A Comprehensive and Conservative Approach for the Restoration of Abrasion and Erosion. Part I: Concepts and Clinical Rationale for Early Intervention Using Adhesive Techniques

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Abstract

Tooth wear represents a frequent pathology with multifactorial origins. Behavioral changes, unbalanced diet, various medical conditions and medications inducing acid regurgitation or influencing saliva composition and flow rate, trigger tooth erosion. Awake and sleep bruxism, which are widespread nowadays with functional disorders, induce attrition. It has become increasingly important to diagnose early signs of tooth wear so that proper preventive, and if needed, restorative measures are taken. Such disorders have biological, functional, and also esthetic consequences. Following a comprehensive clinical evaluation, treatment objectives, such as a proper occlusal and anatomical scheme as well as a pleasing smile line, are usually set on models with an anterior teeth full-mouth waxup, depending on the severity of tissue loss. Based on the new vertical dimension of occlusion (VDO), combinations of direct and indirect restorations can then help to reestablish anatomy and function.

The use of adhesive techniques and resin composites has demonstrated its potential, in particular for the treatment of moderate tooth wear. Part I of this article reviews recent knowledge and clinical concepts dealing with the various forms of early restorative interventions and their potential to restrict ongoing tissue destruction.

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Introduction

Excessive abrasion (attrition) and erosion are two common issues of dental hard tissues, which affect an increasing number of patients.[1-2] It can also be considered a growing challenge in dentistry, because in such patients (particularly those affected by severe parafunctions) the etiology can rarely be successfully and permanently eliminated.[3-5] It therefore implies continuous monitoring to control related pathologies. The most frequent causes of erosion are unbalanced dietary habits with high consumption of acidic food and drinks (carbonated drinks, fruits, fruit juices, vinegar; etc.) as well as abnormal intrinsic acid production in disorders such as in bulimia nervosa, acid regurgitation, and hiatal hernia. Insufficient saliva flow rate or buffer capacity and in general saliva composition changes induced by various diseases, medications, and aging are other etiological co-factors.[6-9]

Regarding abrasion and attrition, awake and sleep bruxisms are two different forms of parafunctional activities that can severely impact tooth integrity;[4-5] preventive and restorative measures are mandatory to correct and limit the extent of further tissue and restoration destruction. An important clinical finding is that a large number of patients with hard tissue loss present combined etiologies, challenging the dental team to provide a multifactorial preventive and restorative approach.[1-9]

The dental consequences of abrasion and erosion are manifold:

- loss of enamel with progressive exposure of large dentin surfaces
- loss of occlusal, facial, and lingual tooth anatomy with impact on function and esthetics
- shortening of teeth with impact on function and esthetics (ie, change in smile line, loss of embrasures)
- adaptive teeth displacement with impact on occlusion and esthetics
- discoloration of exposed dentin surfaces
- tooth sensitivity and pulpal complications
- increased risk of decay
- loss of restoration marginal adaptation and restoration fracture.

Due to the significant impact of abnormal abrasion and erosion on dental biomechanics and health, the challenge is that prevention and treatment should involve different specialties, starting with preventive measures and ending up with full-mouth rehabilitation. Intermediate stages (slight to moderate erosion/abrasion) require other clinical measures, such as various forms of adhesive and partial restorations.

The aim of Part I of this article is to review recent knowledge and clinical concepts dealing with the various forms of early restorative interventions and their potential to restrict ongoing tissue destruction. The impact of different restorative techniques on remaining tooth structure and biology will also be addressed.

A comprehensive treatment approach with focus on early intervention

A modern approach to the treatment of tooth wear is to prevent the progression of this disease before a full prosthetic rehabilitation would be needed, causing large amounts of additional tooth substance to be removed. Such a treatment approach would become totally ineffective because of potential biological complications[10-11] and inadequate biomechanical rationale. A modern treatment model involves three steps:

1) Comprehensive etiological clinical investigation:

- diet analysis
- identification of general/medical risks or disorders (ie, bulimia nervosa, gastric reflux, hiatal hernia, medications)
- identification of local risk factors, such as:
  - bruxism (awake and sleep bruxisms, other habits);
  - abnormal occlusal conditions;
  - carious activity;
  - periodontal diseases;
  - insufficient saliva flow, buffer capacity, compositional changes.

