

Dental erosion: an overview on definition, prevalence, diagnosis and therapy

Erosão dentária: uma visão sobre definição, prevalência, diagnóstico e terapia

Livia Picchi COMAR¹, Priscila Maria Aranda SALOMÃO¹, Beatriz Martines de SOUZA¹, Ana Carolina MAGALHÃES¹

Department of Biological Sciences - Bauru School of Dentistry - University of São Paulo. Bauru, SP, Brazil.

ABSTRACT

Currently, it has been observed a significant increase in the prevalence of dental erosion as a consequence of frequent exposure to acids from foods, drinks and gastric juice. The aim of this review was to give some new insights about the definition and diagnosis of this condition, to clarify the causal factors and to show the preventive strategies and restorative therapy. Dental erosion is complex condition dependent on the interaction of chemical, biological and behavior factors. The diagnosis is generally performed by the analysis of the clinical appearance of the lesions in combination with the patient's history. Some new technologies have been developed to help in early diagnosis and to quantify dental erosion in different phases. Preventive measures are established according to the causal factors, which may include the dietary intervention, modification of acidic drinks, and behavioral changes, or the modification of the tooth surface to increase its resistance against acidic attacks. The restorative treatment may range from minimally invasive therapies to multidisciplinary interventions. The clinicians should know how to detect the condition early, so that preventive measures can be applied before the lesions progress. Therapeutic strategies in high-risk patients should be as conservative as possible, involving multidisciplinary and preventive approaches with a periodic control for the success of the treatment.

KEYWORDS

Epidemiology; Prevention; Rehabilitation; Treatment; Tooth erosion.

RESUMO

Atualmente, tem-se observado um aumento significativo na prevalência de erosão dentária como consequência da exposição frequente aos ácidos oriundos de alimentos, bebidas e do suco gástrico. O objetivo desta revisão foi expor alguns novos direcionamentos sobre a definição e diagnóstico desta condição, esclarecer os fatores causais e apresentar as estratégias para a prevenção e o tratamento. A erosão dentária é uma condição complexa dependente da interação entre fatores químicos, biológicos e comportamentais. O diagnóstico é geralmente realizado por meio da análise da aparência clínica das lesões em combinação com a história do paciente. Novas tecnologias foram desenvolvidas para ajudar no diagnóstico precoce e para quantificar as diferentes fases da erosão dentária. As medidas preventivas são estabelecidas de acordo com os fatores causais que podem incluir a intervenção na dieta, modificação de bebidas ácidas, mudanças de comportamento, ou a modificação da superfície dentária com o objetivo de aumentar a sua resistência ao ataque ácido. O tratamento restaurador pode variar de terapias minimamente invasivas a intervenções multidisciplinares. Os clínicos devem saber como detectar a condição na sua fase inicial, para que medidas preventivas possam ser aplicadas antes da progressão da lesão. Estratégias terapêuticas em pacientes de alto risco devem ser as mais conservadoras possíveis, envolvendo abordagens multidisciplinares e preventivas com um controle periódico do paciente, para o sucesso do tratamento.

PALAVRAS-CHAVE

Epidemiologia; Prevenção; Reabilitação; Tratamento; Erosão dental.

INTRODUCTION

Dental erosion is a tooth lesion caused by exposure to non-bacterial acids, which has been received attention from researchers and clinicians by its increasing prevalence and clinical detection [1,2]. Dental erosion presents two distinct phases recently classified as “Erosion” (Initial phase), in which there is a only softening of the tooth surface and “Erosive Tooth Wear” (Advanced Phase), with tooth surface loss due to the successive erosive attacks with a remained softened surface [2,3]. The remained softened layer presents low resistance to further erosive challenges as well as to mechanical wear by forces such as abrasion and attrition [4-6]. Attrition is defined as the wear of direct contact tooth-to-tooth, while abrasion occurs due to the presence of particles in movement and contact with the tooth surface as, for example, toothpaste and toothbrush [7]. Abfraction is a cervical lesion (shaped depressions) caused by flexural forces at the margin between enamel and cement, leading to enamel rods fracture [7]. When tooth lesion

involves erosive and mechanical challenges is generally defined as “Tooth wear”.

