Caries Process and Prevention Strategies: Erosion

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Introduction
This is part 7 of a 10-part series entitled Caries Process and Prevention Strategies. This course establishes the concept of dental erosion as a condition that is distinct from caries, and as an emerging public health issue with increasing prevalence in people of all ages. Although often generalized under the heading of “tooth wear,” there are actually two distinct tooth surface loss processes that must be taken into account. Tooth surface loss can be the result of physical mechanisms, such as attrition and abrasion, or chemical mechanisms triggered by acid. Both of these mechanisms are discussed, as well as the chemical, biological, and behavioral factors that increase or reduce risk of tooth surface loss. In addition, diagnosis and prevention measures related to dental erosion are introduced.

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Overview
This course establishes the concept of dental erosion as a condition that is distinct from caries, and as an emerging public health issue with increasing prevalence in people of all ages. Although often generalized under the heading of “tooth wear,” there are actually two distinct tooth surface loss processes that must be taken into account. Tooth surface loss can be the result of physical mechanisms, such as attrition and abrasion, or chemical mechanisms triggered by acid. Both of these mechanisms are discussed, as well as the chemical, biological, and behavioral factors that increase or reduce risk of tooth surface loss. For the purpose of this discussion, the impact of physical processes on tooth surface loss, such as attrition and abrasion, will be referred to as tooth wear. The process related to chemical acid attack resulting in tooth surface loss will be referred to as dental erosion. In addition, diagnosis and prevention measures related to dental erosion are introduced.

Clinical Significance Snapshots

Is dental erosion really a concern for me and my patients?
Erosion is more frequently found in ‘healthy’ patients, and this is where the greatest number of cases now occur. Although people adopting healthier diets and caring more for their oral health improve their overall well-being, they are also putting themselves at increased risk of dental erosion. Healthier diets include more fruits and vegetables, as well as their juices, many of which are acidic. In addition, increased consumption of carbonated beverages, with sugar, or sugar-free, and a concurrent decrease in milk consumption has led to increased acid intake and a reduced calcium intake.

Taking all the above into account, patients today have many more perfect, unrestored teeth, all of which are susceptible to acid attack, more acid exposures through changes in diet and lifestyle, and an increased frequency of toothbrushing with (mildly abrasive) toothpaste. A consequence of all these factors is erosive tooth wear. Also, the teeth our patients have must work harder and last longer as life expectancy increases. Wear and tear is only natural, but teeth today have more work to do over a longer period than previous generations that had teeth extracted and wore dentures.

Saliva is one of our main defenses against acid attack. Yet more patients are taking an increased number of prescription and over-the-counter medications, more than 400 of which have the ability to reduce saliva flow, and thus decrease this line of defense.

Minor erosion can be found in nearly every mouth, and should be regarded as a normal response to a healthy lifestyle. If minor, erosion has no noticeable signs or symptoms for the patient. However, minor dental erosion is an indicator of more significant signs (yellowing and loss of whiteness, dullness and loss of luster, changes in shape) and symptoms (dentin hypersensitivity and loss of occlusal contact and/or occlusal height) when advanced in relation to the patient’s age.
Is erosion the most common form of tooth wear?

Evidence of erosion can be found in almost every mouth, and may co-exist with the other physical forms of tooth wear. Erosive tooth wear may be exacerbated by physical wear from inappropriate use of toothpaste, particularly if used immediately after an acid attack, when the surface of the enamel is soft and vulnerable to wear. In this case, the clinical signs often lead to an incorrect diagnosis of “toothbrush abrasion.” Incidentally, nylon toothbrush bristles will not wear away enamel – they are too soft! However, the action of aggressive brushing places greater pressure on the abrasive cleaning particles in toothpaste that can wear enamel, especially if already softened by dietary acids. Soft brushes hold more abrasives against the surface of the tooth and are thus more harmful to the hard tissues than a hard brush.

It is imperative to assess erosive risk factors in all patients demonstrating signs or symptoms of tooth wear, no matter how obvious the diagnosis may be. Seldom does any one element of tooth wear occur alone.

How is dental erosion linked to my patient’s oral hygiene?

After any acid (dietary or stomach) has softened the surface layers of enamel, that enamel is vulnerable to physical loss until the natural forces of saliva have remineralized and thus rehardened it. If oral hygiene is conducted while the enamel is still softened, the oral hygiene procedure may lead to physical removal of some of the softened material, which leads to irreversible loss. Used as directed, most toothpastes are safe. However, if used aggressively or abusively – too much force, too much paste, too frequently – the detergents and abrasive particles essential for cleaning under normal circumstances have the potential to increase physical loss of the softened enamel.