2) Treatment planning and execution:

- full case analysis on mounted models
- partial or full waxup
- setup of a new vertical dimension of occlusion (VDO)
- setup of a new smile line
- posterior (direct or indirect) restorations
- anterior (direct or indirect) restorations.

3) Maintenance:

- protective night guard or other therapeutic appliance
- regular checkups
- repair or replacement of restorations
- additional restorations.

This treatment sequence enables the management of severe tooth wear and erosion as it represents a logical therapeutic approach. It starts with a detailed etiology search and then continues with a full functional and esthetic analysis (on models), which, based on the amount and location of missing tissue, helps to select the best restorative procedure and to program the adequate teeth anatomy, smile line, and occlusal scheme.

The restorative options at hand comprise:

- direct partial composite restorations
- indirect partial restorations
- indirect, partial ceramic restorations
- indirect, full ceramic restorations.

The obvious disadvantages of indirect ceramic/porcelain-fused-to-metal (PFM) restorations are the rather invasive approach combined with more dramatic failure patterns[12] (Fig 1). Therefore, using more conservative restorations such as partially direct and indirect restorations, seems to have an undeniable advantage and promising impact on the treatment of severe abrasion and erosion.[13-18]

Fig 1 Postoperative view of composite overlays (14-15 and 24-25) placed to augment the vertical dimension of occlusion (VDO) in a patient presenting severe tooth wear resulting from erosion and bruxism **(a and b)**. Two years post-treatment shows direct composites and an implant-supported PFM restoration (tooth 16), which completed the treatment of posterior areas **(c and d)**. Eight years post-treatment shows that one PFM restoration failed, while composite indirect and direct restorations survived the demanding functional environment **(e and f)**, demonstrating their potential to treat severe tooth abrasion and use as an alternative to conventional prosthodontics for early intervention.

Dahl's concept

The idea of increasing the VDO to treat or restore patients with abnormal tooth wear has been described and applied for a long time. One of the first clinicians to promote this technique was Dahl who published many articles on this topic. His rationale was to use a metal appliance to elevate occlusion and allow teeth to move passively until once again in occlusion, and then create space for teeth, which were stabilized by the appliance.[14] The dental movements were supposed to occur by a combined supra-eruption of "occlusally free" teeth, together with simultaneous alveolar growth and also intrusion of teeth maintaining contacts. It was shown that such phenomena would occur in an important proportion of patients treated according to this concept.[14] Even though this treatment modality was part of many therapeutic schemes for complex treatment, the value of Dahl's idea was acknowledged and reviewed in several recent papers and review articles.[16-22]

Increasing the vertical dimension of occlusion is in fact a key parameter to reverse and prevent the consequences of pathological wear and erosion.[22-24] Actually, the passive eruption that accompanies the continuous tissue destruction and loss tremendously restricts the space available for restorations, which, due to their limited thickness, would be very fragile or otherwise should invade unnecessarily residual tooth structure. In fact, restoring such patients at the same VDO is not an option. Another advantage of increasing the VDO is to reduce incisal overlap, which appears favorable, in cases of excessive overbite.[24] Recent clinical reports have largely validated this treatment rationale.[25-27]

Treatment outline and objectives

An optimal restorative choice is usually based on a preexisting dental condition (presence of decay, restoration, vital or non-vital status) as well as the amount and localization of tissue loss. This means that various restorative options have to considered and that treatment planning is highly individualized (tooth specific), even though one general principle governs all clinical decisions, namely to be conservative and therefore preserve tooth biomechanical status. Table I describes the various treatments available according to the initial tooth status, in cases of moderate to severe tissue loss.

The majority of patients seem to consult a professional due to the esthetic impact of erosion and abrasion on tooth appearance (proportions, facial anatomy and color) and smile line (flattening and shortening). Then, the therapeutic scheme is logically oriented toward reestablishing first a proper central incisor length and anterior guidance, governing the new VDO. The proper anterior tooth anatomy and function is designed according to objective esthetic guidelines,[28] existing and former tooth anatomy, and functional and phonetic components. The first step is made on study casts in the form of a partial (moderate posterior tissue loss) or full-mouth wax-up (advanced generalized tooth wear/erosion). The global therapeutic scheme is summarized in Fig 2.