Dental erosion etiology is multifactorial involving chemical, biological and behavioral factors. These different factors help to explain the difference in erosion degree and susceptibility between people exposed to similar erosive environment [8]. Intrinsic and extrinsic acids are considered the main factors involved in the etiology of erosion [9]. The extrinsic acids are derived from the diet (acids from food and drinks) and occupation, such as frequent exposure to swimming pool chlorine and sulfuric acid gas from battery industries [10]. The erosive potential of drinks or acidic foods depends on chemical factors such as type of acid, pH, titratable acidity, mineral content, viscosity, clearance and on calcium-chelation properties [8]. Extrinsic acids from the diet are becoming the most important source of erosive attacks due to increasing consumption of acidic drinks [10].

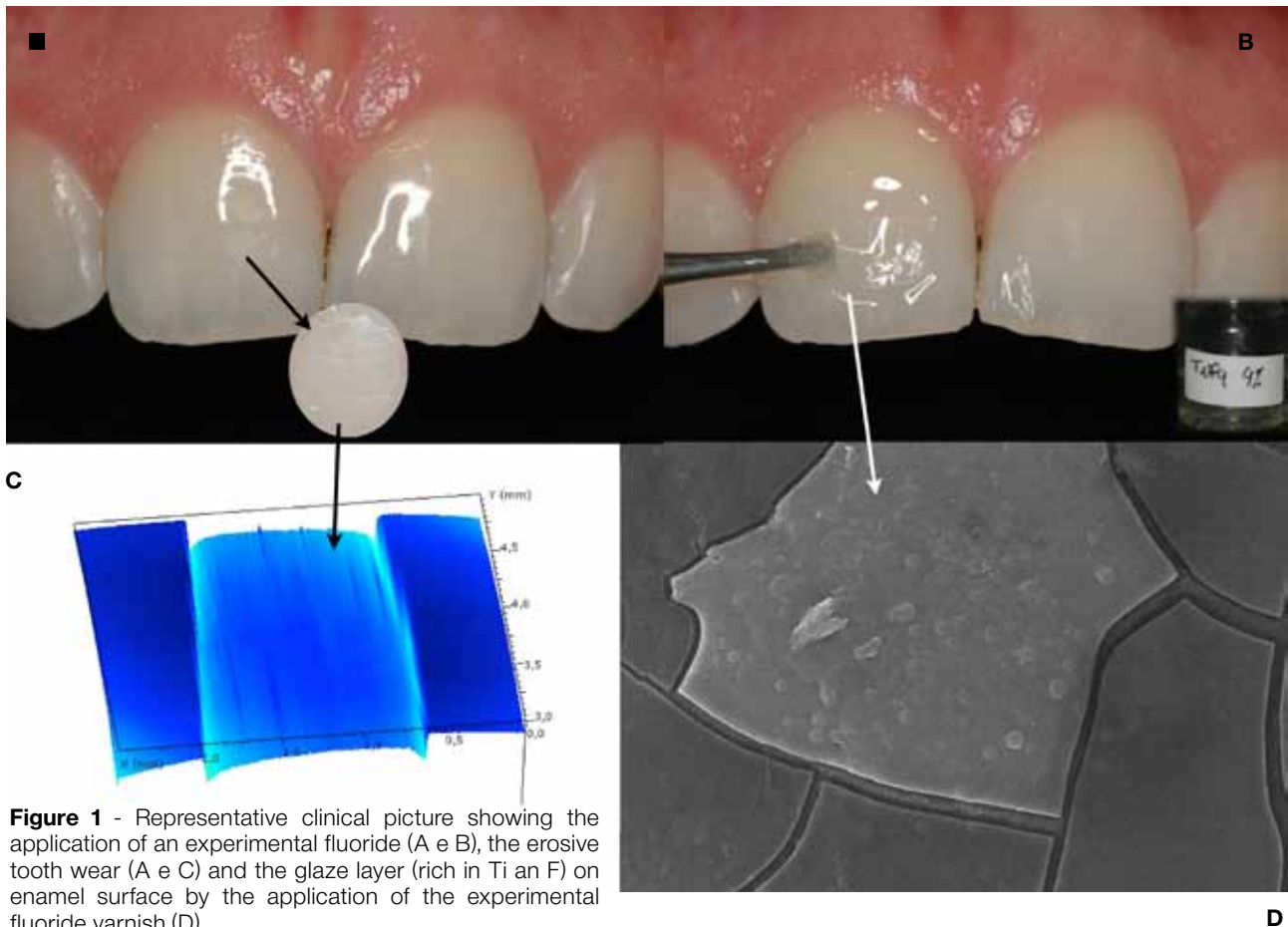


Figure 1 - Representative clinical picture showing the application of an experimental fluoride (A e B), the erosive tooth wear (A e C) and the glaze layer (rich in Ti an F) on enamel surface by the application of the experimental fluoride varnish (D)

On the other hand, intrinsic acid is originated from the stomach in patients with regurgitation, reflux and psychosomatic disorders [11].

