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Effect of erosive conditions on tooth-colored restorative materials

Reem A. Hany [1,*]

[1] *Teaching assistant of dental materials science, Biomaterials Department, Faculty of Dentistry, Cairo University.*

* Corresponding author e-mail: *Reem.Ahmed@dentistry.cu.edu.eg*

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Abstract: Dental erosions are defined as "loss of dental hard tissue due to repeated acid attacks in the absence of the biofilm plaque and without the involvement of bacteria" [1]. Since the etiology shows multiple reasons for the hard tissue loss, the term biocorrosion was recently introduced in the dental literature [2]. This term includes endogenous and exogenous acidic impacts, as well as proteolytic degradation of the teeth induced by proteases, such as pepsin, from the gastric fluid which can destabilize the collagen network of the dentin. We will discuss the effect of erosive conditions on tooth colored restorative materials.

Keywords: *Dental erosion, composite, glass ionomer, ceramics*

Etiology of dental erosion

The acids responsible for the demineralization and loss of hard tissue substance might be from endogenous origin as stomach acid, gastroesophageal reflux disease (GERD) and eating disorders as bulimia or anorexia or from exogenous sources from dietary compounds like acidic beverages or food, citrus juices, and soft drinks [3].

N.B: Aggressive dental erosion is seen in patients with low salivary flow, xerostomia or low salivary buffering capacity because Saliva is considered an important biomodulating factor in dental erosion. It can clear and neutralize erosive acids, form acquired dental pellicle and remineralizes eroded tooth structure [4], figure (1).

Figure 1. Cases of the loss of dental hard tissue (erosion).

Consequences of erosion

Repeated exposure of the tooth enamel to acids results in dissolution of hydroxyapatite and softening the enamel surface making it susceptible to further mechanical abrasion. Therefore, the term erosive tooth wear was created for this two-step chemical–mechanical process [5].

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.

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. In contrast, adult patients with non-cariogenic dental hard tissue loss have shown up with [1,5]

1. Reduced oral health and compromised esthetic appearance of the teeth.
2. Reduced chewing efficiency.
3. Tooth pain and hypersensitivity due to the exposed dentin areas.

In severe situations, as in GERD, a significant loss of tooth structure leads to loss of vertical dimension and function and pulp exposure [5].

Prevention and treatment of erosion induced tooth wear

- When substance loss caused by erosive tooth wear reaches a certain degree, oral rehabilitation becomes necessary.
- As a result of the improvements in composite restorative materials, and in adhesive techniques, it has become possible to rehabilitate eroded dentitions in a less invasive manner.
- Therefore, the treatment options available to rehabilitate patients with erosion range from minimally invasive direct composite reconstructions to adhesively retained all-ceramic restorations [6].

Resin composite restorations (RCR), glass ionomer cement (GIC) and ceramic restorations are usually used [4]:

- If loss of Vertical Dimension <0.5 mm: Sealing or direct flowable Composite restoration is recommended.
- Loss of Vertical Dimension <2 mm: Direct Reconstruction with Composite Materials or glass ionomer restoration are recommended.
- Loss of Vertical Dimension >2 mm: Rehabilitation with indirect Ceramic Veneers and Overlays are recommended.
- Loss of Vertical Dimension >4 mm: Rehabilitation with indirect Ceramic restorations as crowns and bridges are recommended [4].

Figure 2. Severe loss in vertical dimension due to severe erosion in the lower teeth

Effect of erosive conditions on different tooth-colored restorative materials

1. Composite restorative materials

1.a. Effect of erosive conditions on microhardness and surface roughness of resin composite restorations [1]

- Nanocomposites are the most stable under erosive conditions with higher wear resistance and microhardness values. This is due to nano-sized regular particles, which allow the incorporation of a large volume of inorganic fillers.
- Surface roughness values of nanocomposites after erosive challenges are lower than hybrid composites due to homogeneous composition and their particles are less prominent on the surface.
- Immersion of micro-hybrid composites in hydrochloric acid (HCl, pH 2) or soft drink (pH 3.6) for 10 minutes, three times daily for 14 days decreased surface microhardness and increased surface roughness.
- The softening of the resin matrix of bisphenol-A-glycidyl methacrylate (bis-GMA) could be caused by leaching of the diluent agents such as triethylene glycol dimethacrylate (TEGDMA). This promotes displacement of the filler particles, contributing to the formation of a rough surface.
- Application of acidic products, such as acidulated fluoride compounds may led to an increase in toothbrush wear or loss of fillers of composite resin.