Table 1 Various treatment options according to initial tooth status, in case of moderate to important tissue loss (severe to extreme loss excluded).

Area	Tooth status	Preferred treatment	Alternative treatment
Posterior	No caries lesion Non-restored	Direct composite	Overlay*
	Slightly decayed Small to medium size restoration(s)	Direct composite	Overlay*
	Heavily decayed Large restoration(s)	On-Overlay*	Full crown
	Endodontically treated and/or discolored	Overlay*	Full crown
Anterior	No caries lesion Non-restored	Direct composite	Veneer + Direct composite
	No caries lesion Non-restored Loss of facial anatomy	Veneer + Direct composite	Full crown
	Slightly decayed Small to medium size restoration(s)	Direct composite	Veneer + Direct composite
	Heavily decayed Large restoration(s)	Veneer + Direct composite	Full crown
	Endodontically treated and/or discolored	Veneer + Direct composite	Full crown

* Preferably made with tooth-colored material (first choice: composite; second choice: ceramic)

Functional evaluation and laboratory steps

Basic restorative objectives are similar to those of a conventional restorative treatment, namely to reestablish proper anterior overjet and overbite, canine guidance, and an adequate horizontal occlusal plane. Preexisting anatomy and occlusal conditions might of course impose some restrictions to those aims, but they conceptually serve as a reference. In consideration of the amount of tissue to replace and then, the increase of the VDO, a partial or full-mouth waxup is created (Figs 2 and 3). A colored wax (different from the model color) is preferably used so that the surface and thickness of planned restorations can be properly estimated. It is normally advised to have both initial and waxed models mounted on the same articulator so that an anterior index made of silicone or resin (Fig 2) can be used to control and duplicate intraorally the situation created in the laboratory.

A partial waxup is made only in cases of minimal to moderate VDO increase; then the anatomical corrections are visually estimated, which would not be appropriate for an advanced case (com-

prehensive rehabilitation) (Fig 3). When a full waxup is available, silicone indexes are used to fabricate either direct or indirect restorations, whether in the anterior or posterior regions. The second part of this article will provide detailed information about all laboratory and clinical procedures.

Direct composite option

The direct composite option is logically indicated for all forms of moderate to intermediate tissue loss and destruction.[13-18] The advantages of direct composite over indirect restorations are manifold. Among other benefits, one can cite the highly conservative approach, the possibility to replace/re-shape small portions of the tooth, the reparability, the simplified replacement, and relatively limited cost (Fig 1). Conversely, it is more technique sensitive and might create thin layers of material over some surfaces, which are mechanically "at risk." When using a sculpting technique, a correct anatomy can also be created with a direct technique, favoring the selection of a filling material with a "firm consistency" (Fig 3).[29–31]

When correcting the anatomy and function of teeth showing minimal tissue loss, all types of composite can be used, including flowable ones, since permanent anatomical modification is not mandatory as passive eruption will compensate wear. Conversely, when correcting anatomy and replacing missing tissue at the same time, using a strong and wear-resistant material is imperative; hybrid composites are preferred.[29–31]