Salivary properties and tooth position as well mineralization take part of the biological factors. Low salivary flow and buffer capacity may be enrolled in high risk for erosion, [12,13]. Furthermore, the salivary pellicle formation has shown reduce the erosion development and progression [14-16], which has stimulated researchers to look for composition of salivary pellicle and the relationship with erosive susceptibility [17]. Finally, last but not least in importance, behavior factors include the frequency and the way that the patients are exposed to the different acids sources, bulimic practices and toothbrushing habits, such as time of brushing after meals, toothpaste's abrasivity and applied force [8,18].

Nowadays, high prevalence of dental erosion, especially in children and adolescents, is being reported [1,19]. However, the prevalence of dental erosion varies significantly among the studies. Linnet & Seow (2001) [20] showed that the prevalence of erosion in deciduous teeth was from 2 to 57%. Kreulen et al. (2010) [1], in a recent systematic review, indicated that prevalence of wear involving dentin varied from 0 to 82% for deciduous teeth in children up to 7 years old, while in permanent dentition was from 0 to 54%. In this study, deciduous tooth wear increased along to the age. According to Van't et al. (2009) [21] the level of tooth wear in adults is significantly associated with age, increasing from 3% at the age of 20 years to 17% at the age of 70 years. Nahás Pires Corrêa et al. (2011) [22] also found high prevalence of erosion linked with frequent soft drinks, sweets and fruits intake by children and adolescents.

Despite these studies, it is not clear if the prevalence of dental erosion is truly increasing or if only the increasing understanding about erosion has as consequence a more precise diagnosis. Therefore, the aim of this review was to give some new insights about the diagnosis of this condition, to clarify the causal factors and to show the preventive strategies and restorative therapy.

DIAGNOSIS AND RISK FACTORS

Detection of erosive and/or tooth wear and assessment of the risk factors

As previously mentioned dental erosion can be divided in two phases: initial phase denominated as "Erosion" (in which there is only softening) and the advanced phase denominated as "Erosive Tooth Wear" (with tooth surface loss) [2]. Dental erosion can be detected and quantity in both phases by using analytical methods in the laboratory; however, it can be only detected visually (or better clinically) in advanced phase.

A correct diagnosis of erosive or/and tooth wear (combination of different lesions) is essential for developing effective preventive and therapeutic strategies. Considering that erosion may be associated to other lesions, the first question that arises is: when dentist should consider erosive or/and tooth wear as pathological wear? In principle, abrasion and attrition may be considered as physiological wear along with the advance in age [23]. On the other hand, erosion involves acid attack, so it might be considered as pathological at all. In fact, there is no consensus about what it is physiological and pathological; but some points should be taken in mind during the wear diagnosis, to determine the needs of interventions: 1) age of the patient (age of the tooth); 2) the degree of wear (the severity); 3) and the presence of pain and the discoloration (the presence of pigmentation may mean that the lesion is old and not progressing).

The second question is: how to make the correct diagnosis? Clearly, the dentist should combine an adequate patient interview and a clinical examination. The dentist should ask questions that may be involved in the etiology of erosive/ tooth wear, such as: general health, medicine intake (vitamin C, aspirin and anticholinergic drugs, the last medication is involved in salivary flow decrease), drugs (ecstasy), past and present acidic diet (soft drink, citric fruits, alcoholic drink, vinegar), environmental acids exposure (occupational information), the presence of gastro-esophageal reflux disease, vomiting or bulimia/anorexia, toothbrushing habit and bruxism. Assessment of saliva flow rates and buffer capacity, whenever possible, may help in the diagnosis.

From the interview, the dentist can determine the risk factors. Lussi & Schaffner (2000) [24] showed that four or more dietary acid intakes per day, a low buffering capacity of stimulated saliva and the use of hard bristle toothbrush are associated with high risk for

tooth wear. Intake frequency and some habits such as swishing, sucking or holding drink in the mouth are also risk factors for erosive wear [12,22,25,26]. The gastro-esophageal reflux is another important factor associated to increasing risk for erosion [25,26].

