CAD/CAM-based chairside restorative technique with composite resin for full-mouth adhesive rehabilitation of excessively worn dentition

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Abstract

Since the first introduction of the Cerec system (Sirona) in the early 1980s, the use of computer-aided design/computer-aided manufacture (CAD/CAM) technology has spread widely in modern adhesive dentistry. Thanks to this innovative technology, it has been possible to carry out chairside restorations fully managed by the clinician, with the advantages of lower costs for the patient, more rapid execution of the restorations, and the exclusion of the provisional phase. With further improvements in chairside technologies and materials, specifically in the field of composite resin blocks, it is now possible to fabricate multiple ultrathin, minimally invasive or even noninvasive restorations in one single appointment. The clinical case presented here was solved using an innovative approach: It was entirely studied and realized chairside by a dentist on a computer, without any plaster cast or classic articulator. Vertical dimension of occlusion (VDO) augmentation was projected with the 'Incisal Tip' tool on the virtual articulator of the Cerec system. Eight composite resin overlays were designed on the non-prepared posterior teeth of a patient suffering from generalized tooth loss principally caused by a history of bulimia nervosa. The maxillary anterior teeth were restored with six palatal veneers modified with direct composites from the vestibular side, in order to improve the esthetic integration of the restorations. The mandibular posterior teeth were built up with direct composites.

(Int J Esthet Dent 2018;13:2–16)

Introduction

On the one hand, the incidence of dental caries and periodontal disease is declining thanks to the spread of knowledge about the prevention of dental diseases.[1] On the other hand, the incidence of noncarious tooth substance loss is steadily increasing.[2] Tooth substance loss has been described as a physiological process, and according to current knowledge has a multifactorial origin involving the processes of abrasion, attrition, and erosion.[3] However, physiology may turn to pathology when it exceeds certain limits. Confronted with noncarious tooth substance loss, clinicians may have different dilemmas. Firstly, the boundary between physiology and pathology is subjective, and a proper diagnosis may often be difficult to determine. Even if the clinician is able to identify tooth wear, differential diagnosis of erosion, abrasion or attrition may be challenging due to the lack of awareness of the multifactorial and underlying etiologies.[4] Secondly, what is the appropriate attitude for a clinician to take when confronted with these problems? The dental community is divided into two groups of clinicians: those who treat noncarious tooth substance loss excessively, and those who do not treat it at all.[5] In the past, a substantial loss of hard dental tissue automatically implied an invasive therapy approach: Mechanical retention was required and reached by full-crown coverage on post-retained cores following preprosthetic root canal treatment. Nowadays, a minimally invasive approach is considered to be a reliable alternative, thanks to the improvement of adhesive systems[6,7] and composite resin materials.[8] Moreover, different kinds of less-invasive clinical techniques have been well explained and documented, and they show a high success rate in terms of esthetic and functional benefits for the patient.[9-14]

Changes in the vertical dimension of occlusion (VDO) should be made according to the esthetic and restorative needs of the patient. This evaluation is usually realized by studying plaster casts mounted in an articulator, by building up the worn dentition with additive

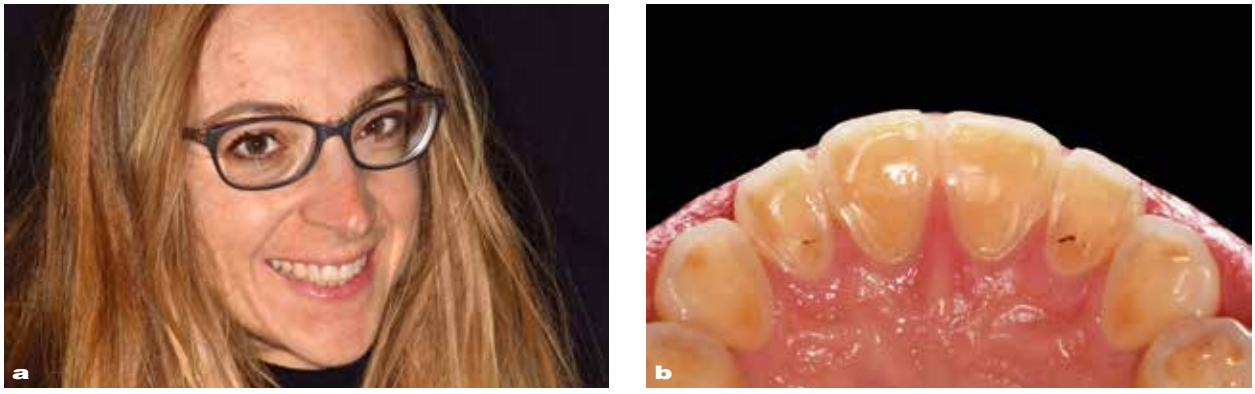

Fig 1a and b The patient's smile shows short central incisors and incorrect dental proportions that jeopardize her esthetic appearance. Especially in the palatal view **(b)**, the damage caused by gastric acid during frequent past episodes of vomiting are apparent.

wax-ups, and by testing the restorative concept on the patient using a direct mock-up.[9,12,13] However, when anterior veneers are not necessary, different criteria should be taken into consideration. As proposed by the modified three-step technique,[15] adhesive rehabilitation could start directly with the restoration of posterior teeth to increase the VDO in order to obtain a regularization of the occlusal planes.

