



CAD/CAM monolithic restorations and full-mouth adhesive rehabilitation to restore a patient with a past history of bulimia: the modified three-step technique

Francesca Vailati, MD, DMD, MSc

Private practice, Geneva Dental Team, Geneva, Switzerland
Senior Lecturer, Dept of Fixed Prosthodontics and Occlusion
School of Dental Medicine, University of Geneva

Sylvain Carciofo, MDT

Chief Dental Technologist, University of Geneva, Switzerland



Correspondence to: Francesca Vailati, MD, DMD, MSc

Geneva Dental Team, Rue Saint Leger 8, 1205 Geneva, Switzerland; E-mail: francesca.valiati@unige.ch



Abstract

Due to an increasing awareness about dental erosion, many clinicians would like to propose treatments even at the initial stages of the disease. However, when the loss of tooth structure is visible only to the professional eye, and it has not affected the esthetics of the smile, affected patients do not usually accept a full-mouth rehabilitation. Reducing the cost of the therapy, simplifying the clinical steps, and proposing *non-*invasive adhesive techniques may pro-

mote patient acceptance. In this article, the treatment of an ex-bulimic patient is illustrated. A modified approach of the three-step technique was followed. The patient completed the therapy in five short visits, including the initial one. No tooth preparation was required, no anesthesia was delivered, and the overall (clinical and laboratory) costs were kept low. At the end of the treatment, the patient was very satisfied from a biologic and functional point of view.

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Introduction

Clinicians are becoming more attentive to evaluating early signs of dental erosion. In addition, thanks to the adhesive techniques available today, a valid solution can be offered to patients to protect exposed dentin.¹⁻²⁵ However, patients rarely seek treatment to prevent further damage of a dentition that they do not even realize is being affected by accelerated wear; most patients seek help at a more advanced stage of the disease, when the erosion has compromised the incisal edges of the anterior teeth (esthetic request). Consequently, while intercepting initial cases of dental erosion should become a more ideal approach, it is difficult for clinicians to convince patients that early dental treatment is necessary, and that it will be more favorable if not postponed (Fig 1).

In addition, since there is no literature to support the premise that exposed dentin is a pathology, not every clinician considers an early intervention appropriate. This division within the dental

community confuses patients who seek a second opinion.

Nowadays, however, with the non-invasive adhesive techniques available, patients should be better informed about the pros and cons of leaving exposed dentin, especially at a young age where the cause of the erosion has not yet been eliminated (eg, bulimia), or when parafunctional habits are also present. To promote a patient's acceptance of an early treatment, a simplified therapy at a reduced cost with a low number of dental appointments should be advocated.

A simplified approach has been developed – the modified three-step technique, to further simplify a full-mouth adhesive rehabilitation, always necessary, even in the early stages of dental erosion. For more details on the classic three-step technique, the articles already published on the topic are recommended.²⁶⁻²⁸

Following this classic three-step technique, and driven by the principle of maximum tooth preservation, the maxillary anterior teeth of patients affected



Fig 1a and b A 30-year-old patient affected by dental erosion detected at an early stage. The loss of enamel and the dentin exposure was visible only to a professional eye. The patient was not keen to start the therapy as she was asymptomatic and unaware of the weakening of the incisal edges.



by severe dental erosion are restored by means of two veneers – a palatal composite and a facial ceramic veneer. This is called the sandwich technique (bilaminar approach).

However, in cases of initial/moderate dental erosion, often the vestibular aspect is minimally compromised, and only at the level of the incisal edges. Consequently, facial veneers are not indicated, even though patients are more willing to start the therapy if these restorations are proposed.

Clinicians should resist the temptation to satisfy only the patient’s esthetic requests with facial veneers, especially if for financial reasons the palatal aspect of the anterior and/or occlusal surfaces of the posterior teeth will not be included in the rehabilitation (partial rehabilitation) (Fig 2).