As part of the diagnosis process, an appropriate clinical examination of cleaned and dried teeth using an artificial light is the most important tool to really detect the condition. Accordingly, the major concerns in the clinical diagnosis are: 1) the detection of early stage (involving enamel only), in which there are few signs and no symptoms; and 2) to differentiate "pure" erosive wear from tooth wear.

The most susceptible surfaces for erosion are labial and palatal aspects of all upper teeth (especially anterior teeth) and occlusal surfaces of the lower first molars. For facial/lingual surfaces, the signs include: the appearance of smooth silky-glazed, sometimes dull (in case of progressive tooth loss), the absence of perikymata and the presence of intact enamel along the gingival margin, which is protected from the acid by the biofilm and/or gingival fluid [8]. As enamel becomes thinner, yellow dentin appears. In advanced phase, concavities wider than deeper and fractures of the incisal borders can be seen. In this stage, patients complain of poor aesthetics and pain.

Facial erosion should be distinguished from wedge-shaped defects (Abfraction), which are located apically to the enamel-cementum junction. The coronal part of wedge-shaped defects has a sharp margin and cuts at right angle into the enamel surface. Besides, the abfraction lesion is deeper than wider and often involves one tooth, e.g. superior pre-molar [8,27].

When erosion is mainly localized on facial surfaces, extrinsic acids may be involved in its development. However, when lingual surfaces are most involved, the intrinsic acids probably are the main cause for the condition. Other important point is that abrasion may also occur on facial surface. Generally, abrasive forces lead to gingival recession and the wear is more localized on cervical areas, showing lines corresponding to the brushing bristles. Besides, abrasion is localized on prominent superior teeth (e.g. canines and pre-molars).

In respect to the occlusal/incisal lesions,

the first signals are similar to the facial/lingual ones. However, in the advanced phases, there is a formation of small cups and the restorations rise above of the level of the tooth surface. In severe cases, the whole occlusal morphology may be rubbed off [8,27]. To distinguish erosion from attrition, one important clinical feature is that attrition involves a flat and gloss area, which corresponds to the contact with antagonist teeth.

It is important to differentiate the type of lesion for better determining the preventive and restorative strategies. However, the differential diagnosis is a challenge once different lesions may occur simultaneously on the same tooth surface. Then, the dentist must use the interview to determine which lesion (erosion, abrasion, attrition or abfraction) is more prevalent.

Other important clinical point discussed by Wang & Lussi (2010) [27] is wherever patients with erosion may present caries lesions. Evidently, tooth surfaces with active erosion (painful and unstained surface) have no caries lesions. However, caries lesions may occur in patients with erosion at other sites with biofilm accumulation.

The third question addressed is: how to monitor the activity and progression of erosive and/or tooth wear? In the sequence of this text, some clinical and complementary approaches will be presented together with the advantages and limitations of each method.

CLINICAL INDICES

Several indices have been developed for epidemiological and clinical purposes. Most indices consider the presence or absence of dentin exposure as clinical criteria to determine erosion severity. The scoring systems mainly differ among them in clinical criteria, scale and chosen teeth.

The first developed index classifies the lesions of four anterior teeth surfaces only in early, small and advanced. This index was created by Eccles (1978) [28] and improved one year later [29]. Thereafter, Smith & Knight (1984) [30], based on Eccles' index, created the tooth wear index (TWI). TWI consists in evaluating the surfaces of all teeth (buccal, cervical, lingual and occlusal/incisal surfaces) and classifies them using 5 scores: 0- no wear; 1- enamel wear; 2- dentin exposed for less than

1/3 of surface; 3- more than 1/3 of dentin exposed; 4- pulp exposure or secondary dentin.

Millward et al. (1994) [31] modified the TWI to study erosive wear in young (primary and permanent teeth). This index excludes cervical surfaces and includes score 9 corresponding to excluded tooth. Two years later, Lussi (1996) [32] created another index to classify erosive wear of facial (4 scores) and occlusal/lingual (3 scores) surfaces from all teeth. In 2000, O`Sullivan [33] worked with an index, which measures: the degree of wear in 7 levels (including score 9- excluded tooth), the affected surface (single or multiple surfaces) and the area of the affected surface (less or more than half surface). All these indices have been applied in epidemiological studies.