Nowadays, thanks to computer-aided design/computer-aided manufacturing (CAD/CAM) technology, all these steps can be grouped, with the goal of simplifying the procedure and making it faster, more reliable, and less costly for the patient.[16]

The aim of this article is to present a simplified CAD/CAM-based chairside full-mouth adhesive rehabilitation technique in the case of excessive wear using the virtual articulator of the Cerec system software, version 4.4 (Sirona), with CAD/CAM composite resin blocks in conjunction with direct composite restorations.

Clinical report

A 37-year-old female patient presented with highly sensitive teeth and was concerned about a marked change in her facial appearance over the last 15 years. She did not refer to any disorders of the temporomandibular joint, but complained about her habit of biting her cheeks and about the esthetic appearance of her smile (Fig 1).

During the intraoral examination, excessive tooth substance loss on the posterior teeth in both arches became evident. After experiencing some years of bulimia nervosa during her adolescence, acid erosion due to frequent vomiting events had especially affected the palatal and incisal surfaces of her maxillary anterior teeth, causing a shortening of the clinical dental crowns. Her bulimia nervosa disorder was solved more than 10 years ago. The patient did not have a high caries activity. She presented with four very old interproximal restorations on teeth 14 to 15 and 46 to 45, three small occlusal restorations on teeth 37, 16, and 17, and one active decay on tooth 33. The loss of hard dental tissue resulted in a loss of VDO without any orthodontic or functional problems.

Preparatory phase

Firstly, the patient received a professional tooth cleaning and oral hygiene instruction. Then, teeth 14 and 15 were restored with direct composite restorations. The occlusal anatomies were not anatomically shaped in order to obtain a better adaptation for the future overlays. Subsequently, a full-arch intraoral optical impression scan of both dental arches was performed (Cerec Omnicam, version 4.4).

The maximal intercuspation position (MIP) was registered in order to establish the occlusal relationship between the arches. Immediately after the impression, it was possible to check whether the vestibular bite was correct. With the new software (version 4.4) it is possible to see the occlusal contact point on the computer. A correspondence between the virtual and real situation can be verified clinically in the mouth with colored

articulation paper. After this appointment, the patient was left without any provisional restorations, as the shape of the teeth had not been changed, and the VDO remained unaltered (Fig 2).

Planification phase

The main purpose of the treatment planning was to be as conservative as possible. Therefore, a no-prep approach was chosen and an increase of the VDO became necessary. Commonly, this parameter is arbitrarily set on real plaster casts with a partial anterior or full-mouth wax-up, depending on the severity of tissue loss. The classic wax-up follows esthetic guidelines with regard to the shape and dimension of the anterior teeth.

The choice to manage the case with a no-prep approach continued with the

Fig 2a to j Preoperative intraoral photographic status of the 37-year-old female patient compared with the first digital model taken by Cerec Omnicam **(b)**. It is easy to see that dental erosion has affected all the teeth apart from the four mandibular incisors, even if the erosion was distributed in both arches to different degrees, localized especially on the palatal surface of the superior incisors and canines.

management of the interproximal spaces. In this case, the good interproximal contact areas had been retained, and it was therefore unnecessary to open these spaces to create the overlay with new contact surfaces.

By using CAD/CAM technology, the esthetic design of anterior teeth can be defined using the software. It is preferable to follow the same rules as for the classic approach when designing the shape of each restoration and evaluating its integration into the patient's smile: Firstly, a width/length (W/L) ratio of ≈ 81% is considered to be most acceptable as a reference regarding the proportions of a normal clinical crown.[17,18] After choosing the new shapes, it is important to estimate the coincidence of the incisal edges with the lower lip, as they should follow parallel lines.[17]

