

## The Dental Learning Network



# Tooth Erosion: Risk Factors and Therapeutics

*5 Homestudy Credit Hours*

Anne P. Dodds, BDS, MPH, PhD.

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## Tooth Erosion - Risk Factors and Therapeutics (5 CEs)

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## Table of Contents

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<b>Answer Sheet – Tooth Erosion (2 Credit Hours)</b> .....	<b>2</b>
<b>Instructions</b> .....	<b>3</b>
<b>Table of Contents</b> .....	<b>4</b>
<b>Course Objectives</b> .....	<b>5</b>
<b>Course Introduction</b> .....	<b>6</b>
<b>About the Author</b> .....	<b>7</b>
Anne P Dodds BDS, MPH, PhD. ....	7
<b>Epidemiology</b> .....	<b>8</b>
<b>Erosion</b> .....	<b>9</b>
The Pathogenesis of Erosion .....	9
Drinks and Erosion .....	10
Foods That May Cause Erosion .....	11
Eating Disorders and Erosion.....	11
Other Medical Conditions Associated With Erosion .....	12
Illegal Drug Use.....	13
Chlorinated Swimming Pools.....	13
<b>Other Causes of Tooth Structure Loss</b> .....	<b>14</b>
Introduction.....	14
Abrasion .....	14
Attrition .....	14
Bruxism.....	15
Resorption .....	15
<b>Clinical Signs and Symptoms of Erosion</b> .....	<b>16</b>
Mild Erosion.....	16
Moderate Erosion .....	17
Advanced Erosion .....	18
<b>Host Modifying Factors</b> .....	<b>19</b>
<b>The Use of an Erosion Index and the Monitoring of Erosion in the Dental Office</b> .....	<b>20</b>
<b>Management and Treatment of Erosion</b> .....	<b>21</b>
<b>Preventive and Provisional Care</b> .....	<b>22</b>
<b>Restorative Treatment of Erosion Lesions</b> .....	<b>23</b>
Introduction.....	23
Treatment of Permanent Teeth .....	23
Treatment of Primary Teeth.....	25
<b>Conclusions</b> .....	<b>26</b>
<b>Test</b> .....	<b>27</b>

## Course Objectives

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At the conclusion of this course the participant should be able to:

1. Describe the epidemiology and pathophysiology of dental erosion
2. Identify the behaviors that have been identified as “high risk” in the development of dental erosion
3. Describe other common causes of tooth structure loss – *Bruxism, Abrasion* and *Attrition, and their relevance to dental erosion*
4. Describe the clinical signs and symptoms of erosion
5. Describe the host modifying factors that affect the development of erosion
6. Apply appropriate dental clinical techniques in the management of dental erosion

## Course Introduction

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The increasing number of children and adults diagnosed with dental erosion presents a clinical challenge to the dental practitioner.

This course describes the epidemiology, pathogenesis, clinical diagnosis and treatment of dental erosion. Erosion is the process by which tooth mineral is irreversibly lost due to the action of acid. This is a direct pH effect that occurs when the critical pH of dental enamel (< 5.5) is breached. All acids, whether from intrinsic (such as that produced by gastric acid reflux) or extrinsic sources (e.g. dietary such as yoghurt, pickles, soft drinks - especially sports drinks), are capable of demineralizing tooth enamel if they produce a pH at the enamel surface that is lower than the critical pH. The early signs of erosion are often difficult to diagnose and a definitive diagnosis may require long-term monitoring of the progression of tooth wear with study casts and photographs. Only preventive, provisional or temporary treatment should be given for erosion lesions until the causative condition is determined and treated and the erosion is controlled and stabilized.

In addition to erosion, there are other forms of non-caries destructive processes that result in a loss of tooth structure. These processes include *abrasion*, *attrition* and *resorption*. Destruction of tooth structure is almost never caused by a single process, as they often co-exist.

## About the Author

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**Anne P Dodds BDS, MPH, PhD.**



Dr Dodds graduated from the University of Edinburgh Dental School and following two years in a community dental practice moved to San Antonio Texas in 1987. She obtained an MPH at the UTHSC- Houston and secured a teaching appointment at the UTHSC-San Antonio in the Dept of Community Dentistry. She obtained a Certificate of Pediatric Dentistry from San Antonio in 2000 and PhD in Cellular and Structural Biology in 2001. Since 2000 she has been a faculty member at the University of North Carolina, Dept of

Pediatric Dentistry where she has carried out research in early dental development and treated patients in Dental Faculty Practice and UNC Hospital. She has been involved in AHEC and has written dental continuing education classes for more than 10 years.