To evaluate which patients require only palatal composite veneers and which should also be restored with facial ceramic veneers, the ACE classification can be used (Fig 3).²⁹ According to this classification, when the incisal edges of



Fig 2 Palatal aspect of a patient affected by dental erosion. Her dentist only delivered two facial ceramic veneers to improve the esthetics of her smile, but did not address the generalized dentin exposure. After 3 years, the dental erosion was still active and the loss of tooth structure was so severe that the patient sought treatment for generalized dentin hypersensitivity. The presence of the facial veneers then interfered with the more comprehensive, full-mouth rehabilitation that had become necessary.

the maxillary anterior teeth are still intact or minimally damaged (less than 2 mm of loss of its original length – ACE class II and III patients), the teeth can only be restored by means of palatal veneers (Fig 4).

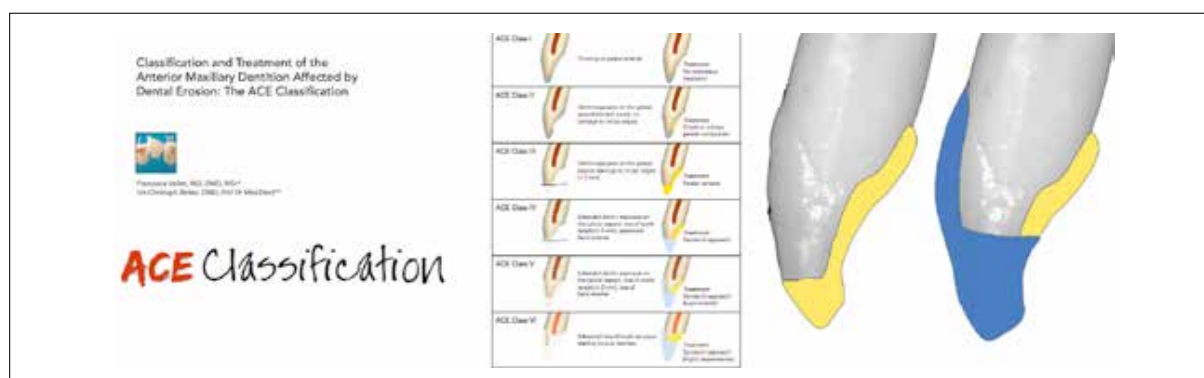


Fig 3 The ACE classification, in which there are six levels of tooth destruction that refer to the maxillary anterior teeth. For each of them, a treatment based on adhesive techniques is proposed (image courtesy of the International Journal of Periodontal and Restorative Dentistry).

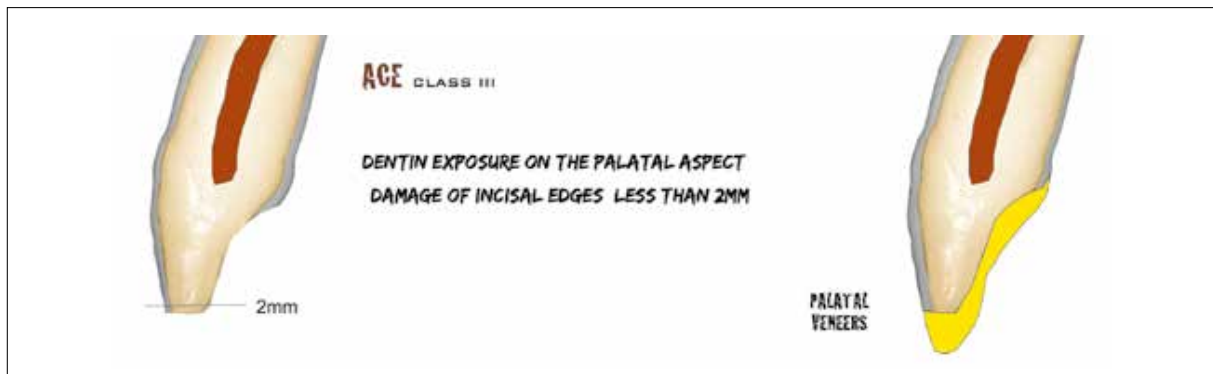


Fig 4 ACE class III patients do not need facial veneers because the vestibular aspect of their maxillary anterior teeth is intact and the incisal edges can be restored by means of palatal veneers alone.