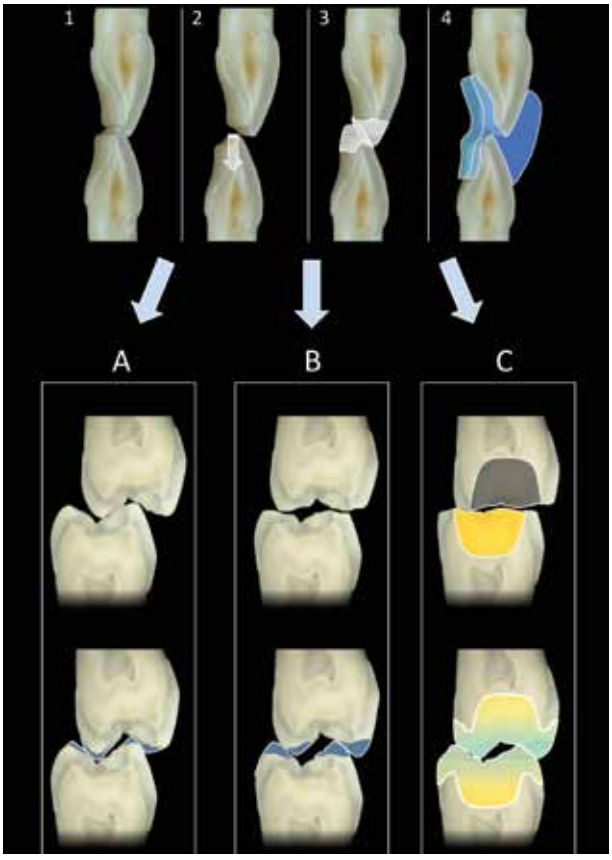

Fig 2 Comprehensive treatment scheme according to anterior and posterior tooth wear/erosion. The length of anterior teeth is reduced by combined attrition/erosion **(1)**; vertical dimension of occlusion needs to be augmented **(2)**; on the models and based on a waxup, a new anterior guidance and smile line are established **(3)** from which an index is made and transferred to the mouth when proceeding with posterior restorations. Three different conditions are encountered in the posterior areas: **(a)** no or minimal tissue loss, occlusal stops are made with composite (any type); **(b)** moderate tissue loss and/or small to medium size restorations, occlusal morphology is reestablished with a hybrid composite and direct technique; **(c)** severe tissue loss and large metal-based restorations, occlusal morphology is reestablished with indirect tooth colored restorations (overlay).

