
Full-mouth Minimally Invasive Adhesive Rehabilitation to Treat Severe Dental Erosion: A Case Report

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SUMMARY

Dental erosion is increasing, and only recently are clinicians starting to acknowledge the problem. A prospective clinical trial investigating which therapeutic approach must be undertaken to treat erosion and when is under way at the University of Geneva (Geneva Erosion Study). All patients affected by dental erosion who present with signs of dentin exposure are immediately treated using only adhesive techniques. In this article, the full-mouth adhesive rehabilitation of one of these patients affected by severe dental erosion (ACE class IV) is illustrated. By the end of the therapy, a very pleasing esthetic outcome had been achieved (esthetic success), all of the patient's teeth maintained their vitality, and the amount of tooth structure sacrificed to complete the adhesive full-mouth rehabilitation was negligible (biological success).

Keywords: dental erosion, palatal veneers, full-mouth adhesive rehabilitation.

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For decades, clinicians have concentrated their efforts on preserving teeth affected by dental caries. The more recent epidemiological surveys show that this effort has been successful.^{31,53} However, particularly in western countries, a new challenge is attracting attention: dental erosion.

Dental erosion is loss of a tooth surface produced by chemical or electrolytic processes of nonbacterial origin, usually involving acids.¹⁶ Articles on this subject have been published since 1947,^{6,8,15,17-19,32,33,55} but only in the past decade has the dental community started paying more attention to its increasing prevalence. National surveys frequently highlight this emerging dental problem.^{3,4,7,13,18,29,35,36,42,52} In the United Kingdom, almost

40% of the British teenagers examined at the age of 14 presented signs of dental erosion, while in Iceland, dental erosion was seen in 30% of 15-year-old adolescent subjects.

Due to a lack of awareness of the problem among patients, as well as clinicians' hesitation to address it, the extent of this disease is often underestimated and its treatment postponed. The dilemma on when and how to treat often very young individuals affected by dental erosion has split the dental community into two different groups: the clinicians who treat eroded teeth excessively and the ones who do not treat them at all.

At the University of Geneva, patients affected by dental erosion are treated as soon as possible after identification of dentin exposure through the Geneva Erosion Study. Only adhesive techniques are implemented, with minimal, if any, tooth preparation (principle of minimal invasiveness). Despite the tendency for adhesive modalities to simplify the clinical and laboratory procedures involved, the therapy of such patients still remains a challenge because of the great number of teeth affected in the same dentition.

To simplify the dental treatment and reduce the financial costs, an innovative approach termed the "three-step technique" has been developed in connection with the Geneva Erosion Study. This article describes the full-mouth adhesive rehabilitation of one of the study patients who was affected by severe dental erosion (ACE class IV). Since emphasis should always be placed on removing

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only the minimum amount of tooth structure when repairing teeth, the patient's maxillary anterior teeth were restored following the "sandwich approach", which consists of reconstruction of the palatal aspect with composite restorations (composite palatal veneers), followed by restoration of the facial aspect with ceramic facial veneers. The treatment goal was attained using the most conservative approach possible, as the remaining tooth structure was preserved and located in the center between the two different restorations.

For more details, it is recommended to review a series of three articles on full-mouth adhesive rehabilitation published earlier by Vailati and Belski¹⁷⁻¹⁹



CASE PRESENTATION

A 25-year-old female Caucasian presented at the School of Dental Medicine at the University of Geneva. Her chief complaint was the deterioration of her anterior teeth. Since she did not want crowns, as proposed by her clinician, over the past three years she had had her fractured incisal edges repaired by means of direct composites. This was a temporary solution, since the restorations were constantly failing and needed to be replaced.

The clinical examination revealed that the patient had generalized severe dental erosion involving the anterior and posterior teeth. She was not wearing an occlusal guard, even though she reported symptoms of parafunctional occlusal habits. All the teeth were vital and highly sensitive to temperature. Since the patient admitted to being bulimic and to vomiting several times a day, no gastroenterological evaluation was requested to establish the etiology of the dental erosion. According to the ACE classification,⁵⁰ the patient was considered ACE class IV, since the palatal dentin was largely exposed and the loss of length of the clinical crowns was more than 2 mm, while the facial enamel and the pulp vitality were still preserved.