Composite palatal veneers are an excellent and economical treatment, not only to strengthen the compromised incisal edges and cover the exposed palatal dentin, but also to reestablish the anterior contact points after the rehabilitation of the posterior teeth at the increased VDO. This treatment is non-invasive since it does not require the removal of healthy tooth structure and allows for the retention of the vitality of

the anterior teeth condemned to elective endodontic therapy (Fig 5).

If facial veneers are not necessary, the adhesive rehabilitation could start directly with the restoration of the posterior teeth at the increased VDO (*step 2*).

Directly restoring the posterior teeth reduces the treatment cost and speeds up the therapy. In addition, the creation of the anterior open bite as early as possible (eg, after the initial visit) eliminates



Fig 5a and b Initial status and 5-year follow-up of a case of severe dental erosion restored with composite palatal veneers at the level of the maxillary anterior teeth. The veneers were delivered without any healthy tooth removal, only caries control and immediate dentin sealing. Note that the teeth kept their vitality even though the palatal destruction had almost reached the pulp. The photo of the follow-up was taken without any prior cleaning/polishing of the restorations.



Fig 6a and b Modified three-step technique in a 45-year-old patient. Due to a limited budget, facial veneers were not considered for this ACE class V patient. No maxillary mock-up was delivered, and the treatment started directly at the level of the posterior teeth.

the focal attrition of the antagonistic mandibular teeth on the compromised incisal edges, helping in their preservation. This approach is called the *modified three-step* technique (Figs 6 to 8).

As with the classic three-step technique, the models in the modified three-step technique are articulated in MIP, and the increase of VDO is first decided arbitrarily on the articulator. Due to the less conspicuous destruction, the occlusal

plane and the incisal edges of the future restorations can be easily determined by analyzing the initial casts, without the need for a maxillary vestibular mock-up (*Step 1* of the classic three-step technique). In addition, since the posterior teeth are often ready to be restored, the clinician may decide to deliver the posterior support of *step 2* directly with the final restorations.



Fig 7a and b *Step 2* – one-arch distribution. The *interproximal* space obtained with the increase of VDO was used to restore only the mandibular arch. During the same visit, the 4 mandibular premolars were restored with CAD/CAM final adhesive restorations, while the first molars (where large amalgam fillings were present) were restored with provisional direct composite restorations, fabricated with transparent keys. The final restorations at the level of the 4 mandibular molars were delivered after the restoration of the anterior teeth.

Authors, I am not sure whether intermaxillary or occlusal is correct?



Fig 8a and b Due to the new posterior support and the creation of the anterior open bite, the focal attrition of the antagonistic teeth was eliminated. The rehabilitation was completed in the anterior sextant with the delivery of the 6 composite palatal veneers, with maximum preservation of the weak incisal edges. Note that all the teeth retained their vitality after treatment.

In a classic three-step technique, since the tooth destruction is more conspicuous, the posterior teeth are generally restored with provisional composite restorations made directly in the mouth with transparent keys (*therapeutic white bite*).

Delivering provisional restorations, however, increases the cost of the treatment, since they require clinical time to fabricate and remove. If the posterior teeth are caries-free, and/or their restorations do not need to be replaced, so that they can be left in place and integrated into the final restorations, it is possible to directly deliver the final restorations during *step 2*. The advantage of this clinical choice is the reduction of the overall treatment time and cost. However, the clinical *step 2* will require more time. Delivering provisional restorations is, in fact, the fastest treatment to achieve posterior support, especially when both the arches need to be restored (two-arch distribution). With the use of four transparent keys, 12 provisional posterior restorations are delivered in a very

short time (2-h appointment), which will be replaced by quadrants after the restoration of the anterior teeth has been completed.