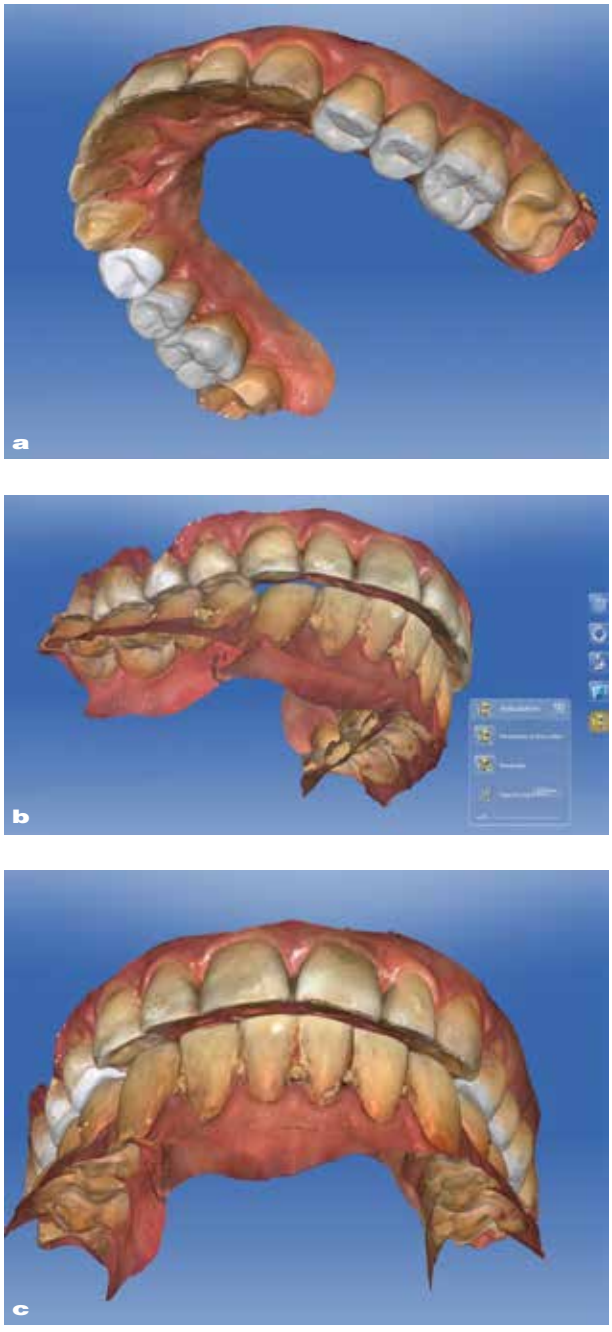

Fig 3a to c Restorative project using the Cerec system. After a full-arch scan made with the intraoral Cerec Omnicam scanner, the VDO augmentation on the incisal guide pin of the 'Articulator' function was 1.2 mm. This distance was enough to fabricate posterior overlays without any preparation.

The case was studied and planned using CAD/CAM digital software (Cerec version 4.4) (Fig 3). The VDO was arbitrarily augmented using the 'Articulator' function (Fig 3b) to obtain enough space for additive restorations without any preparation of the anterior teeth, following esthetic guidelines.

The virtual articulator, like the real one, has many possible settings. Firstly, the incisal guide pin, necessary to increase the VDO, was set to 1.2 mm, which is the minimum necessary to create enough space to restore all the teeth without any preparation. Other possible settings of the virtual articulator are the inclination of the condyle track, the distance between the condyles, Bennett's angle, and Bennett's movement. All the regulations were set to average values.

The introduction of a virtual facebow would certainly make the restorations more precise in case of a complex rehabilitation.

During the digital analysis, the VDO was augmented by 1.2 mm on the incisal tip. Subsequently, overlay restorations were designed using the software in the 'Biogeneric Individual' mode. Overlays on teeth 17 and 27 were realized in a second stage, in order to simplify this phase. Moreover, the support of the last molars is not essential in the management of the VDO augmentation or the anterior palatal veneers.[9] Each restoration was individually shaped and characterized with the circular and anatomic shaping tools, adapted to the previously agreed occlusal plane, and finally milled out of composite CAD/CAM blocks (CeraSmart, GC).

After milling, the overlays were slightly characterized (Kolor +, Kerr), finished

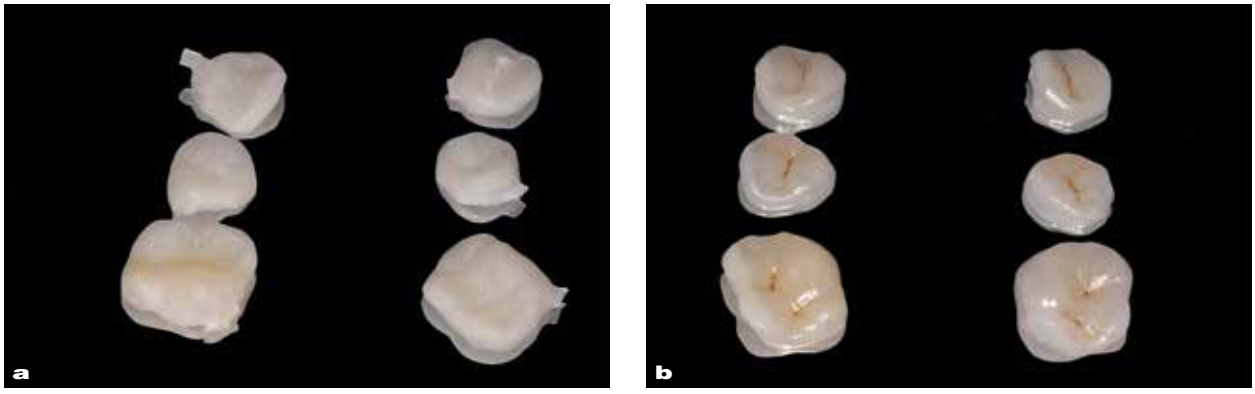

Fig 4 Composite overlays after milling **(a)**. Overlays after final characterization and polishing **(b)**.