During the first visit, photos, radiographs, and full-arch impressions were taken. The initial visit was concluded with a face bow record (Fig 1).

The maxillary and mandibular casts were mounted in maximum intercuspal position (MIP) using a semi-adjustable articulator. To determine the extent to which the patient would have accepted the reconstruction of her dentition (eg, the lengthening of the anterior maxillary teeth and the related esthetic position of the occlusal plane), a maxillary vestibular mock-up visit was planned. To obtain such a mock-up, it was not necessary to make a full-mouth wax-up. In fact, following the three-step technique, the technician waxed up only the vestibular aspect of the maxillary teeth; the second molars were excluded. To save time and to facilitate the next clinical step, neither the cingula of the maxillary anterior nor the palatal cusps of the posterior teeth were included. Subsequently, the information obtained from the maxillary vestibular wax-up was registered by means of a precise silicone key.

At a second clinical appointment, a maxillary vestibular

mock-up was fabricated directly in the mouth. The clinician loaded the silicone key with a tooth-colored autopolymerizing composite resin material (Telio, Ivoclar Vivadent; Schaan Liechtenstein) and positioned it in the patient's mouth.

After removal of the silicone key, all vestibular surfaces of the maxillary teeth were covered by a thin layer of composite, reproducing the shape defined for the future restorations by the laboratory technician (Fig 2). This mock-up visit allowed the patient's wishes to be communicated and enabled clinical validation of the position of the future plane of occlusion (first step).

The increase of vertical dimension of occlusion (VDO), mandatory to restore this patient's dentition, was determined arbitrarily on the articulator, taking into consideration the posterior teeth, where the maximum increase was desirable to maintain a maximum of mineralized tissue, and the anterior teeth, which should not be set too far apart to jeopardize the re-establishment of anterior contacts and the related anterior guidance.

Once the increase of the VDO was decided upon and the plane of occlusion was clinically validated, the technician was asked to produce the wax-up of the occlusal surfaces of the posterior teeth, the two premolars, and the first molar in each sextant. Four translucent silicone keys were then fabricated, each duplicating the wax-up of one posterior quadrant (Elite Transparent, Zhermack; Badia Polesine, Italy).

After etching and application of the primer and bond (Optibond FL, Kerr; Orange, CA, USA), the clinician loaded each translucent key with nanohybrid composite (Miris, Coltène Whaledent; Altstätten, Switzerland), positioned the key in the patient's mouth, and light cured the composite. As a consequence, in the single visit, without any tooth preparation, the occlusal surfaces of all the premolars and the first molars were restored with a layer of composite resin, reproducing the respective diagnostic wax-up (second step). Since the anterior teeth were not touched, an anterior open bite was created. No rubberdam was used, since the contact points were too tight and the margins of the provisional posterior composite restorations were planned to be sufficiently occlusal to assure moisture control.

Generally, the second step of the three-step technique is performed without anesthetizing the patient, not just because no tooth preparation is required, but also to benefit from the patient's full cooperation in checking and adjusting the occlusion. In the case of defective restorations, it is preferable to replace them before starting the second step. Even more so in this particular patient, due to the high risk of continuous fracture of the incisal edges, it was decided to create the anterior open bite as soon as possible.

To accelerate the treatment, the amalgam restorations were not removed before the second step. They were roughened and then covered by the composite layer (Fig 3).

Thanks to the creation of the anterior open bite, after the second step, it was also possible to restore the mandibular anterior teeth by means of direct composite restorations (Figs 4 and 5).