Recently, a scoring system termed the basic erosive wear examination (BEWE) was developed for use in general practice and to allow comparison with other indices [34]. This new index was created to overcome some limitations of the past indices, reducing the overestimation of the prevalence, improving early detection and finally, linking the detection and severity with the therapy. Each sextant is scored independently, as follows: 0- no wear; 1 - initial loss of surface texture; 2 - distinct defect, hard tissue loss <50% of the surface area (dentin involved in most cases); 3 - hard tissue loss > 50% of the surface area (dentin involved in most cases). The highest score found for each sextant (the tooth that presents the worst case) is summed and the final number determines the therapies, according to the severity level: < 2 none, 3-8 low, 9-13 medium and > 14 high. The researchers expect that this index will be adopted internationally to standardize the measurement of erosive wear and the comparison among the epidemiological studies.

Despite the researchers have hardly worked in improving the indices, there is a need of testing the validity, sensibility, specificity and reliability of the indices in erosion diagnosis for research and clinical purposes [23]. Furthermore, the indices must be applied together with the patient interview and the risk assessment, allowing that a more accurate diagnosis of the condition can be achieved [35].

Considering that surface loss, in most cases, progresses slowly, the clinical indices applied in diagnosis are still not enough

sensitive to monitor the progression of erosive wear overtime. Therefore, the dentist can use complementary methods to help in the control of the erosion progression by comparing clinical photographs of the tooth surfaces, study casts and dental radiography (bitewings may show molar mesialization due to occlusal wear) [8].

COMPLEMENTARY METHODS

a. Initial phase (Erosion)

Nowadays, other techniques, involving optical properties changes in tooth, are being applied to detect erosive surface demineralization (first phase) [36]. Currently, the two most promising methods for assessing enamel *in vivo* are quantitative light-induced fluorescence (QLF) and optical coherence tomography (OCT) [2]. For QLF, an area with little or no surface scattering needs to be analyzed as a reference area to calculate relative loss of fluorescence in the demineralized area. This is useful for experimental clinical studies, but not to be applied in diagnosis by clinicians, considering that a reference surface might be not available in the patient with severe case of erosion. Furthermore, there are few studies in this subject [37-39] and the cost-benefit has been discussed. Therefore, QLF should be validated before being applied in erosion assessment.

OCT for erosion is based upon quantitative measurements of the backscattered light intensity at the surface, which indicates surface porosity and also penetration depth of the region of interest, which is reduced when surface scattering occurs. As for QLF, the eroded area should be compared to a reference area, and this is again a limitation for clinical detection. Furthermore, these techniques are applicable to smooth surfaces and not to occlusal ones. Other weak point is that, ideally, accurate repositioning of the probe is required, so that the same area can be measured at different time points to monitor the condition.

Therefore, further studies are required to check if both technics are valid for erosion detection [38]. Several other parameters that may influence the analysis of optical properties changes, such as the presence of an acquired salivary pellicle, teeth abrasion, hydration degree and native tooth color, should be considered in further studies [36].

b. Advanced phase (Erosive wear)

Other approach is the use of the indirect profilometry that is indicated for the longitudinal monitoring of erosive wear in clinical research. Firstly, metal marker must be bonded onto the palatal surfaces of upper incisors as a reference point. Thereafter, impressions and/or study casts are obtained at baseline and at different follow-up intervals, and subjected to scanning using profilometer [40,41]. The differences in height between the metal (acid resistant) and tooth surface are calculated, for monitoring the progression of tooth wear over the follow-up period. However, there are some limitations of the method such as cost, and the need to attach and to keep the metal marker overtime. Furthermore, the metal marker must be not damage, so an adequate interocclusal space is required. Likewise the contact profilometer, other approaches are null-contact profiler and optical 3D sensor [42,43]. However, more studies are needed to check the sensitivity and validity of these methods.

WEAK POINT IN DIAGNOSIS

The differential diagnosis of erosive and tooth wear, especially at the first stages (enamel wear), is not easy to make. Nevertheless, more complicate than the early detection is the monitoring of the lesions overtime. The follow-up is particularly important to determine the progression rate of the wear in physiological and pathological cases. There are few reports about physiological and pathological wear progression. Generally, the studies have shown that the progression varied from 3.7 to 29 and from 35 to 350 μm per year for physiological and pathological wear, respectively [2,11,38,44-46].