using fine diamond burs (Yellow flame bur, Intensiv), and polished with silicone points (Enhance, Dentsply Sirona) and brushes (Polirapid) with diamond paste (Dura Polish, Shofu) (Fig 4).

Restorative phase

The second clinical appointment began with the application of rubber dam (Fig 5). The first and second quadrants were treated separately. Firstly, the restorations were tried in the mouth to check their marginal fit and proximal contact surfaces. Subsequently, adhesive luting was performed procedures were performed in the first quadrant (Fig 5a to f).[18]

Without the opening of the interproximal spaces, the cementation might seem more complex. In this case, the patient kept the natural contact areas, and the shape of the interproximal spaces allowed for the easy passage of dental floss. Thanks to this characteristic, it was possible to correctly manage the cementation and to avoid composite resin excesses.

In cases where the tooth shape in the interproximal area is more square and sharp, the cementation must be managed tooth for tooth, protecting the adjacent tooth by means of metallic or plastic matrices or making a dental preparation, resulting in the loss of the remaining hard tissue.

Once the luting was completed, the restoration margins were finished and polished. Next, the rubber dam was removed from the first quadrant, applied to the second quadrant, and the same luting steps were performed. At the end of the appointment, the static and dynamic occlusion were checked, and after some minor adjustments the patient was dismissed with stable posterior contacts and an open anterior bite (Fig 5g).

Immediately after luting the posterior overlays, another intraoral digital impression was performed, and the palatal veneers were designed (Fig 6). The same procedures and characterizations used for the posterior overlays were followed for the palatal veneers, but luting was performed one tooth at a time after rubber dam isolation from teeth 15 to 25 (Fig 7).

