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Mini review

Dental Erosion and Treatment Methods

Begüm Erpacal*, Emrullah Bahsi, Ezgi Sonkaya

Dicle Üniversitesi Diş Hekimliği Fakültesi, Restoratif Diş Tedavisi A.D., Diyarbakır, Türkiye.

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Dental erosion is the loss of substance that occurs in the hard tissues of the teeth without being related to a bacterial component as a result of acid attacks. This condition, which is caused by continuous acid exposure, is irreversible. The aim of this review is to examine the anti-erosive materials and to present protective and invasive treatment methods. Many materials are recommended to prevent dental erosion. Studies about sodium fluoride, stannous fluoride, casein phosphopeptide-amorphous calcium phosphate and tricalcium phosphate, protease inhibitors, oils, chitosan and multivalent metal ions are available. Beyond all available materials and methods, the most critical point in treatment is the detection and elimination of the erosion causing factor. This is only possible with the early diagnosis of the erosive lesion, and the detection and elimination of the etiological factor with a good anamnesis.

Keywords: Dental erosion, treament methods, acid exposure

The erosion seen in the hard tissues of the teeth is a problem that is increasing nowadays. Changing dietary habits with the development of societies is the main reason for this increase. It is clear that these erosions negatively affect the dentition in long term (1). Erosion-related losses is directly proportional to the level of development of countries, while the rate of loss in the hard tissue due to dental caries is negatively proportional to the level of development of countries (2, 3).

Long-term consensus on the definition and diagnosis of dental erosion has not been established. The term dental erosion is classified under the title of tooth wearing out with the terms abrasion, attrition, and abfraction. This classification is based on the etiology of abrasion. Definitions are frequently confused with each other (4-7). Abrasion refers to the loss of hard tissue caused by some mechanical factors. Attrition is the physiological erosion occurring on the occlusal and aproximal surfaces without a mechanical factor. Abfraction refers to wear caused by intense occlusal forces and present in cervical areas of teeth. Dental erosion is a hard tissue loss that occurs in the hard tissues of teeth without bacterial chemical effects (5, 8, 9).

The prevalence of dental erosion in 1908 was reported to be 0.1%. It was also suggested that factors causing dental erosion may be developmental, systemic or external (2).

Etiology

Dental erosion is considered to have a multifactorial background in which individual and lifestyle differences are important. Despite the methodological differences in research, data from many countries confirm that tooth erosion which progresses rapidly is common in children and young people (4). While the concentration of hydrogen in plaque fluid is the main determinant for erosion

*Correspondence: Dicle Üniversitesi Diş Hekimliği Fakültesi, Restoratif Diş Tedavisi A.D., Diyarbakır, Türkiye.
E-mail: begumerpacal@gmail.com

formation, the net effect is the acid that reaches the tooth surface. In addition, the presence of fluorine and phosphate ions in the plaque fluid, in particular the concentration of calcium, determines the saturation of the dental plaque and causes the critical pH to vary. Therefore, the main reason for dental erosion is acid exposure. However, no critical erosion causing pH was reported (3, 4).

If attacks of the acid are persistent, a visible defect would be seen on the tooth surface, then the dentin would be exposed. In addition, degradation in the structure and quality of saliva, lack of oro-motor function, various medications or oral respiration may also cause pH reduction in the oral cavity, leading to secondary dental erosion development (3, 4). The causes of dental erosion can be considered as extrinsic and intrinsic (1, 5).

Intrinsic factors

Endogenous acids which reach the oral cavity are intrinsic factors that may cause erosion. Gastric acid in the stomach (very low pH values of 1-1.5) causes tooth wear. This content may reach the oral environment due to vomiting, regurgitation or gastroesophageal reflux disease caused by psychological problems such as anorexia and bulimia (4, 10). Among the intrinsic factors, the most common cause of dental erosion was reported as gastroesophageal reflux (11, 12). In order to cause dental erosion, the stomach acid should be contacted chronically for long periods. Palatinal surfaces of maxillary incisors are most frequently affected ın patients having gastric acid contact with teeth several times a week for several years (13).

Extrinsic factors

Consumed acidic products are among the main extrinsic factors. Erosion may also be related to the profession. Dental erosion in wine tasters is one of the work-related wear. In addition, acid-containing products present in the air can cause erosion in workers in some industries (4). Some medicines and oral hygiene products, as well as acid-containing foods consumed for nutrition, cause acidity increase in the mouth. Tablets containing vitamin C, aspirin or hydrochloric acid directly reduce oral pH. Antihistamines, antiemetics, some medications that reduce the flow rate of saliva, and bronchodilators that reduce saliva secretion can cause dental erosion (12). Among the most commonly consumed acids are citric, malic, phosphoric, lactic and tartaric acid. Citric acid is highly erosive by its ability to bind the calcium present in enamel even after the oral pH is raised. In addition, frequent consumption of beverages or consumption by mouth rinsing increases the erosive effect (13).