Learning Objectives
Upon completion of this course, the dental professional should be able to:

• Describe why tooth wear poses a serious public health issue.

• Discuss the difference between physical and chemical wear on hard dental tissues.

• Identify the factors that cause each of the three types of physical tooth surface loss (tooth wear).

• Discuss the multiple factors that cause chemical tooth surface loss (dental erosion).

• Identify the chemical, biological and behavioral factors that influence dental erosion.

• Be familiar with how to diagnose dental erosion.

• Advise the patient on the diet, behavioral, and medical factors that can reduce dental erosion.

Glossary

buffering capacity – Saliva and the fluid in dental plaque possess the ability to buffer. Buffering adjusts the pH of any solution such as saliva or plaque fluid, and can resist changes in pH. Buffering capacity is the degree of buffering that can be brought about.

chelation – As it applies to the oral cavity, chelation is the process whereby citric acid has the ability to demineralize enamel to a much greater degree than its pH can explain. Through its chelating properties, citric acid removes calcium from the enamel surface, and through chelation forms a compound from which the calcium cannot be released. Therefore, the calcium is not available to diffuse back into the tooth. Citric acid also has the ability to chelate calcium in saliva, reducing the remineralizing effect.

demineralization – The chemical process by which minerals (mainly calcium) are removed from the dental hard tissues – enamel, dentin, and cementum. The chemical process occurs through dissolution by acids or by chelation, and the rate of demineralization will vary due to the degree of supersaturation of the immediate environment of the tooth and the presence of fluoride. In optimal circumstances, the minerals may be replaced through the process of remineralization.

dentin hypersensitivity – Tooth pain that is characterized by brief, sharp, well-localized pain in response to thermal, evaporative, tactile, osmotic, or chemical stimuli that cannot
be ascribed to any other dental disease or condition. Exposed dentin is a feature, and therefore the condition is associated with enamel wear (usually erosion) or gingival recession.

developed countries – A term not frequently used today in classifying countries, as no definitive definition exists. The term is used to describe countries with industrialized economies and higher levels of gross domestic product. Developed countries are able to spend more on health systems. These systems are typically treatment-oriented and focus services on the needs of the individual rather than the community.

erosion – Localized loss of dental hard tissue that is chemically etched away from the tooth surface by acids or chelating agents. Can be referred to as Acid Erosion or Acid Wear. Teeth exhibiting signs of erosion lose their surface texture (perichymata), may appear more yellow, and have an altered shape.

fluorapatite – A crystal structure in tooth mineral (Ca₁₀(PO₄)₆F₂) resulting from the replacement of hydroxyl ions (OH-) in the hydroxyapatite structure with fluoride ions (F-). Fluorapatite (also commonly referred to as fluoroapatite, fluorhydroxyapatite or fluorohydroxyapatite) is stronger and more acid resistant than hydroxyapatite.

GERD – Gastroesophageal reflux disease; the reflux of hydrochloric acid generated in the stomach that travels to the mouth. Erosion will occur upon the acid's contact with enamel surfaces.

hydroxyapatite – Crystals of calcium phosphate – (Ca₁₀(PO₄)₆OH₂) that form the mineral structure of teeth and bone. Enamel comprises approximately 98% hydroxyapatite (by weight). Much of the hydroxyapatite in enamel, however, is a calcium-deficient carbonated hydroxyapatite, the crystals of which are readily dissolved by acids. The addition of fluoride creates fluorapatite, which is less soluble and more acid-resistant.

ions - Atoms or molecules that carry either a positive or a negative electric charge in a solution. For example, sodium chloride (NaCl, common table salt) in water dissociates into Na⁺ and Cl⁻ ions.

prevalent – Widespread; widely or commonly occurring.

remineralization – The chemical process by which minerals (mainly calcium) are replaced into the substance of the dental hard tissues – enamel, dentin and cementum. The process requires an ideal environment that includes supersaturation with calcium and phosphate ions, and adequate buffering. In the presence of fluoride, remineralization is enhanced.

tooth wear – The non-caries loss of tooth tissue through the processes of attrition, abrasion, or erosion, occurring alone or combined (most typically abrasion and erosion).

xerostomia – A subjective assessment of mouth dryness, usually but not always associated with low levels of saliva production. Inadequate production of saliva occurs for many reasons, most commonly as an unwanted effect of many prescription and over-the-counter medicines. Saliva is necessary for maintaining a healthy mouth, and, in relation to dental caries, is essential for remineralization.