In cases where final restorations are considered for the entire mouth, a very long appointment is necessary (ie, all day), which may not be easy to fit into the busy agenda of a private practice. In addition, clinicians should respect the individual patient's capacity to keep the mouth open for a long time. To overcome these problems, especially if all four posterior quadrants have to be restored, it is advisable to still restore one arch with provisional restorations. This not only reduces the time of the appointment, but also allows the clinician to perform all the occlusal adjustments only at the level of the provisional restorations, leaving the final restorations intact.

In this article, a clinical case of the *modified three-step* technique is illustrated, where the treatment started directly at the level of the posterior teeth, with both provisional and final restorations.



Fig 9a and b A 32-year-old patient affected by moderate dental erosion with a past history of bulimia. The patient was more concerned about protecting her teeth from further wear than about the esthetics of her smile. It was no surprise that she refused orthodontic therapy just to align her teeth.

Clinical case

A 32-year-old Caucasian woman presented to the author's private practice for a consultation. Her clinician had diagnosed an excessive wear of her dentition, and she sought a second opinion (Fig 9).

During the oral examination, the author confirmed the findings of the previous clinician, and made the diagnosis of dental erosion. Questioned on the origin of excessive acid in the oral cavity, the patient reported a past history of bulimia, which explained the tooth damage localized mainly at the palatal aspect of the maxillary anterior teeth. The posterior teeth also presented a generalized exposed dentin at the level of their occlusal surfaces, but upon air spraying, none of the damaged teeth showed tooth sensitivity, confirming the sclerotic nature of the eroded dentin (non-active lesions).

Due to the loss of structure at the level of the cingula of the maxillary anterior teeth, the antagonistic teeth were su-



Fig 10 Initial status. The patient presented a deep bite, supraerupted mandibular anterior teeth, and an accentuated curve of Spee. Since the incisal edges of the maxillary anterior teeth were not compromised, facial veneers were not indicated.

praerupted, leading to a severe deep bite, and an accentuated curve of Spee (Fig 10).

The patient was classified ACE class II, since there was dentin exposure at the palatal aspect of the maxillary anterior teeth but no damage of the incisal edges, which had been protected from the focal attrition of the antagonistic teeth



Fig 11a and b Intraoral photos of the maxillary arch, which show a moderate but generalized dentin exposure at the level of both the anterior and posterior teeth. The deep bite was severe, but its presence had protected the incisal edges from the focal attrition of the antagonistic teeth.

by the excessive vertical and horizontal overlap (Fig 11).

As the facial aspect of the dentition was intact (except at the cervical level of the mandibular posterior teeth), palatal veneers were considered sufficient to restore the maxillary anterior teeth. Since a maxillary vestibular mock-up was then not necessary, the treatment could have started directly with the restoration of the posterior teeth. A *modified three-step* technique was considered.

During the first visit, two alginate impressions were taken and poured immediately. The two casts were mounted on a semi-adjustable articulator in MIP, using a facebow. Since, when following the *three-step* technique, clinicians make important decisions on fundamental parameters such as the increase of VDO, the two articulated casts were delivered to the clinician before proceeding to the diagnostic wax-up.³⁰ Without the need for a full-mouth wax-up, it was immediately clear that the ideal increase of VDO necessary for the non-invasive rehabilitation in the posterior quadrants

would have been problematic for the coupling of the anterior teeth. As the space gained with the increase of VDO would have been shared between both the maxillary and mandibular posterior teeth (a two-arch distribution), more space was required to guarantee sufficient thickness for the posterior restorations in both arches.