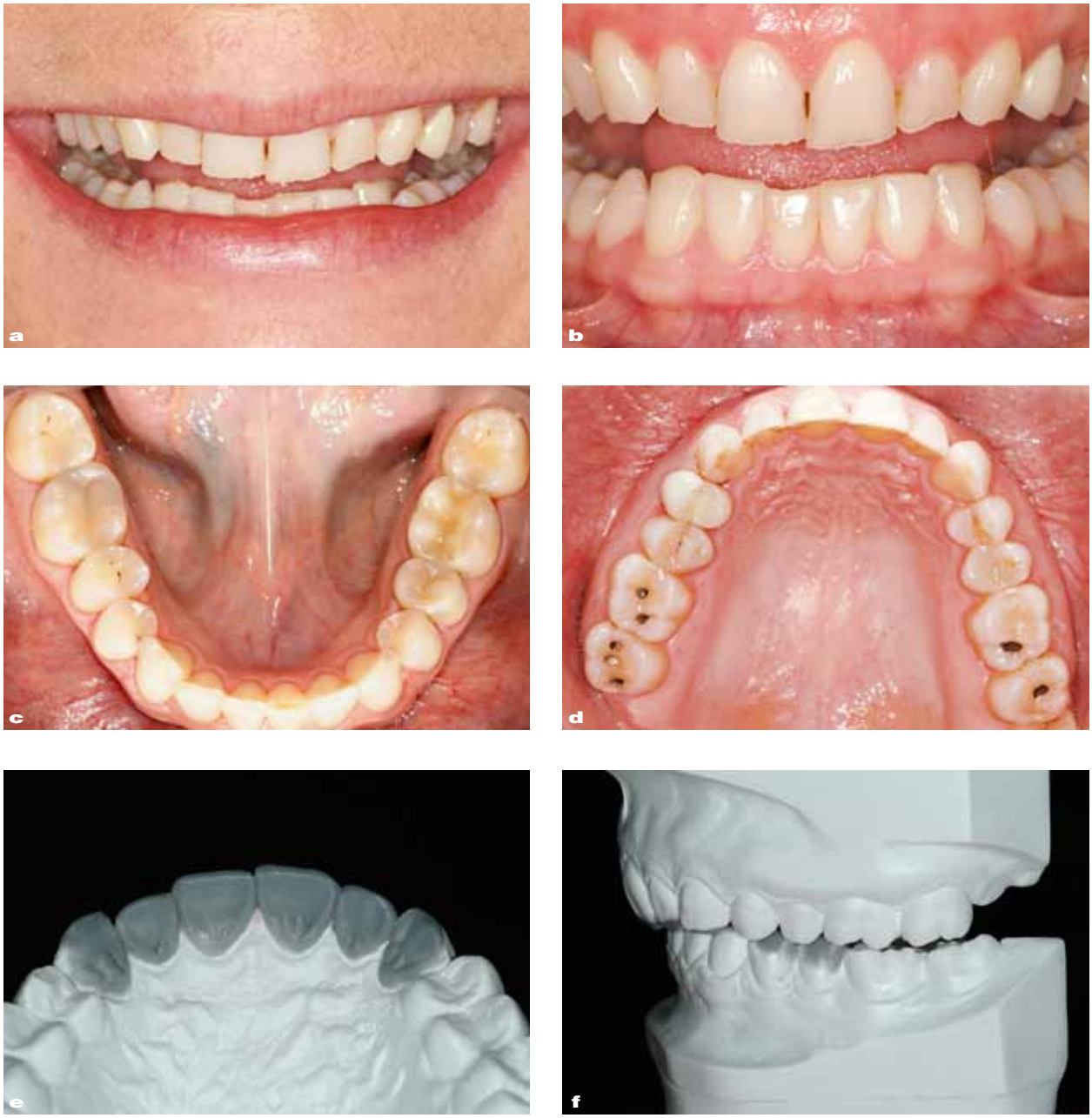

Fig 3 Preoperative view of a patient showing irregular smile line due to attrition of anterior teeth in relation to a deep bite and sleep bruxism **(a and b)**; parafunctional movements are here mainly of a protrusive nature as revealed by clinical evaluation of posterior teeth that show little tooth wear **(c and d)**. Due to the occlusal context and limited loss of hard tissue in the posterior areas, only an anterior waxup was prepared to define the new VDO and an appropriate space for restoring anterior teeth, using conservative adhesive restorations **(e and f)**.

Fig 3 (continued) Intra-operative view of mandibular posterior teeth, which received direct composite restorations. The choice was made to restore/reshape only the mandibular teeth because of the supra-eruption of anterior mandibular teeth. This approach aims to reduce the overbite and at the same time provide the space needed to restore esthetic and functional maxillary anterior teeth **(g and h)**. The postoperative view of the mandibular arch showing the new anatomy, created with direct composites **(i)**. Views of maxillary anterior teeth during and after correction of the smile line made with direct composites; the increase of VDO also helped to provide mechanical resistance **(j and k)**. Postoperative view of the restored smile 1 year later, showing no sign of recurrent wear or mechanical degradation **(l)**. The patient wears a night guard regularly.

Indirect composite option

The indirect option is logically preferred when larger restorations or more severe tissue destruction are present. It also provides more control of anatomy and occlusion in complex or advanced cases. Nevertheless, one should not neglect the direct option considering the fact that occlusion seems not to play a major role in the origin of parafunctions.[4,5,32-34] Since direct and indirect techniques can be used together to treat the same patient, the indirect restorations have to be fabricated first at the new VDO. After cementation, the direct composites can be placed using all anatomical and functional parameters provided by the new indirect restorations and diagnostic waxup/index as well.

The main drawback of an indirect approach arises from the need to create defined margins and geometry to allow for a proper and reliable fabrication of the restoration. It also has a higher production cost, even if significantly less than porcelain or ceramic. However, many other advantages of the direct option such as a conservative preparation approach, reparability, and easy replacement procedures remain.

Other options and material selection

The present debate about whether ceramics or composite is best for such restorations is sometimes based on personal experience and belief, rather than on scientific or clinical evidence. The rather abundant literature dealing with the clinical behavior of composite and ceramic inlay and onlays has not shown a major advantage of either material.[35,36] It is also not possible to ascertain what role is played by the study environment, knowing that clinical trials that evaluated ceramic restoration behavior were performed by experienced and skilled operators, while those dealing with composite restorations embraced various environmental conditions and operator skills ranging from undergraduate students to experienced operators. There are also exclusion criteria (in particular patients with parafunctional habits) in the majority of clinical trials evaluating ceramic restorations, which might favor the overall performance of indirect ceramic restorations.