Introduction

Although erosive tooth surface loss was described as a different condition to caries as early as the 18th century, it was not considered with much importance until the 1990s. In 1996, the European Journal of Oral Science stated that “dental erosion is an area of research and clinical practice that will undoubtedly experience expansion in the next decade”.1 Yet, many dental professionals today are unable to correctly identify signs and symptoms. Considering the increasing longevity of teeth as dental advances have reduced tooth loss, the damaging effect of dental erosion—the non-bacterial chronic loss of dental tissues—is emerging as a serious public health issue.² In fact, erosive tooth surface loss is highly prevalent in developed countries, including the United States, Canada,
Great Britain, and Sweden. Studies suggest a prevalence of 6% to 50% in preschool children, 24% to 100% in school-aged children, and as high as 82% in adults 18 to 88 years old.9-8

The reason for concern is that erosive tooth surface loss can be pathological if the teeth are so worn down that they change in appearance or can no longer function properly.9 When natural reparative processes, such as remineralization, are no longer sufficient to protect the tooth, complications can include pain, dentin hypersensitivity, pulpal inflammation, necrosis, and pathology around the apex of the root of a tooth. There can also be increased risk of temporomandibular disorders.9 What follows is a discussion of physical and chemical tooth wear mechanisms, and the many factors that increase the risk of tooth surface loss.

**Tooth Wear Mechanisms and Etiology**

The mineral in enamel is a calcium-deficient carbonated hydroxyapatite, with the carbonate rendering the tooth more acid-soluble than true hydroxyapatite.2 During a lifetime, one’s teeth are subjected to a number of physical and chemical insults that damage this more soluble hydroxyapatite of enamel, as well as the other hard dental tissues, including the dentin and cementum. This chronic destruction of hard dental tissues due to physical or chemical wear, or a combination of both, has been defined as tooth wear.2 While enamel is the most at risk for dental erosion, as teeth are lasting longer in more recent times, dentists have had to pay more attention to the coronal and root dentin, because their exposure is becoming more common as a result of growing issues related to tooth wear and gum recession.

**Physical Wear (Tooth Wear)**

There are three main types of physical tooth wear mechanisms. These include attrition, abrasion, and abfraction.

1. **Attrition** is the physical wearing away of hard dental tissue due to tooth-to-tooth contact with no foreign substance intervening. It can be physiological when it is involved in the normal wear of the premolars and molars (called occlusal wear), or is caused by a malocclusion—or “bad bite”—that damages buccal, lingual, and interproximal tooth surfaces. However, attrition can also be pathological when it is caused by certain habits of the patient, particularly tooth grinding.10

2. **Abrasion** is the wearing away of hard dental tissue by mechanical processes involving foreign objects, or substances repeatedly introduced in the mouth and contacting the teeth.9 Previously, the definition of abrasion assumed that all abrasion is pathological, but because abrasion can be caused by factors that are beneficial, the word pathological is no longer always associated with abrasion.2 Etiological factors include oral hygiene habits, such as using toothpaste (the major abrasive agent in Western populations), brushing teeth in a way that might be too hard or too long, or excessive flossing; personal habits, such as frequently putting foreign objects, such as a pen, in the mouth; and occupational exposure to abrasive particles.11-15 A special form of abrasion is from demastication, the wear that comes from chewing food.11

3. **Abfraction** occurs as a result of shear stress in the cemento-enamel juncture of the tooth, leading to tooth flexure that causes tiny fractures in enamel and dentin. Stress that leads to tooth flexure can be caused by chewing or by tooth grinding.11,15 These areas of wear and tooth loss typically occur at the
cervical region on the tooth and are more commonly now referred to as non-carious-cervical lesions or NCCLs.

**Chemical Wear (Dental Erosion)**

The chemical dissolution of dental tissue can be caused by acid that is extrinsic, coming from items that are ingested, such as acidic food and beverages; or intrinsic, coming from hydrochloric acid produced by the parietal cells in the stomach. Hydrochloric acid can have a pH as low as 1, so its destructive capabilities are especially severe, and significantly more so than dietary acid.\(^\text{16}\)

However, regardless of the origin of the acid, the effect is the same: a low pH environment in the oral cavity. The initial reaction is that enamel first undergoes softening, the loss of mineral from a layer extending a few micrometers below the surface. As softening progresses over time, dissolution can completely remove portions of enamel, or the whole enamel layer, exposing the dentin underneath. When dentin is exposed to acid, first there is dissolution at the junction of the peritubular and intertubular dentin. Next, there is loss of the peritubular dentin and widening of the tubule lumina. Finally, there is formation of a demineralized collagenous mix that provides some protection of the underlying tissue. However, this layer is also vulnerable to damage and can ultimately be eroded away as well.\(^\text{17}\)