Therefore, clinical and complementary methods must be developed, improved and validated, together with the risk assessment, to evaluate erosion and erosive and/or tooth wear in vivo, and to better plan the preventive and therapeutic strategies.

PREVENTIVE STRATEGIES

Preventive measures for dental erosion, including chemical, biological and behavior factors, should be specific for each patient [27]. Clearly, a reduction in acid exposure is the most effective and universal preventive strategy to be applied in high-risk patients. The consumption

of potentially erosive foods and beverages should be limited to main meals only [27]. Some habits, like drinking and holding in the mouth as well as nipping from a bottle should be avoided, because prolong contact time of acid with the tooth increases the susceptibility to erosion [8,22,25,27].

As oral hygiene measures may be involved in tooth wear, the time point of toothbrushing after an erosive attack as well as the applied force and type of toothpaste used must be controlled [8]. Despite no scientific evidence exists about the time point of toothbrushing; it is advised to wait 30 min to 1 h to brush after meals for high-risk patient [4,6,27]. The toothpaste abrasivity is correlated with type, quantity and size of the abrasive, the fluoride concentration and pH as well [47]. Nevertheless, the dentists do not know the exact toothpaste abrasivity, so no trustful instruction can be given about this issue.

Personal protective equipment (respiratory masks) and adherence to threshold limit values recommended by occupational health legislations are considered an important preventive strategy to decrease occupational erosion [48]. Within behavior factors, erosive tooth wear is a common manifestation in patients suffering from organic or psychosomatic disorders such as gastro-esophageal reflux disease (GERD), anorexia or bulimia nervosa or alcohol abuse. These disorders require a multidisciplinary therapy, including general medicine and psychological treatment, for decrease the intrinsic acid exposure [49].

Studies have also shown that erosion may be associated with biological factors such as low salivary buffering capacity and flow [12,24]. Changes in saliva may be caused by head and neck radiation, use of some medications, as well as GERD [50,51]. Considering that saliva has important functions (buffer capacity and remineralizing effect), salivary stimulation through the use of chewing gum [6] and consumption of cheese or milk after meal [52] can help to reduce the erosion progression. Saliva is also able to promote the acquired pellicle formation. The pellicle is a diffusion barrier that reduces the contact between the acid and the tooth surface [14-16]. Recent researches are focus on the formation, ultrastructure, composition and functions of the acquired pellicle [53,54].

Nowadays, the modification of the tooth surface to increase the resistance against acidic attacks is the most useful strategy studied so far. One approach to increase the tooth resistance is by the fluoride application [55,56]. Topical fluoridation induces the formation of a protective layer on dental hard tissue, which is composed of CaF_2 (in case of conventional fluorides like amine fluoride or sodium fluoride) [56,57] or of metal-rich surface precipitates (in case of titanium tetrafluoride or tin-containing fluoride products) [56,58,59].

There is convincing evidence that fluoride, in general, can strengthen tooth against erosive acid damage. High concentration fluoride agents and/or frequent applications are considered potentially effective approaches to reduce erosive tooth wear *in vitro* and *in situ*. Conventional fluoride has limited effect against dental erosion [58,60]. Then, the use of tin-containing fluoride products, such as mouth-rinse and toothpaste, might provide the best approach for effective prevention of dental erosion [61-63]. Titanium tetrafluoride seems to be promising agent, especially when added into a varnish [58,64]. However, the efficacy of TiF_4 is highly dependent on its low pH [65,66], which implicates in special care during the application, not allowing self-application by the patient. Further clinical studies are recommended to better understand the relative differences in performance of the various fluoride agents and to allow the correct prescription in the clinic.

Recently, new products (especial toothpastes) with anti-erosive ingredients were developed and some included in the market, but few are known about their effectiveness. The possible anti-erosive toothpastes are those containing KNO_3 (anti-hypersensitivity agent), hydroxyapatite (HA) with or without F, Zn-carbonate HA, calcium sodium phosphosilicate (remineralizing agents) and chitosan (act as pellicle) [63,67,68]. Additionally, potential MMPs inhibitor as chlorhexidine and green tea extract has been tested against dentin erosion progression with promising results [69-71]. However, further studies should confirm the results obtained to give support for the establishment of clinical protocols.