Clinical view

Early enamel erosion does not cause clinical discoloration or softening of the tooth surface. For this reason, its detection by clinical examination is difficult. In addition, any symptoms in these early stages are usually absent or very limited. Then, changes in dental morphology facilitate the diagnosis. Cupping lesions are concavities seen in the enamel. This terminology is strongly related to dental erosion, and should be carefully investigated while it can be seen as an indicator of the onset of erosion. The convex areas which are morphologically present on the flat surfaces are firstly flattened, then the concavities are observed in places. The enamel lesion with matte appearance in active erosion may vary from yellow to brown when it reaches dentin. At this stage it becomes more sensitive to heat changes. The erosive lesion may be rough and form small concavities. However, often the surface is slightly round or flat, and rarely can give the impression of "melting" (4, 13, 14).

Today, tooth erosion occurs on all tooth surfaces, but it is more common on the occlusal surfaces of the maxillary anterior teeth and mandibular first molar teeth (4).

Diagnosis and treatment

Basic erosion wear examination (BEWE) and visual erosion dental examination (VEDE) have been developed to ensure coordination between clinicians in grading erosion. In the BEWE index, the mouth is divided into 6 regions, the teeth affected by the maximum degree of erosion in each

region are scored and these scores are summed. In VEDE index, all of the tooth surfaces are evaluated separately (14).

Early erosion forms are difficult to diagnose because several symptoms accompany the lesion. There is no device in the routine dental practice to determine the progression of dental erosion. For this reason, clinical view is the most important sign for dentists to diagnose this condition. A comprehensive history and a clinical examination should form the basis of erosion diagnosis, risk assessment, and treatment decisions. Proper diagnosis is particularly important in the early stages of tooth erosion. At an advanced stage, it may be very difficult to determine the exposure of dentin. Anamnesis is an important marker because during it, the dentist learns the patient's medication intake, oral hygiene habits, usage of oral health care products, his profession and life style, and understands the reason for the visit of the patient. It is extremely important to listen what patients say. For example, if patients feel sensitivity when drinking cold water or brushing teeth, non-carious lesion due to erosion should be associated with other reasons. Another common complaint related to erosion are the shortening of the maxillary incisors and the yellowish appearance of the teeth, which represent further stages of the process (5, 15).

Preventive treatment of dental erosion is very complex because the patient's dietary habits and some patient-related factors direct the progression of lesions. Early recognition of the initial symptoms of lesions is important because eliminating risk factors and ensuring appropriate interventions can be done in this way (16).

Sodium fluoride (NaF), casein phosphor-peptide-amorphous calcium phosphate (CPP-ACP), chitosan, oils, multivalent metal ions, and protease inhibitors can be used to prevent dental erosion development (3, 16). In order to remove the sensitivity, toothpastes and mouthwashes can be applied by patients at home, and gels or varnishes can be applied in clinics by clinicians. Potassium salts, sodium citrate, strontium salts and fluoride containing compounds may be effective in removing the sensitivity of pastes (13).

Fluoride

Sodium fluoride-containing toothpastes can prevent the loss of material caused by erosion, but their effects are limited, especially against severe tooth wear. Fluoride causes remineralization of the enamel with the formation of calcium-fluorine-like components on the tooth surface. At the same time, however, some research suggests that abrasive ingredients present in toothpastes prevent precipitation (3, 17). Although all fluorides help to strengthen teeth against caryogenic acids, the current fluoride sources do not provide the same degree of erosion protection. The daily use of a stabilized stannous fluoride tooth cleaner has been shown to be the most effective way of protecting teeth against the risk of tooth wear (18, 19).

Calcium and phosphate

Calcium can accumulate on enamel surface which can be either an erosive or intact surface, and can provide substantial protection of the enamel from acid attacks (20). Dodecyl phosphates prevent the dissolution of the natural surfaces of hydroxyapatite and provide solidity (21).

Casein phosphopeptide amorphous calcium phosphate (CPP-ACP)

Casein phosphopeptide-amorphous calcium phosphate (CPP-APC) is a compound with remineralization effect, and can be added to mouthwashes and gums to prevent erosion. However, some studies indicate that it is insufficient to prevent erosion (22, 23).