**Major Causes and Acid-related Risk Factors**

The three major causes of dental erosion are:

1. **Regurgitation**, which brings erosive stomach acid into the oral cavity and can occur in bulimia or during pregnancy.
2. **Excessive consumption of acidic foods** such as sweets or even healthy foods like citrus fruit.
3. **Excessive consumption of carbonated beverages.**\(^\text{2}\)

Especially problematic is the habit of swishing soda in the mouth to prevent the uncomfortable sensation of carbonation in the throat. This habit enhances the dissolution process because the solution on the surface layer adjacent to tooth mineral will be readily renewed. Also of concern is the increasing consumption of soda among children: It rose 20% between 1994 and 2004, and is linked to the presence and progression of erosion when other risk factors are present.\(^\text{2,18}\)

As explained before, the acid that erodes teeth can come from intrinsic or extrinsic sources. An increasingly prevalent cause of intrinsic acid is the gastric acid that enters the mouth in gastroesophageal reflux disease (GERD).\(^\text{19}\) In Western populations, GERD is reported to affect up to 30% of adults,\(^\text{20}\) and an estimated 15% of people complain of weekly GERD symptoms.\(^\text{21}\) GERD is itself a multifactorial condition caused by diet, posture, overly strenuous exercise, alcohol consumption, pregnancy, or obesity. Other conditions that cause gastric acid to enter the oral cavity include chronic alcoholism and rumination, a psychological disorder in which patients regurgitate and re-chew their food and swallow again.\(^\text{2,22}\)

Additional extrinsic sources of acid include excessive consumption of other acidic items such as fruit juices, alcohol, herbal teas, energy drinks, supplements such as hydrochloric acid (taken for indigestion), chewable or effervescent vitamin C, aspirin, and some oral hygiene products, including some mouth rinses.\(^\text{2,22}\)

**Non-acid Risk Factors**

The presence of acid is not the only way in which the wear of enamel occurs. Another mechanism is called chelation. Certain agents can complex with calcium to remove it from enamel, thus triggering demineralization. Or, agents can complex with calcium in saliva, reducing saliva’s supersaturation and ability to remineralize the tooth surface. Some calcium-chelating agents include mouth rinses that include the ingredient EDTA, and food and beverages that contain citric acid. Up to 32% of the calcium in saliva can be complexed by citrate at concentrations common in fruit juices, reducing the supersaturation of saliva and driving the equation to dissolution of tooth mineral.\(^\text{23}\)

Another non-acid erosion risk factor is dry mouth. This can be caused by dehydration, salivary gland dysfunction or by the use of some medications such as anti-histamines, anti-emetics, anti-
depressants, tranquilizers, or illegal designer drugs. Because the mouth is dry, the teeth have significantly less protection from acid.²

Chemical Factors that Influence Erosive Tooth Surface Loss

The term “chemical factors” is used to describe parameters inherent to erosive beverages, food, or other products. The three main parameters are:

1. **pH and Buffering Capacity:** In general, the greater the buffering capacity of an edible item, the longer it will take for saliva to neutralize the product’s acid. So a beverage with a higher buffering capacity will be more erosive than others within the same pH class. Even if a product is at a low pH, it is possible that other factors are strong enough to prevent erosion. Similarly, it is also possible that a less acidic product can cause erosion because it has the capacity to complex calcium, pulling the mineral out of the tooth surface to cause demineralization. While pH is an important factor, there is no specific pH of a product below which damage will occur.²

2. **Acid Type:** The erosive character of lactic and citric acid in products is higher than that of acetic, maleic, phosphoric, and tartaric acids.²⁴

3. **Calcium, Phosphate, and Fluoride Concentration:** Solutions oversaturated with respect to dental hard tissue will protect against dental surface softening.²⁵,²⁶ A low degree of undersaturation with respect to enamel or dentin leads to a very initial surface demineralization which is followed by a local rise in pH and increased mineral content in the liquid surface layer adjacent to the tooth surface. This layer will then become saturated with respect to enamel and will not demineralize further. A high degree of undersaturation with respect to dental tissue will demineralize the tooth surface considerably more.²⁵,²⁶

Studies have shown that a drink which contains citric acid that was supplemented with calcium, phosphate, and fluoride reduced the erosive potential of the solution.²⁷ The same was true when acidic carbonated drinks were modified with these three minerals.²⁸ Yogurt, which is acidic with a pH of 4 hardly has any erosive effect due to its high calcium and phosphate content, which makes it supersaturated with respect to the hydroxyapatite in enamel.²