In addition, the curve of Spee was very accentuated, and in order to flatten it, a significant space would also have to be given to the mandibular posterior teeth, leaving only 20% to the maxilla. Finally, an important increase of VDO was also advocated to reduce the excessive vertical overlap (deep bite).³¹

Unfortunately, the patient was a skeletal class II, and already with a minimal increase of VDO, the anterior teeth would have been set too much apart to achieve final anterior contacts using only regular-size palatal veneers. Orthodontic treatment was then considered necessary, but only to follow the restorative treatment, which would have first flattened the curve of Spee and reduced the deep



Fig 12a and b The VDO was arbitrarily augmented, based on biological and restorative needs. The restorative objectives were to flatten the accentuated curve of Spee and reduce the deep bite.

bite, then thickened the palatal aspect of the maxillary anterior teeth. Thereafter, the orthodontic therapy would have solved the anterior open bite.

To confirm the increase of VDO, the clinician asked for a partial wax-up only at the level of the posterior teeth where the occlusal plane's position would have been dictated by the mandibular teeth (flattening of the curve of Spee). The laboratory technician waxed up only the 2 premolars and the first molars, in both the arches. The articulated models, with the partial posterior wax-up, were again evaluated by the clinician (Figs 12 and 13).

Analyzing the waxed-up teeth, the clinician confirmed the increase of VDO and decided to deliver final restorations in the mandibular arch during *step 2*. The mandibular arch was selected not only because the teeth were free of caries, but also because from the wax-up it could be seen that the restorations would have been thicker than the antagonistic teeth. Even though the maxillary teeth were also caries-free, the

clinician preferred to restore them with provisional composite restorations, fabricated directly in the mouth by means of transparent keys.

This clinical choice offered several advantages:

1. *Cost.* The patient would have only paid for half the number of indirect restorations previewed. The cost of replacing the maxillary teeth would be deferred to later on in the future.
2. *Chair time.* The appointment to deliver the posterior restorations (*step 2*) would have been shorter, since only 6 final restorations would have been delivered (instead of 12).
3. *Occlusal adjustments.* These would easily have been done only at the level of the maxillary provisional restorations, leaving the mandibular final restorations intact.

Thanks to the partial wax-up (only 12 occlusal surfaces), the clinician confirmed the treatment plan, which was offered to the patient. As the patient refused any fixed orthodontic therapies, a compro-



Fig 13a and b Already with a minimal increase of VDO (see separation at the level of the 2 molars), the anterior teeth were set too far apart to reestablish the anterior contacts only by means of palatal veneers. The position of the vestibular cusps of the maxillary posterior teeth (esthetic plane of occlusion) was considered adequate, and no wax was placed at this level.

mise was reached. The full-mouth rehabilitation would still take place to correct the curve of Spee and improve the deep bite by restorative means at the preselected increased VDO. An anterior open bite would be created, which would only be partially reduced by the thickness of the palatal veneers. However, after treatment, the patient would have to undergo orthodontic treatment to correct the open

bite, based on a removable functional appliance (Soulet-Besombes activator) (Fig 14).³²⁻³⁵ The patient accepted the overall treatment plan.

In order to deliver the final restorations, a final impression of the mandibular arch was taken. Without any tooth preparation, an impression was taken in polyvinyl siloxane (PVS) material. Metal matrices, placed between the posterior teeth and captured in the impression, allowed for the fabrication of the cast for the final restorations, with the contact points closed intraorally but open on the cast.⁵ On the new cast, guided by the previous wax-up, six CAD/CAM composite onlays (Lava Ultimate, 3M ESPE) were fabricated to restore the 2 premolars and the first molars (Fig 15).

Even though the maxillary restorations were meant to be provisional, it was not clear when the patient would be able to afford to replace them with final ones. The clinician preferred to consider them as semi-final and improve the chances that the *white bite* could have been made



Fig 14 Soulet-Besombes activator.



Fig 15a, b and c The wax-up of the 6 mandibular posterior teeth was used to fabricate 6 monolithic CAD/CAM composite onlays (indirect final restorations), with no tooth preparation required.