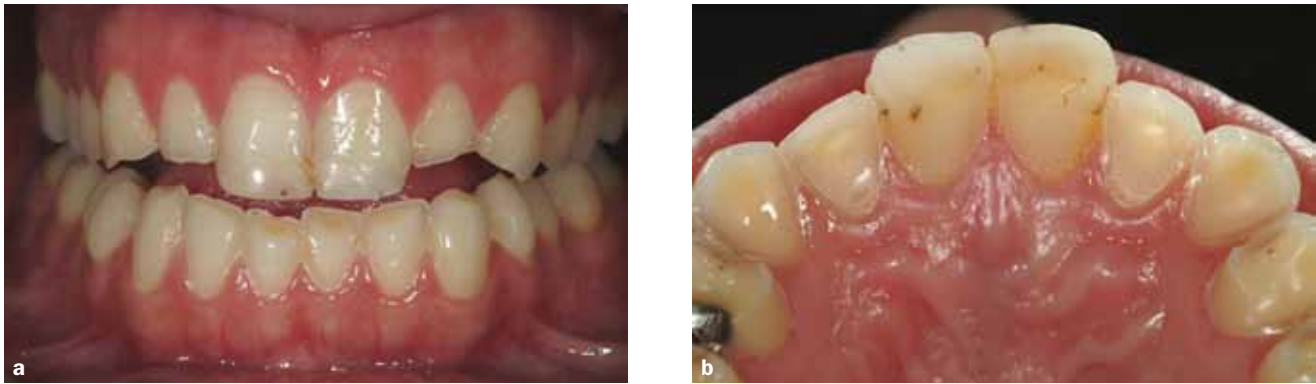


Fig 1 (a) Initial status. Note the presence of direct composite restorations on the two central incisors and the loss of tooth structure also on the lower incisors (frontal view with open mouth). (b) At the palatal aspect the dentin was largely exposed. The severe dental erosion also affected the posterior teeth, especially the maxillary premolars.



Fig 2 Maxillary vestibular mock-up immediately after elimination of the silicon key and removal of the excess cervical material (a). While the patient was contemplating her new smile, the clinician's attention was directed to the harmony between the incisal edge plane and the occlusal plane. Note that during the initial examination, it was planned to restore the vestibular aspect of the maxillary teeth 15 to 25. (b) The final treatment instead was more conservative, leaving all these surfaces intact except the four maxillary incisors (principle of minimal invasiveness).



Fig 3 Four transparent keys were fabricated, reproducing the wax-up of the posterior teeth at the increased VDO. All the premolars and first molars were restored using the transparent silicon keys. The erosion had especially affected the palatal aspect of the teeth in the maxillary arch up to the cervical third (a). However, the wax-up was modified so that the final margins were more occlusal and more easily finished (b). Note the presence of the amalgam filling on the first molar under the composite layer (c).



Fig 4 The restoration of the mandibular anterior teeth was carried out only after the VDO had been increased and the anterior open bite created.



Fig 5 At the completion of the second step, all the posterior teeth except the four second molars were restored with direct composite restorations. Consequently, the anterior teeth were set apart. The creation of an anterior open bite, necessary to restore the anterior teeth, did not disturb the patient.



Fig 6 Without any tooth preparation, only roughening of the sclerotic dentin, the palatal aspects were prepared for the composite veneers. Note that the dentin was immediately sealed using Optibond FL and flowable composite (Tetric flow T, Ivoclar Vivadent).

The protocol of the Geneva Erosion Study recommends an arbitrary observation period of approximately 1 month to assess the patient's adaptation to the newly established VDO. Since after 1 month our patient felt comfortable with the new occlusion, two alginate impressions and a new facebow record were taken. In order to mount the casts in MIP, an anterior occlusal bite registration was also required. The type of restoration best indicated to restore the palatal aspect of the maxillary anterior teeth was then selected. Generally, if the interarch space is reduced (<1 mm), the composites are done directly free-hand. If the interocclusal distance between the anterior teeth is, instead, significant, fabrication of indirect restorations (composite palatal veneers) is preferred. In this particular case, the indirect approach was selected, and an appointment was scheduled to prepare the six maxillary anterior teeth for the palatal veneers.

In general this procedure does not require local anesthesia; however, due to this patient's hypersensitivity, the teeth were anesthetized. The interproximal contacts between the maxillary anterior teeth were slightly opened by means of stripping using thin diamond strips, and the incisal edges were smoothed by removing the unsupported enamel prisms. The palatal dentin was also cleaned with nonfluoridated pumice, and the most superficial layer was removed with diamond burs. The exposed sclerotic dentin was immediately sealed with Optibond FL and flowable composite (Tetric flow T, Ivoclar Vivadent) before the final impression.^{10,20-22,38} No provisional restorations were placed (Fig 6).