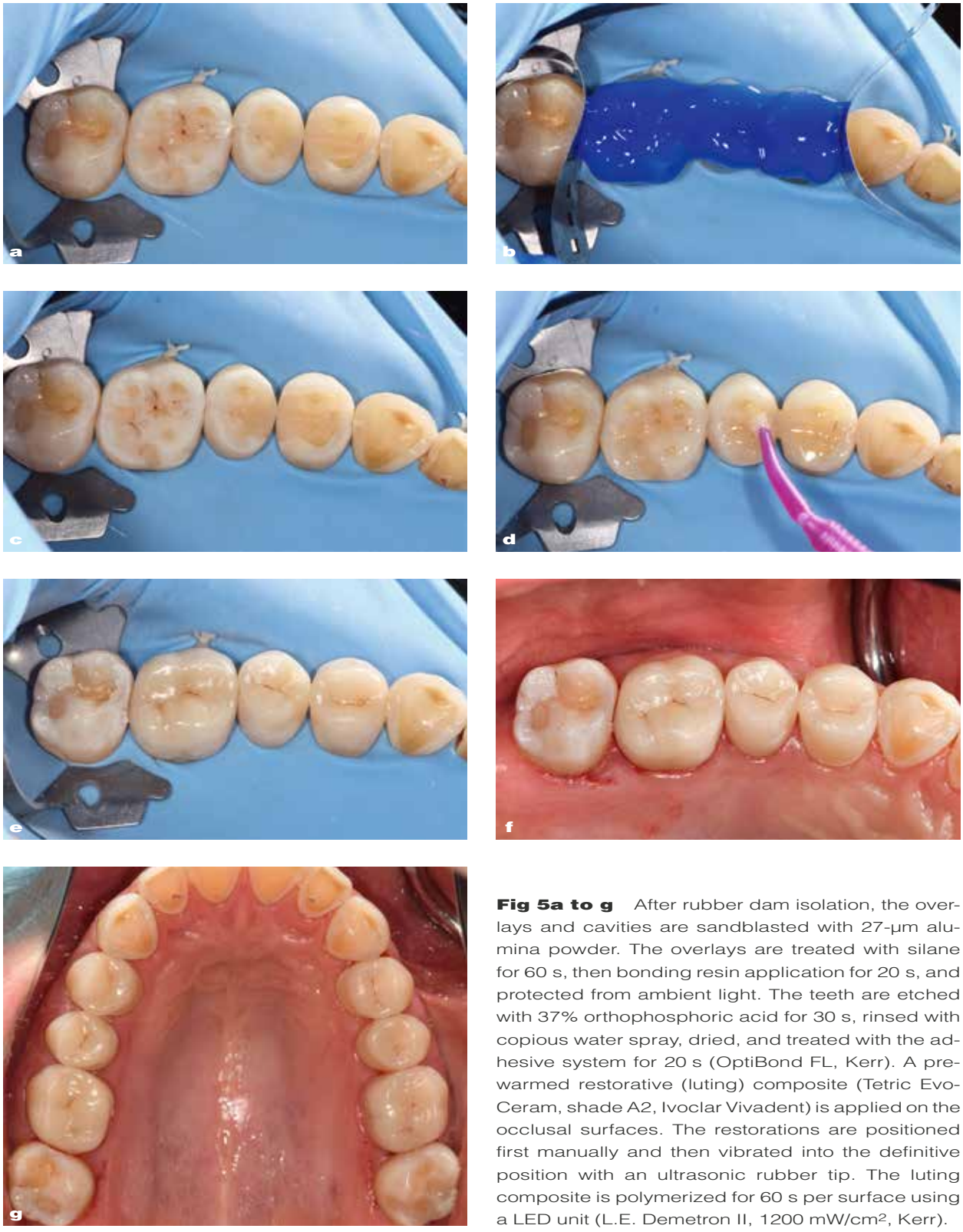

Fig 5a to g After rubber dam isolation, the overlays and cavities are sandblasted with 27-µm alumina powder. The overlays are treated with silane for 60 s, then bonding resin application for 20 s, and protected from ambient light. The teeth are etched with 37% orthophosphoric acid for 30 s, rinsed with copious water spray, dried, and treated with the adhesive system for 20 s (OptiBond FL, Kerr). A prewarmed restorative (luting) composite (Tetric EvoCeram, shade A2, Ivoclar Vivadent) is applied on the occlusal surfaces. The restorations are positioned first manually and then vibrated into the definitive position with an ultrasonic rubber tip. The luting composite is polymerized for 60 s per surface using a LED unit (L.E. Demetron II, 1200 mW/cm^2, Kerr).

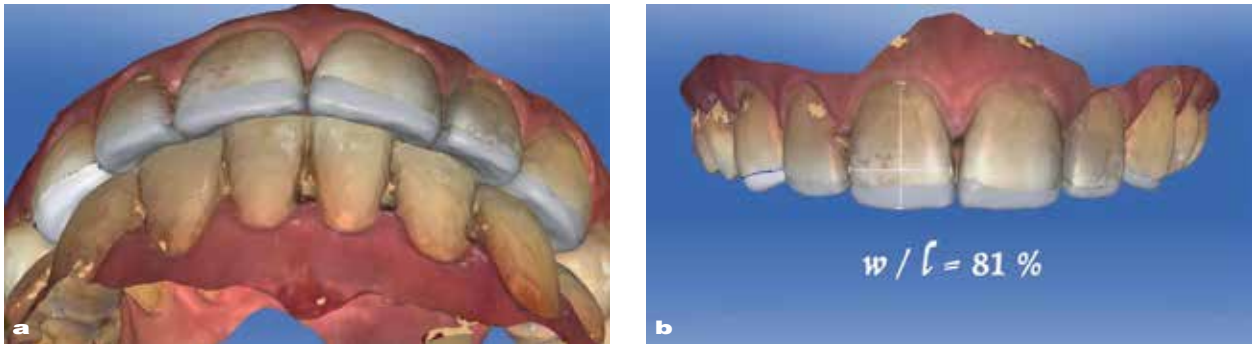

Fig 6a and b Palatal veneers are designed in a way that gives more importance to the two central incisors by recreating their correct, natural W/L ratio.

