technique is completely based on digital tools, which allows the integration and repetition of data in an accurate way. Knowledge, expertise, and investment in digital devices are therefore necessary.

Conclusions

The presented clinical case report describes an adhesive prosthetic treatment using a fully digital workflow. This proposal splits the maxillary and mandibular arches into four zones, with the specific objective of achieving, on a digital basis, the integration of facial esthetics and occlusion. The proposed EGOP technique may be a reliable approach to treat patients with worn dentition. More clinical publications are necessary to ensure rigorous scientific support and to further assess the possible benefits associated with this proposal.

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