CPP-APC and tricalcium phosphate (TCP) may prevent remineralization of abrasive lesions (24).

Protease Inhibitors

Recent studies have focused on the role of protease inhibitors on erosion. The use of protease inhibitors in dentine tissue to protect the organic matrix after an erosive attack may have a protective role against future mineral losses. However, in spite of promising results in *in situ* studies, these

preventive measures are not evidence-based. Clinical trials are required to confirm these findings and establish the protocols to be used (16).

Oils

Oils in the pellicle protect the tooth tissues against decreasing pH. In one study, it was observed that it protects the tooth surface against abrasion. Use of oils with fluoride-containing agents may be recommended (3).

Chitosan

Chitosan is an antibacterial agent that contributes to tissue regeneration. It may be present in toothpastes. It has anti-erosive properties as it has high positive charge at acidic pH. It may prevent the formation of dental erosion by forming a protective layer on the teeth by connecting to the pellicle (13).

Multivalent metal ions

Metal ions such as stannous and titanium, have strong effects on erosion. Stannous fluoride, stannous chloride or titanium tetrafluoride are some of these materials (13).

Discussion

According to many researchers, it is possible to prevent erosion by taking preventive measures with early diagnosis of at risk patients (14).. Oral hygiene affects the formation of dental erosion. The use of toothbrushes immediately after acidic foods consumption is not recommended clinically. Moreover, up-to-date studies do not see brushing as a useful preventive measure. Brushing teeth immediately after acidic food causes more enamel loss, although it has been suggested that this idea should be reviewed again. It has been reported that active ingredients found in toothpastes, such as fluoride, can prevent their mechanical damaging effects and reduce the progression of dental erosion (15, 17, 25, 26).

Various dental care products are sold to prevent dental erosion, but there is still no ideal material to prevent erosion (3, 4).

The main aim of treatment is to maintain the tooth structure without preparation. Restoration with usage of various restorative materials may be considered, especially in patients whose sensitivity cannot be eliminated by conservative methods or whose needs are aesthetic requirements. However, it should be kept in mind that surface change may occur in materials where acid exposure persists. In cases of excessive substance loss, prosthetic treatment may be required (13).

In a study based on the Radboud Tooth Wear Project conducted in 2018 in the Netherlands for the treatment of patients who suffered from severe tooth wear, it was concluded that restorative treatment is not indicated at all times even in patients with excessive tooth wear. If the patient does not have any complaints, keeping it under observation is probably the best option. According to the study, in restorative treatment, direct composite's life requires a five-year follow-up, and if this material is suitable for long-term the rehabilitation is increased in vertical dimension. However, it should be noted that all restorations have a certain life span (24).

A study to investigate the effects of temperature-related enamel erosion which used orange juice, Coca-Cola zero, Sprite zero, two different fruit tea, and citric acid (as a control group) has showed that the temperature of the liquid does not lead to a significant change in pH. In enamel, citric acid and fruit tea caused respectively the highest and lowest material loss. Sprite zero and both fruit tea caused a significant loss of enamel at high temperature, while no significant change was observed in other beverages. As a result, it is recommended that some corrosive beverages should be consumed at as low as possible temperature to reduce the risk of substance loss (27).

In another study, participants were divided into two groups. The first group consumed the usual diet for 30 days and the second group the usual diet and 125 ml of orange juice four times a day. The first group was instructed to take the food into their mouths and swallow immediately, while the second group were asked to keep the drink in their mouths for a while before swallowing. In the second group

significant levels of tissue loss were found on all tooth surfaces. Especially the occlusal of mandibular molar teeth, palatal of maxillary anterior teeth and lingual faces of the mandibular anterior teeth were found to be most affected (28).

An *in situ* study investigated the ability of a CPP-ACP gum for preventing erosive enamel loss. CPP-ACP was compared with sugar free gum, traditional sugar-free gum, and gum-free control group. Less enamel loss was observed in the group who chew gum (with and without CPP) compared to the control group. No significant difference was observed in enamel loss when comparing gums with and without CPP-ACP. As a result, the gums with CPP-ACP are not anti-erosive (29).

In an experiment, changes in the protein profile of *in vivo* acquired enamel pellicle (AEP) were evaluated after the administration of hydrochloric acid (HCl), 180 different proteins were identified and it was shown that the number of proteins determined was directly proportional to pellicle formation. Only 4 common proteins were found in all groups: IgA, serum albumin, and statherin isoforms. Even short-term AEP was found to have proteins such as serum albumin and statherin that were resistant to removal by HCl. In addition, many resistant proteins were revealed during long-term (120 min) HCl application. In other words, protection against intrinsic acids is directly proportional to the duration of pellicle formation (30).