Fig 16a, b and c To favor the opening of the interproximal contact points, the technician had already weakened the marginal ridges. To ensure that embrasures would be free of composite, the wax was clearly removed at the level of the marginal ridges, before duplicating it with the two transparent silicone keys.

of individual restorations, by weakening the interproximal contacts already on the wax-up. Thus, before the duplication of the wax-up with the transparent keys, the wax was clearly removed at the level of the marginal ridges. This wax-up modification was possible because the amount removed was minimal and the contact points were already centered on the cusps due to the Angle class II molar relationship (Fig 16).

The patient was scheduled for a 4-h appointment (*clinical step 2*). The mandibular onlays were bonded under rubber dam, following an adhesive protocol developed by Pascal Magne,³⁶ differing only in the selection of the composite used to bond (Enamel plus HRi, Micrierium). The restorations were bonded

individually, using metal matrices to isolate the teeth and to help remove the excess cement.⁵ The bonding procedure was favored by the fact that the clinician did not have to worry about the contact points, since they were already present and they did not need to be modified with the restorations. In addition, the rubber dam isolation was very simple due to the occlusally positioned margins (Figs 17 to 19).

After the delivery of the 6 onlays, the treatment continued at the level of the maxillary posterior teeth. Still without anesthesia, the exposed dentin was roughened with a very course diamond bur. The patient was not disturbed by the procedure, confirming the sclerotic nature of the exposed dentin. The 3 teeth involved



Fig 17a and b Try-in of the 6 monolithic onlays in the mandible before rubber dam placement. These restorations covered the exposed dentin and flattened the curve of Spee, without any tooth preparation. The onlays did not extend to the cervical margins to replace the existing direct composite restorations, which were considered still clinically acceptable. The patient preferred not to replace them just for esthetic reasons, and the bonding procedure to deliver onlays instead of veneer/onlays was easier for the isolation of the operatory field.



Fig 18a and b Close-up of the try-in of the onlays in quadrant 4. Each onlay fitted to the corresponding tooth without interfering with the adjacent teeth.

in each sextant were isolated with metallic strips during the etching (30 s for both the enamel and the sclerotic dentin), and the bonding adhesive was applied (Optibond FL, Kerr). After the polymerization of the bonding, the matrices were removed and the transparent keys, loaded with warmed-up composite (IPS Empress Direct, Ivoclar Vivadent), were pressed onto the teeth. After an initial

polymerization through the keys (60 s), the polymerization continued in contact with the restorations after the removal of the keys. Finally, a layer of glycerin was applied, and each tooth was polymerized for a further 20 s (Figs 20 to 22).

The appointment was concluded with the occlusal adjustments, with the patient not anesthetized and sitting upright and fully cooperative on the dental chair.



Fig 19a and b The onlays were bonded individually, without anesthesia. Since the existing contact points were left intact, metal matrices were necessary to keep the teeth apart during the cementation and to facilitate the removal of excess cement.



Fig 20a, b and c Provisional posterior composite restorations fabricated with transparent keys. Clinical preparation of the maxillary posterior teeth. The dentin was roughened with a course diamond bur, and the tooth surfaces were treated to receive the composite restorations. No anesthesia was necessary. The bonding was polymerized with the metal matrices in place to improve the chances of delivering restorations with open contact points.

As previously mentioned, all the occlusal adjustments were done at the level of the maxillary provisional composite restorations, while the CAD/CAM composite onlays were left untouched. A further objective of the occlusal adjustments was to verify that no mandibular deviation was present upon biting. Bilateral group function movements were then evaluated. The final eccentric occlusal

adjustments were done using chewing gum, where the patient was asked to test the new occlusion, and confirm that she was comfortable to chew on both sides of the mouth.³¹

The patient was scheduled for a 1-h follow-up after 1 week, when she reported that after the first 2 days of adaptation she had become comfortable with the new occlusion. No phonetic impair-