The modification of beverage or food is other preventive strategy, related to chemical factor, which is less dependent on the patient's

behavior. The reduction of the erosive potential of acidic beverages can be achieved by adding ions (calcium, phosphate and fluoride) that make the beverage more saturated in respect to HA [72,73] or polymers (pectin, alginate and gum arabic polymers), which adsorb the enamel surface, protecting it mechanically [74,75]. The addition of calcium or polymer has been shown to reduce the erosive potential of pure acids and acidic drinks [72-75]. However, future studies should give special emphasis on the consequences of the modification regarding taste, stability of the solution and systemic effects for the patients.

Since preventive strategies may fail and dentist may not detect dental erosion early, new insights into therapy strategies are necessary. Therefore, the last part of this review is focus on the possibilities and outcome of restorative treatment.

Therapeutic approach

The restorative treatment is indicated when the tooth integrity is threatened, the esthetics is impaired, or there is dentinal hypersensitivity and the pulpal exposure is likely to occur [27]. The first step of the treatment is based on the elimination or control of the causal agents for preventing the progression of wear [44].

According to Johansson et al. (2008) [76], it is recommended that serial observations be performed using study casts or photographs at approximately 6-12 months intervals. Based on the assessment of progression rate of the wear and the symptoms, it is possible to decide whether intervention is necessary or not. However, in cases in which an active erosive influence has been installed, some procedures should be carried out as soon as possible.

Currently, there are several options for the treatment of tooth wear, which can range from a conservative (adhesive and composite resins restorations) to more invasive procedures (crowns, bridges or even full-mouth reconstruction) in cases of severe tooth wear [27,77].

For primary and mixed dentition, in which the child does not present any symptom, restorative treatment usually is not indicated. In this case, the follow-up is particularly important to control the etiological factors that may implicate in high risk for erosion in permanent

teeth [78]. However, if teeth are sensitive, small areas of erosion can be covered with composite resin and larger areas may require composite crowns on anterior teeth and preformed metal crowns on posterior teeth [78]. For severe symptoms, extraction may be indicated depending on the tooth's age.

Different from dental caries, tooth wear generally involves several teeth. Therefore, the rehabilitation is more complex and expensive, involving multidisciplinary approaches (operative dentistry, prosthesis, orthodontic, implants, periodontology and endodontic).

In case of localized and shallow wear in permanent tooth, without symptoms and progression, the dentist can only monitor without the need to repair the tooth. Other option in this case is the application of adhesive agents, which may be effective in reducing sensitivity and preventing further wear for approximately 3-6 months [79-81].

When restorative treatment is required, it is important to choose a material resistant to erosion and that allows the preservation of the tooth as much as possible [82]. Accordingly, glass ionomer cements seem not to be the best option, as they are susceptible to acid dissolution [83]. Honório et al. (2008) [84] demonstrated that the glass ionomer cements exhibited higher hardness loss and wear compared to a composite resin and amalgam, after 35 days of erosive challenges *in vitro*. The application of a composite resin has the advantage of providing good longevity and aesthetic. Additionally, it has shown success in the rehabilitation of eroded dentitions [81,85], reducing the sensitivity and improving the appearance.

In the sequence of this text, the treatments for permanent teeth are described according to the area and degree of severity.

Anterior teeth

Buccal and palatal surfaces can be mostly restored with composites or combination of composite resin and glass ionomer cement; the last option is applicable for deep tooth wear and cervical lesions. In aggressive cases, veneers or ceramic/ metal-ceramic crowns are options for rehabilitation [78]. Endodontic treatment is the last choice for extreme dentin hypersensitivity, which cannot be treated more conservatively, or when periodontal surgery is required [76].

When the wear involves palatal and incisal surfaces, the assessment of the space in the intercuspal position (ICP) is indispensable for a correct rehabilitation [78]. Extensive wear may result in changes in the occlusal vertical dimension (OVD) [76]. In case of severe wear involving anterior and posterior teeth, multidisciplinary approach should be studied [76].

The OVD can be increased by orthodontic treatment, using fixed or removable appliances, such as the Dahl appliance. This management may avoid the need of additional tooth wear [86]. The Dahl appliance allows relative extrusion of posterior teeth and intrusion of anterior teeth, in order to gain space for the restoration of eroded upper anterior teeth [78]. Thereafter, the eroded tooth can be reconstructed [85]. Other treatment option for mild cases of OVD loss is the placement of veneer on lingual surface that can allow the extrusion of posterior teeth in some extent.