Other parameters to consider are the calcium-chelating properties of the product being consumed, and the stickiness of the product being consumed, with more sticky products generally being linked to higher erosion risk.²

Biological Factors that Influence Erosive Tooth Surface Loss

Saliva

This is the most important biological factor in the prevention of dental erosion. It starts acting even before the acid attack with an increase in salivary flow in response to visual or olfactory stimuli or to chewing, increasing the buffering system and diluting and clearing acids on tooth surfaces during the erosive challenge.² The properties of saliva that influence dental erosion are:

**Salivary Flow Rate:** A low salivary flow rate due to xerostomia, dehydration, use of certain medications, salivary gland pathology, or when there are no stimuli to trigger a protective salivary response (such as when a patient is suffering with GERD) means that teeth are less protected during an acid attack.²²⁹ A high salivary flow rate, on the other hand, has a protective effect against acid, particularly because it has the ability to clear acids from teeth surfaces.

**Saliva’s Chemical Composition and Buffering Capacity:** A higher hydrogen bicarbonate content increases the capacity of saliva in neutralizing and buffering acids to protect from erosion, while a low buffering capacity is strongly associated with increased erosion. In addition, saliva that is supersaturated with calcium and phosphate ions is more effective at maintaining the integrity of teeth by remineralizing the hydroxyapatite in enamel, while saliva that is undersaturated with calcium and phosphate cannot replenish enamel’s mineral content.²³⁰ The degree of supersaturation of hydroxyapatite, fluorapatite and calcium fluoride also increases as saliva flow is stimulated and increases. It is also important
to note that sites poorly bathed by saliva or mainly bathed with mucous saliva (which typically contains fewer mineralizing ions) are more likely to show erosion when compared to sites protected by saliva that is serous in nature. ³¹

**The Acquired Pellicle**

Saliva plays a role in the formation of this protein-based layer which forms within minutes on the surface of a tooth after its removal by toothbrushing, chemical dissolution, or prophylaxis. This barrier prevents the direct contact of an acid and the tooth's surface, and can serve as a reservoir of remineralizing electrolytes.³²,³³ This protective effect could be clearly visualized by a scanning electron microscopy study where the 2-hour formed pellicle was able to reduce erosion by an acidic beverage.³⁴,³⁵ The acquired pellicle also contains salivary mucins, proteins that have the capacity to increase enamel surface protection against demineralization.² The enzymatic composition of the pellicle also plays an important role: The presence of the enzyme carbonic anhydrase VI in the pellicle may protect against tooth erosion because it speeds the neutralization of demineralizing hydrogen ions on the tooth's surface.³⁵

The pellicle reaches its full thickness in 2 hours, but after this, there is further maturation that allows it to become most acid-resistant. If it is removed often due to factors such as excessive brushing, it will not be allowed to reach maximal thickness or maturation, and risk of erosion is higher.³⁶

**Tooth Position and Soft Tissues**

Where the tooth is situated in the mouth can make it more or less susceptible to dental erosion. This is because different sites in the mouth are affected by variations in salivary flow and composition, and affected by soft tissues like the tongue. As such, facial surfaces of upper incisors have higher susceptibility to erosion because the exposure to saliva is lower, while lingual surfaces of lower teeth have lower erosion susceptibility because the exposure to protective saliva is higher.² The most severe erosive lesions are typically found in the palatal surfaces of the upper teeth because of the abrasive effect of the tongue. It has been shown that the tongue is able to remove already softened enamel and dentin.³⁷

**Behavioral Factors that Influence Erosive Tooth Surface Loss**

Behavioral factors play a significant role in determining the extent of erosive tooth surface loss. The factors can include the manner in which dietary acids are introduced into the mouth (such as sipping, gulping, swishing, or using a straw) as this affects how long the teeth are in contact with the erosive challenge. Factors can also include diets high in acidic food (including sweets, fruits, and vegetables) and acidic beverages, oral hygiene practices (such as using toothpaste or excessive toothbrushing or flossing), the use of

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**Figure 1A.** Transmission electron microscopy image of the 2-h in situ formed pellicle on enamel surface.

**Figure 1B.** The 2-h pellicle after 10 min of erosive challenge in situ by orange juice.

of acidic medications or oral hygiene products, consumption of alcohol, frequent consumption of designer drugs, and nighttime baby-bottle feeding with acidic beverages.  