In another research, thirty sugar-free sweets were analyzed to measure the nutritional acid content and the corrosive potential. Surface micro hardness was examined *in vitro* in order to examine the effects of sugar-free candies on human enamel in artificial saliva. The change in surface micro hardness was used to classify the confectionery as high, medium and low erosion potential. It was found that 17 out of the 30 sugar-free candies has high erosion potential. In the packaging of 10 high erosion potential substances, tooth-friendly images were observed. As a result, some sugar-free candies, even if they have tooth-friendly messages on the product label, should be remembered to patients that they contain high amounts of food acids, and may cause erosion (31).

In a study that aimed to determine the relationship between physical exercise, dental erosive wear and salivary secretion, healthy young adults who exercised at least twice a week were selected as experimental group. Enamel lesions in central incisors were the most observed lesion (33%). Also, dentin lesions in mandibular first molar were frequently observed (27%). Erosive wear in dentin was significantly higher in men than in women. When the groups with or without erosion were compared, it was seen that the flow of saliva decreased during exercise. This study showed that physically active young adults has highly erosive lesions, and hard exercise decreases saliva flow rate which can be associated with wear (32).

The effect of viscosity and frequency of application of fluoride (F) and stannous chloride ($SnCl_2$) containing solutions were investigated to prevent enamel erosion in a study. When the solutions were applied once a day at high viscosity, it was seen that erosion induce decreased enamel erosion. The application of the solutions twice a day did not differ surface loss in high viscosity solutions, but caused less surface loss for low viscosity solutions (31).

The effect of saliva preparations containing low calcium (Ca) and inorganic phosphorus (Pi) on tooth erosion caused by hydrochloric acid (HCl) was also investigated. Enamel loss in the artificial saliva group that imitated mild or severe hypocalcemia differed from normocalcemia condition. Root dentin loss was found to be higher in saliva that stimulated severe hypocalcemia in comparison with mild, hypo and normocalcemia. In this study, saliva formulations similar to serum hypocalcemia have been shown to affect surface loss due to erosion and re-intensification, although it was dependent on the mineral content of the tooth (33).

A study where 1368 patients were examined

for dentin hypersensitivity, found that 285 teeth showed sensitivity in 73 patients. The hypersensitivity susceptibility rate was 5.3%. While sensitivity was more common in 40-49 years age group, it showed that women were more affected than men. The most affected tooth was maxillary premolar. Also, the most common cause was consumption of cold beverages. No significant difference was found between smokers and nonsmokers. The most common etiological factor for sensitive teeth was gingival recession (34).

If the dentist suspects the patient for having gastroesophageal reflux disease, he must send the patient to the gastroenterologist. Treatment should be aimed to change the patient's lifestyle, avoiding foods that could cause reflux (such as wine, citric acid, vinegar, fatty foods, tomatoes, mint, coffee, black tea, carbonated beverages, chocolate), reducing alcohol consumption and encouraging weight loss (16).

Patients with non-rational drug use, chronic alcoholism and bulimia should be directed to a doctor. Patients should be advised to wash their mouth after vomiting. Saliva has an important protective role and patients with reduced saliva flow can benefit from the use of chewing gum. Chewing gum and swallowing frequency can increase saliva flow rate by the patient. Chewing gum also improves the protective effect of saliva against tooth erosion and accelerates the clearance of stomach acids in the esophagus (17). It should be advised that acidic beverages should not be kept in the mouth for a long time, should be consumed with a straw in main meals. In summary, stimulation of saliva flow with sugar-free chewing gums, alkaline or neutral food consumption which increase the oral pH are important recommendations for patients with acidic feeding or vomiting (14, 16).

Dental erosion is a multifactorial lesion that is directly related to the individual's living conditions. Early diagnosis is difficult especially differential diagnosis from other non-carious lesions. Erosion can be prevented by non-invasive methods but only with a good anamnesis at an early stage. The materials used in the treatment eliminate the sensitivity caused by the loss of substances. Although there are many materials in the market for this purpose, an ideal material for treatment is not available yet. For the time being, fluoride-containing applications can be regarded as the most effective prevention method available for wear. Researches for the development of relevant materials are still ongoing.

In advanced cases, more interventional methods are used. Prosthetic treatment may be needed in case of substance loss which cannot be removed by restorative treatment. Beyond all existing materials and methods, the most critical point in treatment is determining and eliminating erosion factor. Thus, early diagnosis of the lesions, determination and elimination of the etiological factors are significantly important topics.

Conflict of interest

The authors declared no conflict of interest.

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