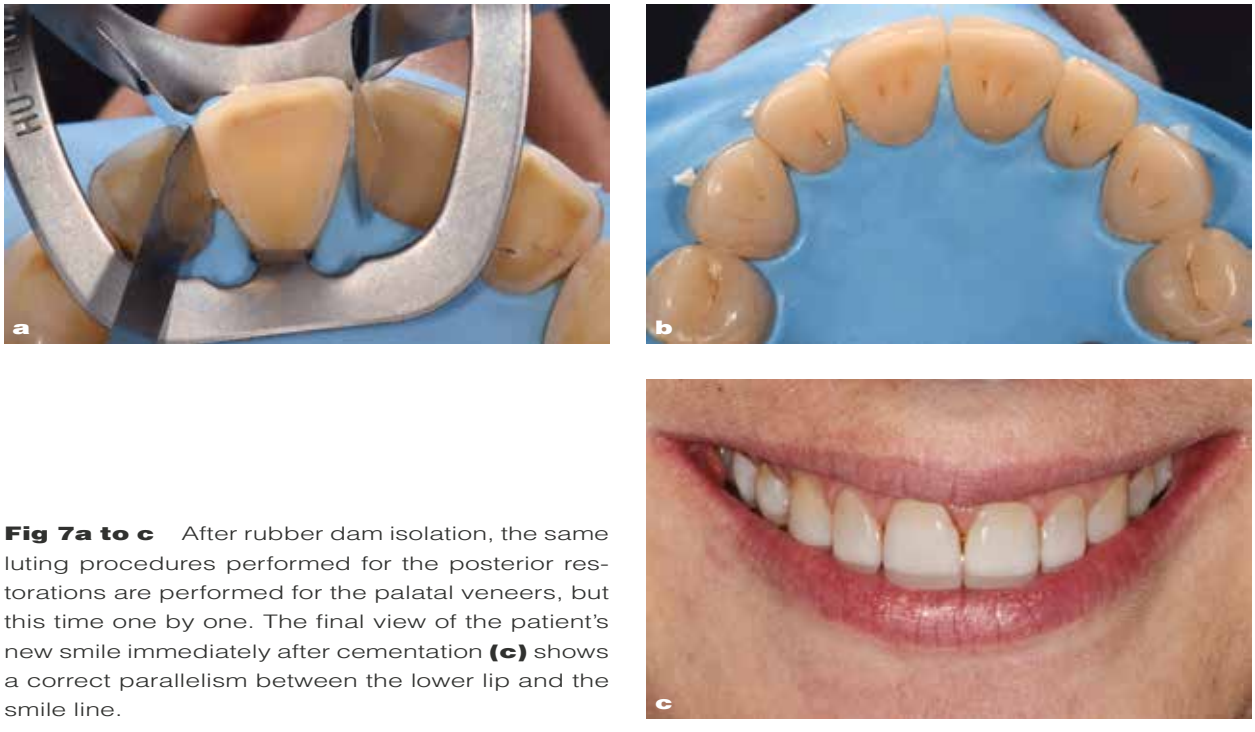

Fig 7a to c After rubber dam isolation, the same luting procedures performed for the posterior restorations are performed for the palatal veneers, but this time one by one. The final view of the patient's new smile immediately after cementation **(c)** shows a correct parallelism between the lower lip and the smile line.