After one week, the palatal veneers were bonded, one at a time, using rubber-dam isolation. The palatal sealed dentin was sandblasted (Cojet, 3M ESPE; Seefeld, Germany), the surrounding enamel was etched (37% phosphoric acid), and the adhesive (Optibond FL, Kerr) was applied but not cured. The composite veneers were also sandblasted (Cojet), cleaned in alcohol and with ultrasound, and three coats of silane were applied (Silicup, Heraeus Kulzer; Wehrheim, Germany). A final layer of adhesive (Optibond FL, Kerr) was used without curing. A warmed-up composite was then applied to the restorations (Miris, Coltene Whaledent) before they were placed on the teeth and light cured.

The open contact points facilitated the bonding procedures, from positioning of the veneers to excess removal. Thanks to the presence of a composite "hook" at the level of the incisal edges of the veneers, it was easier to achieve correct positioning, even on the "slippery" palatal surfaces. The hooks were subsequently removed during finishing and polishing (Fig 7). The restoration of the palatal aspect of the maxillary anterior teeth concluded the three-step technique. At this stage, the patient reached stable occlusion in the anterior and posterior sextants. The VDO was clinically tested, and the anterior guidance was re-established (Fig 8).

Before replacement of the posterior provisional composite resin restorations with permanent composite resin onlays, restoration of the facial aspect of the maxillary anterior teeth was completed with ceramic veneers (sandwich approach). A new mock-up was performed to finalize



Fig 7a Palatal composite veneers on the cast. The bulky appearance at the incisal edges corresponds to the composite "hooks" made of the same resin material.



Fig 7b Occlusal view after bonding. Note that the interproximal contacts were left open, to facilitate the next restorative step (facial ceramic veneers), and that the incisal "hooks" were eliminated.

the shape of the facial veneers. Following the principle of minimal invasiveness, the option of leaving the facial surface of the canines unrestored was discussed with the patient. Since the facial aspect of the canines was perfectly intact, including these teeth in the veneer preparation would have led either to veneer preparation that was too aggressive or to final canines that were too bulky. Although the margins between the palatal veneers and the tooth structure of the canines were visible close up, at a social distance this was completely acceptable, so that the patient decided to have only the four maxillary incisors restored (Fig 9).

The veneer preparation was carried out without local anesthesia, due to the minimal removal of tooth structure and the lack of dentin exposure. The interproximal contact areas, already open, were further adjusted with a metallic strip. A light chamfer was prepared at the cervical level, following the curve of the marginal gingiva, with no need to extend the preparation to the



Fig 8 At the completion of the three-step technique, the patient had stable occlusion, comprising posterior support at a new clinically tested VDO and anterior guidance. At this stage, the patient was ready for restoration of the facial aspect of her maxillary anterior teeth.



Fig 9 Mock-up of only the four maxillary incisors (a). The unrestored facial surface of the canines blended nicely into the rest of the dentition (b). The decision was also made not to cover the entire vestibular aspect of the maxillary posterior teeth (principle of minimal invasiveness), although this had originally been a part of the initial treatment plan.



Fig 10a Incisal edge reduction key before facial veneer preparation. Note the interproximal open contacts before the veneer preparation, which facilitate the fabrication and the subsequent bonding of the facial veneers.



Fig 10b After veneer preparation, the original tooth length was not affected, since the space necessary for the fabrication of the veneers (1.5 mm) was obtained by removing the length added by the palatal veneers.

gingival sulcus (in contrast to the crown preparation of devitalized teeth), since the color of the underlying tooth structure was ideal. Since the palatal aspects, restored with composite veneers, were considered an integral part of the respective teeth, no particular effort was made to place the preparation margins on tooth structure. At the incisal level, all the length created by the palatal veneer was removed, and a flat preparation was performed, paying attention to smoothing all the line angles (Fig 10).

After the impression, a provisional was fabricated with the same silicon key used for the mock-up. The key was loaded with provisional composite material (Telio, Ivoclar Vivadent), and retention was achieved by both the contraction of the product and the presence of minimal interproximal excess.

The bonding of the veneers was carried out after 2 weeks, following the protocol developed and published by Pascal Magne.^{9,23-26} The only difference was the type of composite used. Due to the extremely reduced thickness of these veneers and the high risk of fracture, a

flowable composite (Tetric flow T, Ivoclar Vivadent) was preferred (Figs 11 and 12).