One point of note is that even healthy dietary lifestyles, such as vegetarianism and raw foodism, have been linked with more dental erosion due to the large amounts of acidic fruits and vegetables consumed. Other healthy lifestyle habits, such as drinking herbal tea (such as rose hips and lemon, which have a pH of 2.6 to 3.9) also promote erosion. Even cosmetic procedures may pose a problem: Some whitening gels have been found to soften and alter enamel, suggesting an increased susceptibility to dental erosion.  

### Interaction between Physical and Chemical Tooth Surface Loss

Tooth wear can be the result of interaction between two or more tooth surface loss processes. The most common presentation of tooth wear involves dental abrasion with erosion. Acid partially dissolves the outer layer of mineralized tissue, which increases the potential for abrasion from toothbrushing with or without toothpaste. For example, there can be interaction between dental attrition and dental erosion in individuals who regurgitate often, such as bulimics.  

### Risk Assessment and Diagnosis

It is important to evaluate the different etiological factors in order to identify which patients are at risk and to suggest preventive measures, particularly if erosion is detected early. Erosion not diagnosed in the early stages may render preventive measures too difficult. In order to assess risk, gathering information on a patient’s medical and dental case history is an important first step. Information about the patient’s dietary habits are the most useful, and it is advised that dentists ask their patients...
to record their complete dietary intake for 4 consecutive days, including time of day and quantity of all foods and beverages, as well as medications and supplements. In addition, it is useful to ask the patient about gastric symptoms (like vomiting, acid taste in mouth, chronic heartburn, etc.), drug use (alcohol, anti-emetics, anti-histamines, etc.), use of acidic medicines or supplements, and oral hygiene habits (like technique or frequency of brushing). It is also useful to conduct tests for unstimulated saliva flow rate, stimulated saliva flow rate, and saliva buffering capacity to determine if the amount and quality of saliva is posing a risk of erosion.2,39,40

Clinical detection of dental erosion is important once dissolution has started. In the early stages of erosion, the appearance of the teeth is the most important sign for diagnosis. Early signs include a smooth silky-glazed enamel surface and grooving on occlusal surfaces. In more advanced stages, changes in the original morphology occur. In general, buccal and lingual surfaces of the upper incisors appear smooth and shiny with a generalized loss of anatomy, while palatal surfaces of the upper incisors might show smooth exposed dentin, often with a halo of enamel surrounding the lesion.3

**Qualitative and Quantitative Assessment**
There are many frequently adopted techniques for analyzing the erosively altered dental hard tissues in dental research, but these are routinely performed on extracted teeth and are not useful for clinical evaluation of patients. Due to the complex nature of dental erosion and dissolution, a single technique may not provide a full enough picture of the extent of damage, and different approaches may be needed for full understanding. The most established and well-evaluated techniques include, but are not limited to:

- **Scanning Electron Microscopy:** This is a subjective, qualitative method for closely observing surface alterations of teeth. It is one of the few methods that are suitable for early erosion.
- **Surface Hardness Measurements:** This is a low-cost quantitative method that uses a diamond tip for calculating the tiny indentations of the tooth surface where enamel or dentin has been eroded.
- **Surface Profilometry:** This is a time-consuming quantitative method that uses a laser beam or contact stylus to scan surface roughness.
- **Iodide Permeability Test:** This is a low-cost qualitative method that only provides information about pore volumes, with larger pores signifying more erosion.
- **Confocal Laser Scanning Microscopy:** This provides high-resolution, 3-D images for quantitative assessment and interpretation of hard tissue destruction or mineral dissolution. It is suitable for early erosion.
• **Ultrasonic Measurement of Enamel Thickness:** This is a quantitative method that calculates enamel thickness by measuring the time interval between the transmission of an ultrasonic pulse on the enamel surface and the echo produced by the amelodentinal junction.

In addition, it is recommended that dentists use simple methods like photography or silicone impressions to assess further progression in a clinical setting.

**Prevention and Treatment Strategies**

While dental erosion is not entirely preventable, it can be slowed down considerably. To this end, building awareness in the patient and patient education is key. Consider discussing the following with your patients:

• **Dietary factors** – including the benefits of reducing consumption of acidic foods and beverages.

• **Behavioral habits** – including not holding acidic liquids in the mouth, avoiding aggressive brushing, switching to a softer toothbrush, and avoiding toothbrushing after an erosive challenge to allow the acquired pellicle to provide protection.

• **Medications** – including those that reduce salivary flow (such as antihistamines and antidepressants), and those that can trigger GERD.