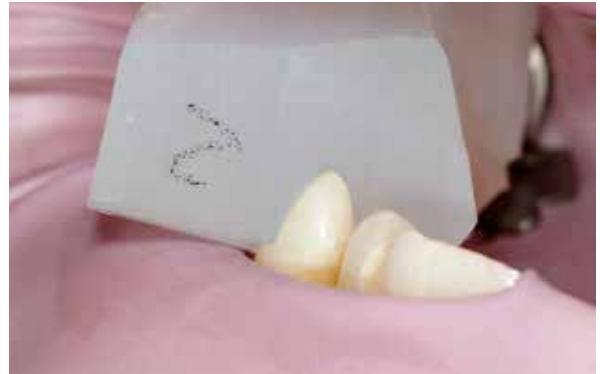
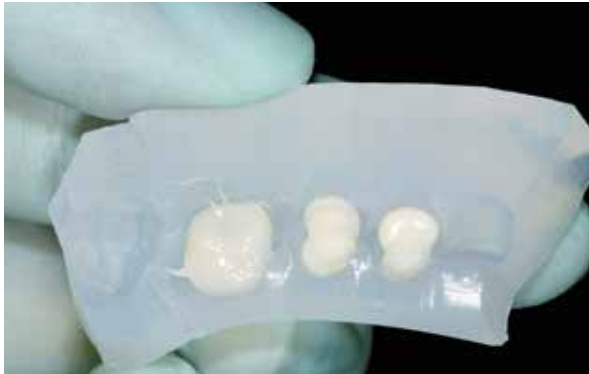


Fig 21a and b The silicone keys (Elite Transparent, Zhermack) were filled with a warmed-up hybrid composite and pressed onto the teeth. Due to the transparent nature of the keys, an initial polymerization was possible to harden the material with the keys in place. After their removal, the polymerization was then completed.



Fig 22 Provisional posterior composite restorations after the occlusal adjustments. The contact points were centered on each tooth, while the interproximal contacts were kept open, which would allow the patient to floss.



Fig 23 1-week follow-up after the delivery of 12 final and provisional indirect and direct restorations. Minor occlusal adjustments were necessary to equilibrate the two sides of the mouth.

ments (eg, the “s” sound) were experienced, since excessive air escaping through the anterior open bite was still prevented by the remaining vertical overlap. The occlusion was again verified, once more with the patient sitting upright in the dental chair. Minor occlusal adjustments were required to obtain equal contact points on all the restored posterior teeth, and were all performed on the maxillary arch (Fig 23).

During this follow-up visit, the maxillary anterior teeth were also prepared for the palatal veneers by immediately sealing the exposed dentin.³⁷⁻⁴¹ A final impression of the maxillary teeth was taken in PVS, with the metal matrices in between the teeth. Only an alginate impression for the antagonistic arch was necessary. The visit was concluded with an anterior bite registration in MIP, and a facebow record. The new casts were

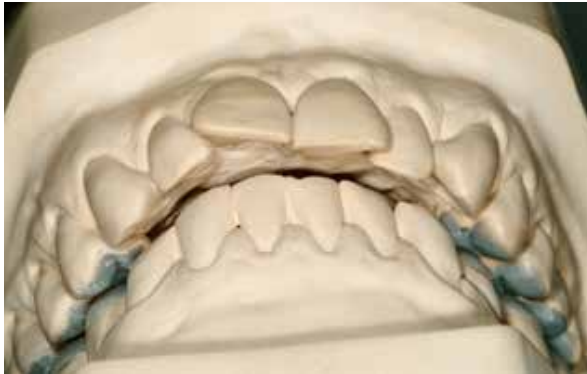


Fig 24a and b After *step 2*, as planned on the casts, the open bite created by the posterior restorations was too significant to be closed only with the palatal veneers.



Fig 25a and b The 6 palatal veneers in composite. Since the laboratory technician fabricated the veneers at a correct size, the anterior contacts were still missing.

mounted on the articulator. On analyzing the articulated casts, the clinician found, as expected, that the curve of Spee was flat and the deep bite had improved, but the anterior open bite was too important to be closed only with clinically acceptable palatal veneers (Fig 24).