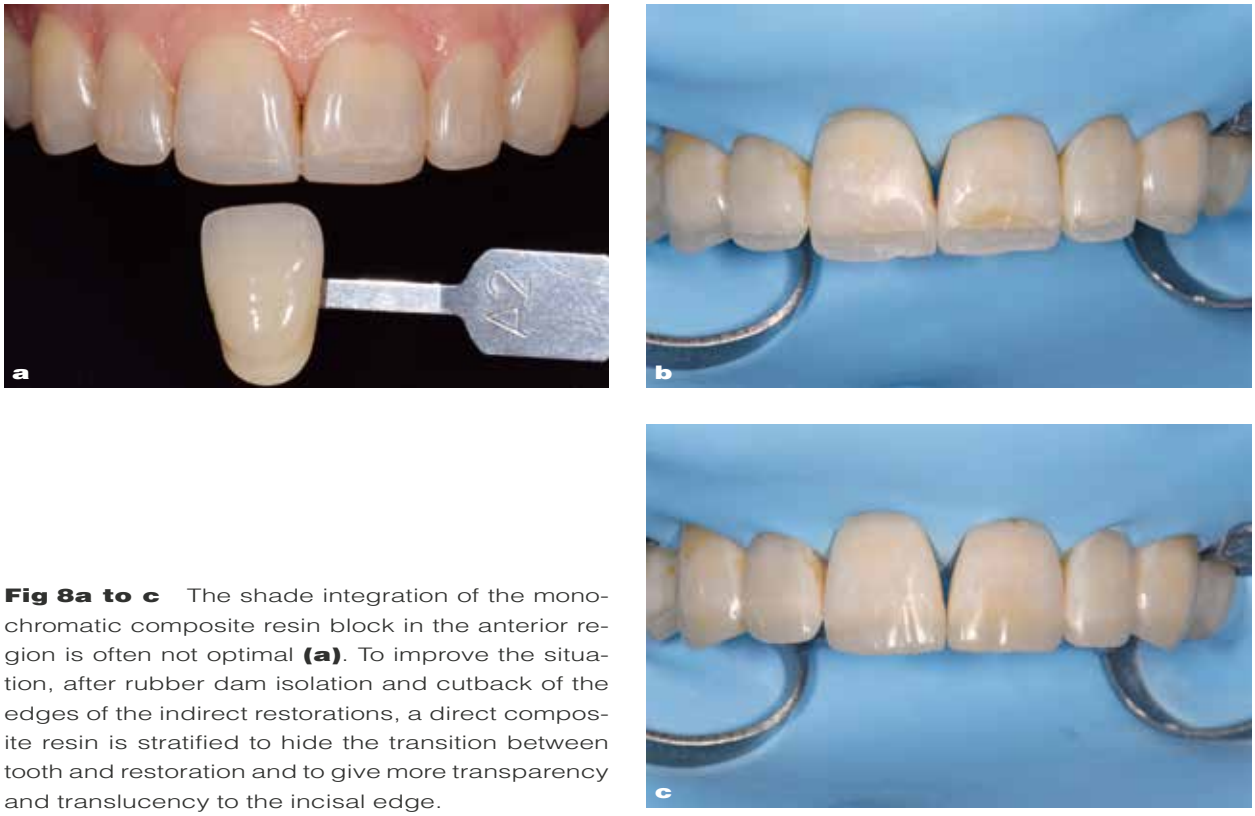

Fig 8a to c The shade integration of the monochromatic composite resin block in the anterior region is often not optimal **(a)**. To improve the situation, after rubber dam isolation and cutback of the edges of the indirect restorations, a direct composite resin is stratified to hide the transition between tooth and restoration and to give more transparency and translucency to the incisal edge.

In the following appointment, two chairside overlays on teeth 17 and 27 were realized using the Cerec system. Also, direct restorations of the vestibular abrasions on teeth 13, 14, and 24 were built up with direct microhybrid composite resin (Tetric EvoCeram, shades A3 and A3.5).

The adhesive rehabilitation was finalized in the mandibular arch by performing direct restorations. The same microhybrid composite resin used for the maxillary anterior teeth (Tetric EvoCeram, shades A2, A3, and A3.5) was directly stratified. The goal was to balance the occlusal surfaces, cover the exposed dentin, and restore the normal and functional anatomy of each tooth.

The decision to perform direct restorations in the mandible was taken because the occlusal plane did not require major adjustments, and it was not necessary to increase the VDO of the mandibular teeth. Choosing to perform indirect restorations in the mandible, although with minimum thicknesses, would not have been a good decision. In fact, it would have led to an inverse Spee's curve, making it necessary to increase the length of the mandibular incisors (which did not need any restoration), thereby performing overtreatment and jeopardizing the esthetic result.

The shade integration of the monolithic restorations in the anterior teeth was not perfect. Stratification with direct