• **Causes of intrinsic acid erosion** – (such as bulimia), advising the patient to seek medical attention if necessary.

Treatments may include the application of fluoride, which has been found to be especially beneficial at early stages of erosion, but not completely restorative. There is a growing body of evidence that suggests toothpaste formulated with stannous fluoride (SnF₂), and in particular stabilized SnF₂, is a particularly effective agent in the prevention of dental erosion, due in part to its ability to deposit a stannous-containing barrier layer onto the tooth surface during brushing. Studies have demonstrated the ability of the SnF₂ to retain on the treated tooth surfaces for a significant amount of time after treatment helps provide enhanced protection to these surfaces against erosive acid attack. The use of saliva-stimulating lozenges or medications, the application of neutralizing strategies and calcium phosphate or hydroxyapatite containing products, and the use of adhesive restorative materials or minimally-invasive composite fillings to protect the affected regions might also prove to be helpful at reducing the progression of dental erosion.

**Conclusion**

Dental erosion is becoming increasingly prevalent and its damaging effect is emerging as a serious public health issue. There is no doubt that erosive tooth surface loss can become pathological, leading to complications such as pain, dentin hypersensitivity, pulpal inflammation, and increased caries risk, if measures are not taken to prevent the loss of dental tissue. Knowing the factors that promote dental erosion as well as preventive strategies can go a long way in averting erosion or significantly slowing its progression. The use of fluoride toothpaste formulated with stabilized stannous fluoride is particularly useful for its ability to deposit an invisible barrier layer onto exposed tooth surfaces that aids in the prevention of dental erosion. Becoming familiar with how to assess the level of damage and treat it can prevent the onset of related complications.
Course Test Preview
To receive Continuing Education credit for this course, you must complete the online test. Please go to: www.dentalcare.com/en-us/professional-education/ce-courses/ce374/start-test

1. Which of the following statements about dental erosion is true?
   a. Dental erosion is not a serious public health issue.
   b. Dental erosion is caused by bacteria.
   c. Dental erosion is non-bacterial chronic loss of dental tissues.
   d. Dental erosion is only prevalent in less developed countries.

2. Why is dental erosion of particular concern to dentists?
   a. When reparative processes can no longer protect teeth, complications can include pain, dentin hypersensitivity, and pulpal inflammation.
   b. It can lead to oral cancer.
   c. Dental erosion is not a serious concern for dentists.
   d. It can be an indicator of future caries.

3. Which of the following is correct about attrition?
   a. Attrition is only caused by pathological behavior, like tooth grinding.
   b. Attrition can be physiological when it is due to normal wear or pathological when caused by certain habits of the patient, like tooth grinding.
   c. Attrition only damages the premolars and molars.
   d. Attrition is the wearing away of dental tissue by foreign objects in the mouth.

4. Which of the following is correct about abrasion?
   a. Abrasion is the wearing away of dental tissue due to tooth-to-tooth contact.
   b. Abrasion is only caused by pathological behavior.
   c. Abrasion causes include oral habits like using toothpaste and brushing teeth in a way that may be too hard.
   d. Abrasion only damages the premolars and molars.

5. Which of the following is correct about abfraction?
   a. Abfraction is a mechanical process caused only by foreign objects in the mouth.
   b. Abrasion only damages the premolars and molars.
   c. Abfraction is caused by “bad bite.”
   d. Abfraction occurs as a result of shear stress that leads to tooth flexure that causes fractures in enamel and dentin.

6. What is the first step of tissue loss during the dental erosion process?
   a. Enamel exposed to acid first undergoes softening, and as softening progresses over time, dissolution can remove portions of enamel or the whole enamel layer.
   b. There is dissolution at the junction of the peritubular and intertubular dentin.
   c. There is formation of a demineralized collagenous mix.
   d. There is the widening of tubule lumina.

7. Which factors below are major causes of dental erosion?
   a. Regurgitation
   b. Consumption of carbonated beverages
   c. Consumption of acidic foods and beverages
   d. All of the above.
8. Which of the following is not an extrinsic source of erosive acid?
   a. Chewable vitamin C
   b. Gastric acid
   c. Mouth rinses that contain sodium chloride
   d. Herbal teas

9. What percent of calcium in saliva can be complexed by citrate in fruit juices?
   a. 12%
   b. 47%
   c. 32%
   d. 81%

10. Which of the following is true about the calcium, phosphate, and fluoride concentration of a beverage?
    a. Solutions oversaturated in calcium, phosphate, and fluoride with respect to dental tissue will protect against dental surface softening.
    b. A low degree of undersaturation does not impact enamel at all.
    c. A high degree of undersaturation will only cause an initial surface demineralization.
    d. Supplementing a solution with calcium, phosphate, and fluoride does not affect its erosive potential.