In a clinical study, Hemmings et al. (2000) [87] restored localized anterior tooth wear with direct composite restorations in patients with loss of interocclusal space, increasing the OVD. The restorations were placed to increase the OVD, creating a posterior disclusion of 1 to 4 mm. After follow-up of 30 months, the authors observed success with 89% of the restorations in place. Furthermore, the patient satisfaction was reported as good.

Other possibilities for obtaining space for the rehabilitation are the use of temporary crown and the combination of tooth preparation/wear and periodontal surgery. In the last case, some conditions should be analyzed as bone quantity and quality, size of the root and the smile line in case of anterior teeth.

POSTERIOR TEETH AND GENERALIZED WEAR

Tooth wear involving only posterior teeth is an unusual condition. When tooth wear is localized in posterior tooth, composite restorations and crowns are able to restore the condition depending on the severity [78]. However, generalized erosion wear may result in mandibular over-closure, in which compensatory over-eruption is likely to maintain the existing OVD [78]. In some cases, it is necessary to increase the OVD, where interocclusal space is critical for rehabilitation [76].

According to Jaeggi et al. (2006) [88], for the OVD loss lesser than 0.5 mm, sealing or restorations with composite resin are indicated. In case of loss between 0.5 and 2.0 mm, the teeth can be reconstructed with composite resin, because the patient can tolerate this small increase in OVD. When the posterior tooth wear is localized and not severe, an option to allow the tooth rehabilitation without the need of increase the OVD is the periodontal surgery. A careful analysis of the root and bone conditions should be done prior the surgery. For loss between 2.0 and 4.0 mm, indirect porcelain veneers or provisory crowns may be used for the treatment. In case of severe tooth wear, metal-ceramic crowns are more appropriate. In case of OVD loss higher than 4.0 mm, the recovery must be performed using alternative techniques as orthodontic appliances and mini-implants [76]. Table 1 shows the most useful options for tooth rehabilitation according to the worn area and the degree of severity. In this Table, the guide for clinical management according to the BEWE risk level is also available.

In cases of full-mouth rehabilitation, the preparation of multiple teeth for conventional crowns or the placement of implants requires great care, especially in case in that some

preserved natural teeth are in occlusal contact with crowns or partial denture [76,89]

Follow-up

Regular follow-up is critical for the treatment success. Cases should be reviewed at least annually when new study casts and photographs should be taken. Furthermore, preventive regimens should be often revised. The determination of the interval between the visits should be based on the risk assessment as stated in the BEWE index (Table 1).

CONCLUSION

As there are signs that the prevalence of erosion is increasing in several countries, the dentist should have knowledge about its etiology and be prepared for early diagnose. Therefore, future researches should give advances in early diagnosis, so that preventive measures can be applied appropriately. When dental erosion involves dentin with pain, function and aesthetic limitation, rehabilitation is required. Therapeutic strategies in high-risk patients should be as conservative as possible, involving multidisciplinary and preventive approaches with a periodic control for the treatment success.

Table 1 - Guide for clinical management according to Jaeggi et al. (2006) [88] and BEWE [34]

Area	Enamel (0.5-2 mm)	Shallow dentin (2-4 mm)	Deep dentin (>4 mm)	Cumulative score (BEWE)*	Management
Anterior (one face)	Monitoring Application of adhesive or fluid resin	Restoration with composite resin	Restoration with composite resin and glass ionomer cement or veneer	3-8	Identify the causal factors; advice about oral hygiene and diet; follow-up intervals of 1-2 years
Anterior (several faces)	Monitoring Application of adhesive or fluid resin	Restoration with composite resin with or without glass ionomer cement or crowns	Metal-ceramic or ceramic crowns**	9-13	The same as above plus fluoride application; avoid restorations; monitoring each 6-12 months
Posterior	Monitoring Application of adhesive or fluid resin	Restoration with composite resin with or without ionomer cement or crowns	OVD recovery with orthodontic or surgery; metal-ceramic crowns	»14	The same as above plus restorative treatments (severe lesions); follow-up at each 6 months.

* BEWE score « 2: follow-up at 3 years intervals; ** OVD recovery may be necessary in case of generalized tooth wear.

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Livia Picchi Comar
(Corresponding author)

Al. Octávio Pinheiro Brisolla 9-75,
17012-901. Bauru, SP, Brazil.
Phone/ Fax + 55 14 3235-8497
E-mail: acm@fob.usp.br

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