Nevertheless, the Empress® material (Ivoclar, Schaan, Liechstenstein) has shown a reduced range of annual failure rates, compared to composites (laboratory or direct restorative systems) or fired porcelain in/onlays.[37] These findings might speak also in favor of new lithium disilicate pressed ceramics (IPS e.max Press®, Ivoclar), which exhibit a much higher flexural strength than former Empress materials and were shown to have more satisfactory fatigue resistance, compared to layered zirconia restorations.[38] So it is currently the best choice when restoring patients with ceramics in the presence of heavy parafunctions, even though the real benefit and long-term clinical performance of this new technology is still unknown.

Treatment sequence

The treatment of severe tooth wear and erosion requires careful and logical plan-

ning. First of all, when indirect restorations are needed (in/on/overlay to full crowns), they should be fabricated first, according to the new VDO preestablished on the study models. Then the other teeth, which require direct buildups, are treated accordingly. This implies working on one arch until completion (one or two sessions, scheduled preferably over a single day) and then follow up with the opposite one, giving the patient a few interocclusal contacts and some degree of functional balance in between the two treatment phases. Generally, the whole treatment can be organized within a relatively short period of time to respect the patient's comfort and fulfill functional and esthetic objectives.

Longevity and maintenance of conservative restorations placed to correct severe tooth wear and erosion

Theoretically, preventive measures linked to erosion or abrasion lesions should be based on a different strategy, aiming either to reduce the contact between acids and hard tissues or protecting the teeth from mechanical stresses. In fact, the authors' experience has shown that patients showing moderate to severe erosion often also present some degree of parafunctional activities, which of course complicates case management and maintenance. In addition to the control of diet and other medical conditions responsible for erosion, all patients receive a night guard, which seems to be the most effective measure, knowing that occlusion is neither the cause nor the treatment of parafunctional activities.[4,5,33-35]

It has been shown that the most important value of night guards or other forms of occlusal appliances are their protective effect, while their potential therapeutic action in the treatment and amelioration of temporomandibular disorders (TMDs) remains rather controversial.[39,40] This might have a strong impact on the maintenance strategy. The use of thicker and enveloping devices will be restricted to patients with severe TMDs such as acute pain, clicks, and luxations, who would possibly profit from a significant VDO elevation. The majority of other patients will receive simplified appliances such as heat-formed rigid or semi-rigid night guards, which serve as protection. The authors' experience has shown that this form of appliance enormously improves patient tolerance and compliance.

In consideration of the heavy forces involved with sleep and awake bruxism and the fact that patients seldom wear their night guard regularly or accurately follow guidelines provided by the dental team, some mechanical problems or failures are likely to happen. Repair and replacement of restorations are then part of the treatment approach and patients should be aware of that. Clinical studies have shown that the performance of composite in treating advanced tooth wear is adequate and that partial fractures represent the most likely complication, which can be corrected by a repair or uncomplicated restoration replacement.[41-43] The 10-year survival rate of PFM crowns proved slightly superior to composite restorations but with much more severe complications; actually, PFM failures led mainly to endodontic treatments or extractions, while com-

posite failures/fractures could be either repaired or replaced.[44] This is why again the conservative and adhesive approach is favored in all kinds of initial to moderate forms of tooth wear and erosion.

Conclusions

The incidence of tooth wear represents an increasing concern for the dental team and has multifactorial origins; actually, behavioral changes, unbalanced diet, and various medical conditions and medications inducing acid regurgitation or influencing saliva composition and flow rate trigger erosion. In addition, awake and sleep bruxism are widespread functional disorders, which also cause severe abrasion. It is then increasingly important to diagnose early signs of tooth wear so that proper preventive and, if needed, restorative measures are taken.

The treatment usually starts with a comprehensive clinical evaluation and a waxup of anterior teeth – possibly as well of the full mouth – to reestablish a proper occlusal and anatomical scheme as well as a more pleasing smile line. Then, based on the new VDO, direct and indirect restorations will replace missing tissues and create better anatomy and function.

The use of adhesive techniques and composite has demonstrated its potential, in particular, for the treatment of moderate tooth wear. Modern hybrid composites are the materials of choice to restore directly or indirectly anterior and posterior teeth as well. Part II of this article will present various clinical applications of adhesive techniques and, in particular, partial restoration in the context of tooth wear. It will also include step-by-step descriptions of the aforementioned procedures.

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