After the completion of the sandwich approach (palatal composite veneers and facial ceramic veneers), the treatment continued with the replacement of the posterior provisional composite restorations. Whereas all the premolars and first molars were restored with indirect restorations (composite onlays), the second molars were restored with direct restorations, due to a lack of interocclusal space. Finally, an occlusal guard was delivered to the patient, who was entered in the Geneva Erosion Study after completing her dental treatment and is seen every 6 months as part of the protocol.

The patient was clearly satisfied with the overall treatment, which she did not consider stressful at any time in spite of the full-mouth rehabilitation undertaken. The restorations integrated nicely with the rest of the dentition (color and shape) (Fig 13), and the soft tissues were healthy (esthetic success). Finally, the amount of tooth structure removed was minimal, and all the teeth retained their vitality (biological success) (Fig 14).

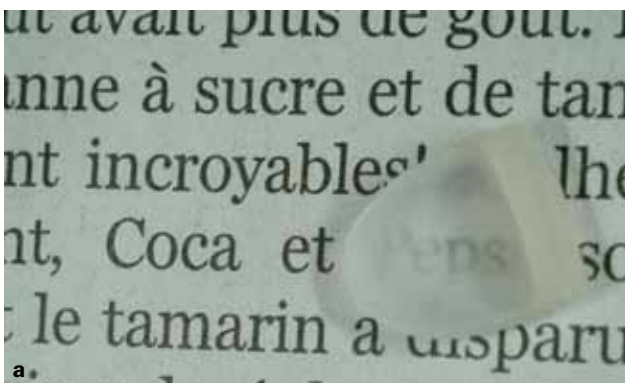


Fig 11 (a) The facial ceramic veneers were extremely thin, due to the very conservative tooth preparation. (b) Each veneer was bonded separately under perfect moisture control conditions, using a flowable composite (Tetric Flow T, Ivoclar Vivadent).



Fig 12 Comparison between the initial status (a), the veneer preparation (b), and the final restorations (c). All the teeth retained their vitality, and the hypersensitivity disappeared. Note the soft tissue health before and after treatment.



Fig 13 Straight profile before (a) and after (b) the treatment. To avoid preparing the vestibular aspect, the restored maxillary incisors were made bulkier, but their emergence profile remains very natural.



Fig 14 Before treatment (a) and final result (b) of the patient restored with the “three-step technique” and the “sandwich approach”. The esthetic and biological success (all teeth vital) could not have been achieved with any other type of restorations (eg, conventional crowns).

Table 1 ACE classification

	Palatal enamel	Palatal dentin	Incisal edge length	Facial enamel	Tooth vitality	Suggested therapy
Class 0	Preserved	Not exposed	Preserved	Preserved	Preserved	No restorative treatment
Class I	Reduced	Not exposed	Preserved	Preserved	Preserved	Preventive measures, no restorative treatment
Class II	Lost in contact areas	Minimally exposed	Preserved	Preserved	Preserved	Preventive measures, palatal composite restorations
Class III	Lost	Distinctly exposed	Lost \leq 2 mm	Preserved	Preserved	Preventive measures, palatal onlays
Class IV	Lost	Extensively exposed	Lost $>$ 2 mm	Preserved	Preserved	Preventive measures, sandwich approach
Class V	Lost	Extensively exposed	Lost $>$ 2 mm	Distinctly reduced/lost	Preserved	Preventive measures, sandwich approach (experimental)
Class VI	Lost	Extensively exposed	Lost $>$ 2 mm	Lost	Lost	Sandwich approach (highly experimental)

DISCUSSION

Dental erosion is increasing, but the dental community often appears to underestimate the extent of problem, even when the signs of loss of tooth structure are already visible and progressive. Two attitudes may explain this hesitation: the “fear of early engagement” and the “10-year deal”. The former involves early diagnosis with no intervention, and the latter involves postponed treatment with excessive intervention. Both lead to loss of precious tooth structure.

The first group (fear of early engagement) comprises clinicians who are concerned about what the future holds for young people who undergo oral rehabilitation which is too extensive. Since no dental restoration ages as well as healthy teeth, a tooth, once restored, will always need further attention. A patient who receives full-mouth rehabilitation at a very young age will need several remakes over the course of her or his life, and every time a restoration is replaced, some additional loss of tooth structure may be involved: a direct composite restoration becomes an onlay, and afterward a crown, and then another crown, with the accompanying loss of vitality of the tooth, and finally that tooth is replaced by an implant (“dental countdown”). Consequently, these protective and conservative clinicians tend to postpone such care until patients reach a more advanced age. However, leaving a dentition affected by dental erosion unrestored may have more severe consequences (eg, tooth supraeruption, fracturing of the incisal edges and shortening of the clinical crowns, pulp necrosis, and alteration of the plane of occlusion).

