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Impact of erosive conditions on tooth-colored restorative materials

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ABSTRACT

Objectives. To give an overview of the impact of erosive conditions on the behavior of tooth-colored restoratives and performance of dental adhesives.

Methods. Acid-induced erosive lesions of enamel and dentin often need restorative procedures for rehabilitation. Nowadays, mostly tooth-colored restoratives (ceramics or resin composites), which are adhesively fixed to the dental substrate are used for this purpose. In some cases it might be necessary to seal the exposed dentin before achieving this goal in order to combat hypersensitivities and to protect those teeth from further erosive and abrasive loss. Moreover, it is conceivable that patients will fall back into their old "erosive behavior" after the application of restoratives. The following overview describes in how far intra-oral erosive conditions might affect the integrity of restorative materials, such as composite resins and ceramics, or of dentin sealants. Additionally, the use of erosively altered enamel and dentin as substrate for adhesive technologies is elucidated.

Results. In the literature, information of the behavior of tooth-colored restoratives under still persisting erosive conditions are limited and mostly based on in vitro-studies. There is information that the adhesion of dental adhesives to eroded dentin is compromised as compared to regular dentin. The impact of erosive conditions relevant for the oral cavity on ceramics and resin composites seems to be rather low, although only few clinical studies are available.

Significance. The review showed that erosive conditions might have only little impact on behavior of tooth-colored restorative materials, such as composites and ceramics. Dentin sealants also seem to be rather resistant against erosive conditions and might therefore serve as an intermediary treatment option for exposed dentin surfaces. The adhesion of dentin adhesives to eroded dentin might be increased by mechanical pre-treatment of the substrate, but needs further investigation.

1. Introduction

Dental erosions are defined as loss of dental hard tissue due to an attack of acidic substances, which might be additionally modified by impact of proteolytic chemical degradation. Since the etiology shows multiple reasons for the hard tissue loss, the term "biocorrosion" was recently introduced in the dental literature [1]. This term encompasses not only endogenous and exogenous acidic impacts, but also proteolytic

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degradation of the teeth induced by proteases, such as pepsin, from the gastric fluid. Pepsin is able to destabilize the collagen network of the dentin. The acids responsible for the demineralisation and loss of hard tissue substance might stem from endogenous origin, stomach acid, or from exogenous sources from dietary compounds like acidic beverages or food [2]. Although this new term "biocorrosion" was recently introduced, the term "erosion" will still be used in the following, since it is more common.

The acid attack results in a loss of softening and demineralization of the tooth surface, which is prone to further abrasive wear [3]. This means that two actions are responsible for the erosively induced tooth wear observed in the oral cavity: (1) The dissolution and loss of dental hard tissue, which is directly induced by the acid attack. (2) The wear of the softened surface by mechanical impacts, such as toothbrushing, rubbing with the tongue, tooth-to-tooth contacts or chewing of food. Recently the term "erosive tooth wear" was coined for this two-step chemical–mechanical process [4].

Analysis of epidemiological data has shown that the prevalence for erosively induced hard tissue loss with exposed dentin amounts to about 23% in children and to 10% in adolescents [5]. In adults, distinct dental hard tissue loss due to erosion or abrasion and attrition were found for about 3% of the 20-year-olds and for up to 17% in the age group of 70 years [6].

A recent study has shown that tooth erosion with low severity did does not impact oral health-related quality of life in 11- to 14-year-old children [7]. In contrast, adult patients with non-cariogenic dental hard tissue loss has shown up with reduced oral wellness due to compromised esthetic appearance of the teeth, reduced chewing efficiency and tooth pain due to the exposed dentin areas [8]. Also in this age group, intensity of discomfort was related to the severity of the dental hard tissue loss. This means that in many cases protection of the exposed dentin or restoration of the lost dental hard tissues is necessary for oral rehabilitation of the dentition. Clearly, before restoration of the teeth, abolishment of the causative erosive factors have to be achieved. Thus, nutrition control and/or medical and psychological treatment should be applied, and patients have to be instructed about measures how to prevent erosion [9–12].

The erosively induced loss of dental hard tissue often leads to a reduction of the vertical dimension. Rehabilitation of a severely worn dentition with loss of vertical dimension is often associated with many difficulties for the practitioner as to follow an appropriate and stringent therapeutic strategy [13].

The rehabilitations might be conducted using direct or indirect restorative procedures [14–21]. Nowadays, it should be striven to save as much dental hard tissue as possible, when restoring teeth. This minimal-interventional approach is usually based on the use of adhesive technologies to fix the restorations properly to the erosively altered dental hard tissues. Thus, for restoring and protection of the worn dentition composite restorative materials and ceramic restorations are preferably used. Also, dentin sealants or desensitizers might be applied to protect and seal exposed dentin areas. This procedures might be beneficial at initial stages of hard tissue loss or when final restorations are not yet applicable. It might be used in patients, in whom the anti-erosive strategies and change of behavior have not been fully implemented.

As already mentioned, restorative procedures in patients with erosions should be applied at best not before the achievement of these anti-erosive strategies and change of behavior. However, in severe cases it might be necessary to even treat the dentition e.g. with resin composite and simultaneously eliminate the cause e.g. vomiting. This procedure might help to combat hypersensitivities of affected teeth and to protect the teeth from further erosive and abrasive loss. Moreover, it is conceivable that patients will fall back into their old "erosive behavior" after the application of restoratives. Personal observations in patients still suffering from chronic bulimia after application of composite resin restorations give hint that adhesively fixed composite restorations may rapidly be disintegrated after a comparable short period of time (Figs. 1–3).

Thus it is important to know, how restorative materials behave under still existing erosive conditions. Moreover, it should be known, if special treatments of the eroded enamel and dentin substrate are necessary for establishing a proper adhesive fixation of restorations and sealing materials.

The following review will describe in how far intra-oral erosive conditions might affect the integrity of restorative materials, such as composite resins and ceramics, or of dentin sealants. Additionally, the use of erosively altered enamel and dentin as substrate for adhesive technologies is elucidated.

1.1. *Composite restorative materials*

Improvements of the composite restorative materials make them suitable for direct and indirect restorative procedures to rehabilitate worn dentitions [22–25]. Laboratory studies have shown that CAD/CAM designed ultrathin composite occlusal veneers of 0.6 mm thickness yielded a decreased risk of failure as compared to lithium disilicate ultrathin occlusal veneers [26,27]. The use of ultrathin occlusal veneers might be regarded as a conservative approach to treat erosive lesions, with the aim to save as much dental hard tissue as possible.

Using composite for direct restorations allows for a minimally invasive treatment, only replacing the dental hard tissue lost under the erosive conditions. Additionally, using direct restorations might be regarded as an expectative approach allowing to render the patient familiar with the new vertical dimension. Moreover, during this period anti-erosive strategies might be implemented in the patients' behavior. At later stages indirect restorations might be fabricated [17–19]. Numerous long-term studies document that composite restorations in posterior teeth behave well under clinical conditions [28–31]. Nevertheless, some studies showed conflicting results for extensive composite restorations with cuspal coverage [21,32,33].

Recently, the results of a case series of six patients after an average of 5.5 years of follow-up were published (Figs. 4 and 5). In these patients a vacuum-formed matrix template was used for reconstruction of the posterior vertical bite with composite resins [14]. The matrix was fabricated based on wax-up models, allowing replacement of the missing vertical dimension avoiding freehand forming. This positive outcome of using direct composite restorations was also recorded in an

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