The laboratory technician proceeded to fabricate 6 CAD/CAM monolithic palatal veneers (Lava Ultimate, 3M

ESPE), without striving to achieve anterior contact points (*step 3*) (Figs 25 and 26). After 1 week, the composite palatal veneers were bonded, following the adhesive protocol previously mentioned (Fig 27).³⁶

Since the open bite was only partially corrected with the palatal veneers, as had been anticipated, the patient started wearing a removable appliance, but only at night.



Fig 26a and b The impression was taken with the same metal strips used for the posterior teeth. The technician was instructed to stay inside the interproximal contact points, and to partially restore the teeth that were not completely accessible palatally due to crowding.



Fig 27a and b Step 3. Bonding of 6 composite palatal veneers, and the final result at the 6-month follow-up. For the maxillary anterior teeth, as for the posterior teeth, the existing interproximal contact points were kept intact, and metal strips were used not only during the impression but also during the cementation of the palatal veneers.

At the 1-year follow-up the anterior teeth were also in contact, and the mandibular teeth presented a more expanded arch, noticeable at the level of the improved occlusal relationship of the first premolars. In addition, thanks to the open bite, the mandible was finally free to be in a more protrusive position. A careful analysis of the temporomandibular joints (TMJs) showed no signs or symptoms of dysfunction. The patient

was very comfortable sleeping at night with the activator, and decided to continue wearing it. No fixed retention (eg, lingual wire) was delivered (Figs 28 to 30). Even the unrestored second molars presented occlusal contacts at this stage. Furthermore, the gingival recession at the level of the 2 central incisors was improved, despite the fact that no periodontal therapies had been carried out.



Fig 28a and b At the 1-year follow-up, the anterior contact points were reestablished and the patient was very satisfied with her new occlusion. Note the presence of interproximal calculus. The photos were taken without any cleaning/polishing of the dentition to show the real aging of the composite restorations.



Fig 29a and b Initial status, and 1-year follow-up. The gingival status of the patient was improved overall, even though the patient's oral hygiene was not perfect.

The patient was very happy with the overall result, and asked if it was really necessary to replace the maxillary provisional restorations with final ones. The clinician decided that there was no need to change these restorations for the following reasons: the restorations were made with a hybrid composite material, they were opposing the same type of materials (CAD/CAM composite onlays), the restored teeth were caries free, and

their interproximal contact points were open. The status of the restorations will be monitored in the future.

Conclusion

A full-mouth rehabilitation may represent an overwhelming procedure. Many clinicians therefore prefer to postpone the treatment until more damage has



Fig 30a and b Initial status and 2-year follow-up. Note the generalized improved aspect of the soft tissue.

occurred and patients are forced to undergo complicated and expensive treatments for the compromised esthetic and functional alteration of their dentitions. Non-invasive dentistry, without any removal of healthy tooth structure, based on simpler and less-expensive procedures, should be an alternative that may persuade more patients to start the therapy at an early stage and stop further damage of their dentition.

In this article, a clinical case of a patient affected by moderate dental erosion is illustrated. During the treatment planning, the clinician was able to determine that a rehabilitation with correct anterior contact points and adequate posterior restorations would have been impossible to obtain through restorative means only, and the use of orthodontic therapy was advocated to complete the treatment.

The restorative therapy consisted of five appointments only, with a high level of patient acceptance and satisfaction. As the patient did not need a facial veneer, a modified approach of the *three-step* technique was proposed. The rehabilitation started directly with the posterior restorations, both final in the mandibular arch and semi-final in the maxillary arch. Following that, the patient wore a removable functional appliance to restore the anterior contacts.

At the end of the therapy, all the exposed dentin was protected, and the patient's oral health was enhanced due to more favorable occlusal contacts, as was documented by the improvement of the periodontal status of the teeth.

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