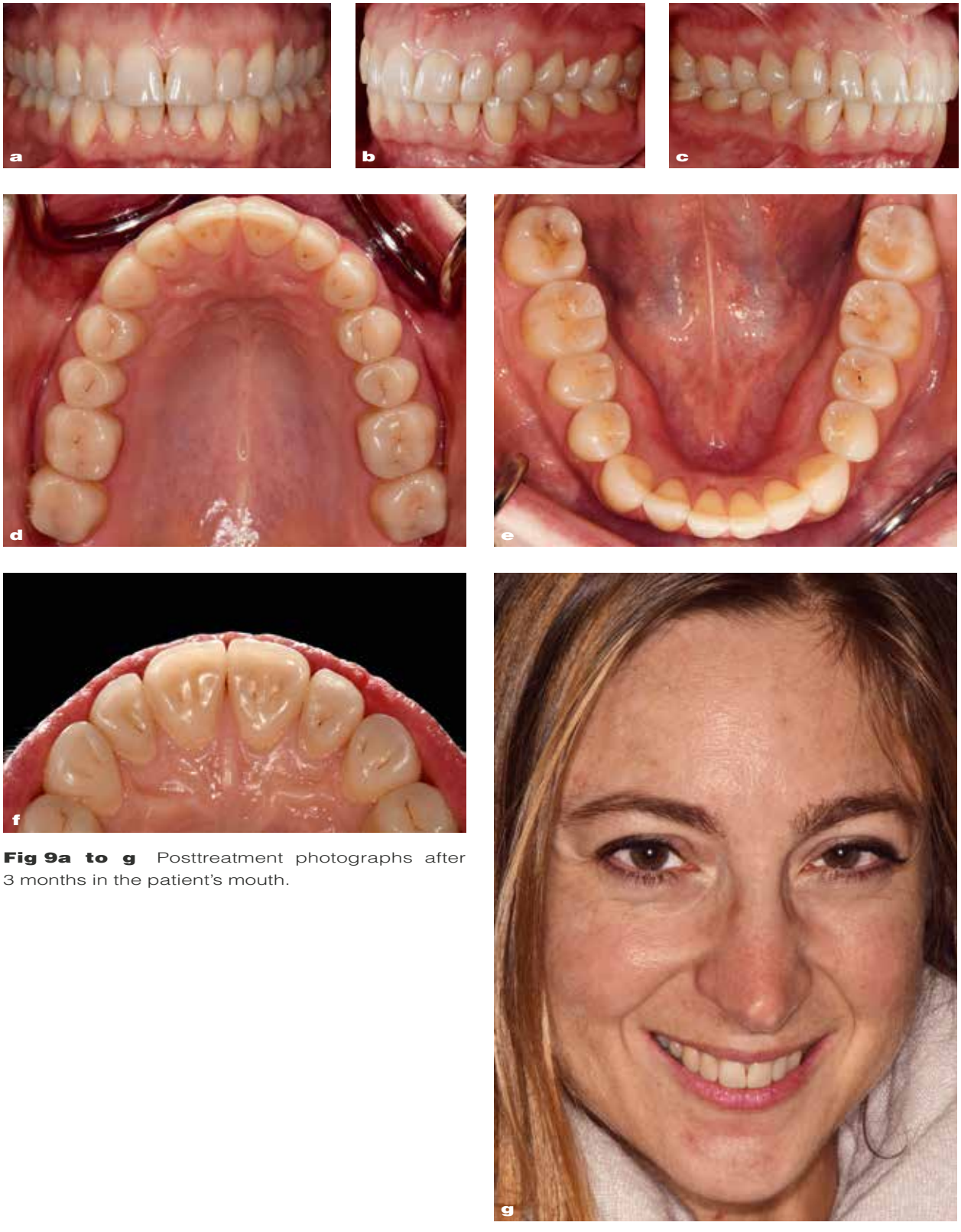

Fig 9a to g Posttreatment photographs after 3 months in the patient's mouth.

Fig 10a and b The patient's smile before and after treatment.

composite resin after a cutback on the block may improve this esthetic aspect. This procedure is minimally invasive, rapid, cost-effective, and repairable. It also avoids the use of vestibular ceramic veneers (Fig 8). Figure 9 shows the stability of the final result after 3 months. Figure 10 shows the patient's smile before and after treatment. The incisal edges and the lower lip follow parallel lines.

Discussion

During the last decades, patients presenting with tooth wear caused by erosion, attrition or a combined pathology have dramatically increased.[19] A correct diagnosis and adequate treatment planning are fundamental for these cases in order to obtain a satisfactory result. In the past, treatment typically required full crown coverage with a significant sacrifice of healthy dental tissue. Moreover, these classic rehabilitations were very time-consuming, complicated, and expensive. The use of modern chairside CAD/CAM technologies means that many laboratory steps can be avoided, which saves time and dramatically reduces the cost for the patient.

Even though some authors have expressed concerns and reservations about increasing the VDO,[20,21] to date there is no clear evidence supporting a possible pathological consequence of its modification. For dentitions suffering from significant tooth substance loss, VDO augmentation facilitates the restorative treatment, allowing the clinician to obtain the minimum thickness necessary for the restorative material. Recent reviews of the scientific literature[22,23] indicate that an increase in VDO of up to 5 mm is a safe and predictable procedure with no negative functional/biologic consequences.

In the specific case documented in this report, the VDO augmentation did not provoke any temporomandibular disorders or symptoms. On the contrary, the patient reported that she stopped biting her cheeks, a habit she complained about before the treatment. However, it is obvious that there is a strong need

for further investigations to better understand the relationship between VDO augmentation and repositioning of the jaw, with its functional consequences.

The choice of the appropriate restorative material is another critical aspect that needs an analysis from different points of view. The longevity of restorations depends on many factors involving not only the material itself but also the patient and the operator. With the development of adhesive systems and minimally invasive dentistry, composite resins and ceramics are commonly considered to be reference materials for indirect restorations. Despite the popularity of zirconia and lithium disilicate, they are not always the most appropriate materials. From a biomechanical point of view, CAD/CAM composite resins have a lower flexural strength and wear resistance than ceramic materials, aspects that are particularly important in patients affected by bruxism. However, different studies[24-26] have demonstrated that restorations made out of CAD/CAM composite resin blocks show good clinical performance and are well suited for cases with very high occlusal loads. Composite resins also have other advantages:

- A lower risk of fracture during luting, finishing, and polishing.[27]
- Lower costs, making the treatment affordable to more patients.
- A dentin-like modulus of elasticity.[28]
- They are less abrasive against opposing natural cusps than ceramics.[8,26]
- They are repairable and modifiable in case of small esthetic adjustments, like the individual coloration of the occlusal fissures or integration of margins.[26]

Furthermore, these materials have high tolerance against subsurface damage during occlusal retouches with burs,[29] which is a crucial advantage, especially in cases of VDO augmentation.

Conclusions

This case report shows that even in a complex clinical situation in a severely worn dentition, chairside CAD/CAM techniques with composite resin blocks, in combination with direct composite restorations, may simplify the clinical procedure and allow for good functional and esthetic results. This type of treatment considerably reduces costs for the patient, making it more manageable and affordable. Long-term clinical studies should be initiated to generate data on the long-term behavior of this type of treatment.

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