11. What helps the salivary pellicle have a protective effect?
    a. It is a source of remineralizing electrolytes.
    b. It cannot be removed once fully formed.
    c. It contains acid-neutralizing enzymes, like carbonic anhydrase VI.
    d. A and C

12. On which teeth surfaces are the most serious dental erosions typically found?
    a. Facial surfaces of the upper incisors
    b. Lingual surfaces of the lower teeth
    c. Palatal surfaces of the upper teeth
    d. All tooth surfaces.

13. What information is useful in assessing a patient's risk of dental erosion?
    a. The patient's oral hygiene habits
    b. The patient's use of medications and supplements
    c. A record of the patient's dietary intake
    d. All of the above.

14. What qualities describe the appearance of enamel in early erosion?
    a. Smooth, silky, glazed
    b. Bumpy, dull, yellow
    c. There are no detectable changes in early erosion
    d. Thick, bumpy

15. Which source of fluoride has been identified as particularly beneficial for its ability to help protect against dental erosion?
    a. Sodium fluoride
    b. Sodium monofluorophosphate
    c. Stannous fluoride
    d. All fluorides protect equally.
References


About the Authors

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Dr. Higham is a Professor of Oral Biology in the Department of Health Services Research and School of Dentistry, University of Liverpool, United Kingdom. She is Director of Postgraduate Research in her University Research Institute and is the National Institute of Health Research, Comprehensive Research Network Oral and Dental Specialty Research Group Lead for North West Coast and National Industry Lead.

Dr. Higham has a background in microbiology and biochemistry, a PhD focused on dental plaque metabolism from the University of Liverpool, Chartered Biologist status and a member of the Royal Society of Biology. She was appointed as a Research Fellow in the Department of Clinical Dental Sciences at the University of Liverpool and later promoted to Senior Lecturer and then to Professor.

Dr. Higham has supervised more than 40 postgraduate students and has published more than 370 book chapters, peer-reviewed papers and peer reviewed abstracts. Her main research interests are in the use of in vitro and in situ models and clinical trials to study dental diseases, together with the development of optical technologies for the quantification of mineral loss/gain in vivo. She has been involved in University teaching at all undergraduate and postgraduate levels for over 30 years. Dr. Higham has been a scientific advisor for the European organization for caries research (ORCA) for many years and is a dentistry panel member for the Research Excellence Framework (REF) in the UK. She has been elected as Vice-President of the Cariology Group of the International Association of Dental Research (IADR) and will serve as President in 2020.

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Chris graduated with a degree in Microbiology at the University of Liverpool in 1994 and then went on to study for a PhD in Chemical Engineering at The University of Birmingham. This somewhat unconventional entry into dental research came via biofilm modeling which led to his appointment at the Eastman Dental Institute – University College London as a research fellow between 2000 and 2005.

In 2005, Chris was appointed as Lecturer in Oral Biology at the University of Liverpool where his experience of biofilm modeling complimented the research group themes of caries and plaque-related disease. Chris developed a biological model of dental caries which acquires enamel lesions in less than two weeks and continued his interests in imaging by studying the natural fluorescence of dental plaque. More recently, he has revisited photodynamic therapy by looking at the lethal photosensitization of periodontal pathogens by means of their intrinsic porphyrins.

Chris served on the British Society for Oral and Dental Research (BSODR) Oral Microbiology and Immunology Group (OMIG) management committee from 2008 to 2011 and then again for a second term from 2015 to 2018. Chris was also elected onto the management board of the BSODR in 2017. He is also on the editorial board of the Journal of Medical Microbiology.

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Phil is currently Senior Lecturer and Honorary Consultant in Restorative Dentistry at Liverpool University Dental Hospital and he has been an NHS Consultant since 1998. He has been actively involved in teaching, research and clinical service, and is lead clinician for restorative care of CLP patients in Liverpool and North West (West) Region. He has also gained experience in managing clefts from time spent at Oslo. He has published widely including authoring/co-author of 3 textbooks and has been supervisor, mentor and advisor for a number of postgraduate students and trainees. He is a reviewer for Journal of Dental Research, Journal of Dentistry, British Dental Journal, Dental Materials, Journal of The European Journal of Prosthodontics and Restorative Dentistry, and Dental Update. He is also part of a team from Liverpool that has been commended in the recent Medical Futures Innovation awards and is currently President of the British Society of Prosthodontics.

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