Clinicians in the second group (the 10-year deal) agree to treat this patient population, but want to be able to

guarantee the longevity of their restorations. Dentistry is the only field in medicine where clinicians feel the pressure to guarantee a 10-year result. To do so, many colleagues prefer restoring patients with durable long-term restorations (such as crowns); however, these require a considerable (iatrogenic) additional loss of tooth structure. In the case of early diagnosis of dental erosion, these clinicians also choose to wait until more tooth structure is lost, so that the more aggressive treatment (eg, “thicker” onlays or crowns) can better be justified. But at what expense? Is it justified to wait for more loss of tooth structure in order to provide a more durable restoration? Or would it be wiser to accept that a “weaker and thinner” restoration could be used which would potentially need to be replaced more often, but which would not compromise the underlying tooth any further? What is not completely explained to patients is what will happen over the very long term to “stronger restorations”. Looking at the relevant literature, there are no reliable long-term studies (more than 15 years) available on the results of conventional therapy.^{11,14,34,37,45,51}

Especially for devitalized teeth, data addressing long-term prognosis are lacking.^{12,27,39,41,43,54} Consequently, many clinicians have to base their clinical judgment on personal experience and expert opinions. If the first crown is not replaced for esthetic reasons, its short-term survival could be anticipated to be very high (at least 5 years).^{5,28,30,40,44,46} However, the same tooth receiving a similar type of crown for the second or third time may not have the same positive prognosis. In the case of a devitalized tooth, the prognosis becomes even more pessimistic. Once a tooth is restored with a crown, there is no other re-treatment available except repeating the same type of restoration until the tooth is no longer restorable. When

a tooth is restored with a direct composite instead, and its underlying structure is almost intact, there will always be the option of replacing the composite, when it wears off, with another composite, without affecting the tooth's inner strength. In other words, repair the teeth more often but use the same conservative type of restoration. It is preferable that the restorations wear down rather than the underlying tooth structure. Patients whose dentition is affected by dental erosion should receive more information on the "pros and cons" of the different philosophies of treatment so that they can choose when and how to treat their affected teeth.

At the University of Geneva, all the patients affected by dental erosion are immediately treated if they present signs of dentin exposure. Following the ACE classification (Table 1), already ACE Class-II patients are informed about their dental problem and treated.

Criticism about treatment of our patient could arise with regard to the etiology of the dental erosion (bulimia). Several authors have stated that they prefer to wait for the disease to resolve before treating patients affected by psychiatric diseases.^{1,2} In patients affected by dental erosion caused by pathologies such as gastric reflux, the acid attack is chronic but mild, so that the dentinal tubules have the time to be clotted and the pulp protected. In the case of bulimic patients, on the other hand, the vomiting is often frequent and significant, and the pH of the hydrochloric acid is very low (pH = 1). Thus, the pulp vitality is at higher risk of being lost. In our opinion, clinicians should not postpone treatment if patients with bulimia are willing to undertake it. Covering the exposed dentin is not only a protection against further damage due to erosion and attrition, but also protects against loss of pulp vitality.

CONCLUSION

Dental erosion is increasing, but the dental community often appears to underestimate the extent of the problem. The frequent lack of timely intervention is related not only to the slow progression of the disease, which can take years before becoming evident to patients, but also to clinicians' hesitation to propose restorative treatments based on noninvasive adhesive procedures in asymptomatic patients.

In this article, the treatment of a 25-year-old ACE class IV patient was successfully completed. The two main goals – minimal tooth preparation and tooth vitality preservation – were achieved, showing that early intervention could be a very reasonable solution even for very young patients affected by dental erosion.

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Clinical relevance: Dental erosion is an increasing problem for which maximum tooth structure preservation is the key to treatment. Adhesive dentistry and solid knowledge of occlusion are the most valuable tools to achieve predictable esthetic, biological, and mechanical success.