1.b. Effect of erosive conditions on adhesive bonding strength and microleakage of resin composite restorations [7]

- Composite specimens subjected to thermal/erosive cycling showed microleakage and decreased bond strength of etch- and-rinse and self-etching adhesives with no significant differences between them.
- In addition to dissolution of enamel and dentin margins. The effects on bonding are more pronounced on enamel than on dentin because erosion primarily affects the inorganic part of the tooth and bonding to enamel is mainly achieved by a micromechanical interlocking of resin into microporosities of the acid-etched surface. In contrast, the dentinal hybrid layer is composed of organic matrix, residual hydroxyapatite crystallites, and resin monomers.
- However, in case of GERD, the gastric protease (pepsin) leads to organic matrix degradation and progression of erosive lesions in dentin.

1.c Recent advances in composite resin restorations for treatment of erosive tooth wear [5]

- Recent improvements of the composite restorative materials make them suitable for indirect restorative procedures to rehabilitate worn dentitions.
- The CAD/CAM composite can be used to produce ultrathin occlusal veneers. Laboratory studies have shown decreased risk of failure of this conservative approach as compared to lithium disilicate ultrathin occlusal veneers.
- The CAD/CAM composite restorations behave similarly or even better than human enamel with respect to two-body wear and toothbrushing wear.

2. Glass Ionomer cement

2.a. Effect of erosive conditions on microhardness and surface roughness (Ra) of Glass Ionomer cement (GIC)

- Compared to resin composite, glass ionomer cement is more unstable and experiences a decrease in hardness values and an increase in surface loss under erosive conditions. This is due to the dissolution of the silicate-glass hydrogel network peripheral to the glass particles [1,8].
- Conventional low-viscosity GIC shows lowest microhardness and highest surface degradation compared to high-viscosity GIC and resin modified glass ionomer (RMGI) [1,8]. Moreover, conventional GIC does not provide enough protection against erosion for the surrounding enamel and dentin because it shows more marginal than bulk degradation.
- The RMGI shows gradual decrease of surface microhardness under acidic challenge, however, it is less susceptible to acidic degradation compared to conventional GIC, due to the presence of reinforcing resin within the matrix.
- Moreover, RMGI provides protection against erosion for the surrounding enamel and dentin and can be considered material of choice among fluoride releasing materials for restoring erosive lesions [9].

- However, the increase in the surface roughness of RMGI is due to the presence of glass particles, and possibly porosities, in its composition [8,9].

3. Ceramic restorative materials

The reconstruction of excessively eroded dentition opposing ceramic restorative materials is mandatory when there is need to restore the occlusal vertical bite, figure (3).

Figure 3. Severe erosion and attrition of maxillary incisors, Ceramic veneers for maxillary incisors fabricated on dies, maxillary incisors were restored with ceramic veneers luted with resin composite cement.

3.a. Effect of erosive conditions on microhardness and surface roughness (Ra) of Ceramic restorative materials

- Although ceramics have high chemical durability, strong acids such as HCl from gastric regurgitate (GERD) can etch the surface of glass-based ceramics, resulting in increased surface roughness and a decrease in the hardness values of the ceramic restorations.
- Zirconia is less reactive to the acidic environment [10].

N.B: Local hydrolysis in ceramic cracks is accelerated in acidic pH, as GERD, leading to crack propagation and, hence, ceramic corrosion. The subsequent increase in surface roughness can increase the accumulation of bacterial plaque on the ceramic restorations [10].

Conclusion

Ceramic and resin containing materials are effective in providing protection of enamel in advanced cases of erosion and can withstand the erosive environmental conditions. While the traditional GIC materials are susceptible to severe damage in patients experiencing strong citric acid or gastric acid induced erosion.

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