Erosion is the process by which tooth mineral is irreversibly lost due to the action of acid. This is a direct pH effect that occurs when the intraoral pH drops below the critical pH of dental enamel (5.5). All acids, whether from intrinsic (such as that produced by gastric acid reflux) or extrinsic sources (e.g. dietary such as yoghurt, pickles, soft drinks - especially sports drinks), are capable of demineralizing tooth enamel if they produce a pH at the enamel surface that is lower than the critical pH. This results in erosion lesions. Some medications, especially those that are delivered by inhaler, have low pH and may contribute to erosion e.g. Albuterol (*Ventolin* - sulfuric acid is used to adjust the pH to between 3 and 5) and Cromolyn (*Intal* - pH of 5.5). Vitamin C supplements are often low pH due to the citric acid content and are particularly harmful if taken last thing before retiring. There have even been reports in the literature of swimmers' teeth being affected by the low pH of chlorinated pools.

Erosion is difficult to measure consistently (many different indices exist) and so it is hard to compare data from different studies (e.g involving adults, children, different countries, occupational exposures). In studies of 5 year old children in Ireland, 47% had erosion, and in a 1993 UK National Survey of Child Dental Health (17,061 children were examined) more than 50% of the 5 and 6 year olds had erosion, 25% of these with dentinal involvement. In the 11 year and older age group, almost 25% had erosion, 2% with dentinal involvement in the mixed dentition.

In a US study of 11-13 year olds 41% had erosion. In adults the situation is similar. In a Swiss study of subjects aged between 26 and 30 years, 7.7% had facial erosive lesions with dentin involvement and 29.9% had occlusal tooth loss into dentin. In the 46-50 year old group, 13.2% exhibited facial erosive lesions into dentin and 42.6% had occlusal erosion involving dentin.

Taken as a whole, studies suggest that the prevalence of dental erosion (of all causes) ranges from 5 to 50% in various populations and age groups.

## The Pathogenesis of Erosion

***This is a microbiologically sterile process and as such is very different to dental caries resulting from acid produced by decay producing (cariogenic) bacteria.***

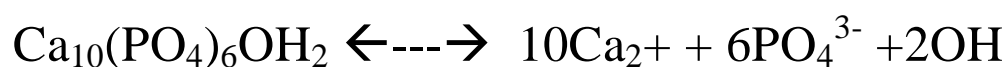
Clinically, erosion may be detected initially as opacities or white spots on enamel smooth surfaces, progressing to a flattening of the cusps and a loss of vertical dimension, cupping and/or grooves on the occlusal surfaces, and increased translucency due to generalized thinning of the enamel. If the erosion progresses slowly it allows for the deposition of tertiary dentin resulting in a reduction in the size of the pulp chamber. If the erosion progresses rapidly it quickly results in dentin involvement and exposure of the pulp. A characteristic feature in moderate to severe erosion is that existing restorations begin to stand “proud” of the surrounding enamel that is undergoing dissolution. Erosion does not itself cause, but predisposes a tooth to additional tooth structure loss from bruxism, abrasion and attrition.

When the intraoral pH drops below the critical pH of dental enamel (5.5), the prism core or inter-prismatic enamel demineralizes leading to the development of a “honeycomb” structure. Further demineralization of the peri-tubular dentin results in enlargement of tubules that eventually involves the inter-tubular dentin. While rapid erosion is associated with increased sensitivity to temperature and sweetness, erosion that progresses slowly is often asymptomatic.

Enamel consists mainly of calcium phosphate hydroxyapatite (97%) (HAP) and exists as a supersaturated liquid phase surrounding HAP crystallites.

The solubility of HAP is dependent upon the ambient pH.

- At low pH values (below the critical pH) a higher concentration of ions is needed in the liquid phase surrounding crystallites to maintain saturation and so the driving force is towards dissolution.
- At high pH values (above the critical pH) a lower concentration of ions is needed in the liquid phase to maintain saturation leading to precipitation.
- At neutral pH this equation is in balance, with dissolution (to the right side of equation) occurring at the same rate as precipitation (to the left side of equation).



If the frequency of low pH events is high, re-deposition of mineral is not complete before the

next demineralization episode, leading to a cumulative loss of enamel substance, in other words an erosion lesion is formed.

The reactive fluoride ion can substitute for the hydroxyl (OH) and carbonate ions (CO<sub>3</sub>) making the HAP crystallites less soluble during acid exposure. This process (incorporation of foreign ions into HAP during this cycling) is known as post-eruptive maturation and may result in the so called "mature enamel" being either more or less soluble than that found on newly erupted teeth (incorporation of carbonate ions makes it more soluble while fluoride ions result in a less soluble product).

### **Drinks and Erosion**

A high risk behavior for the development of dental erosion is the frequent consumption of (acidic) soft drinks. US data from the past 20 years has shown a three-fold increase in soft drink consumption by males and a two-fold increase among females. Eating excessive amounts of acidic foodstuffs, and frequent use of low pH medicines/ supplements such as those previously mentioned may also contribute to the development of these lesions. A dramatic increase has been demonstrated in the number of individuals diagnosed with eating disorders, especially *Bulimia nervosa* where frequent vomiting results in enamel erosion. Although not a "behavior," untreated gastroesophageal reflux (GERD) also is frequently associated with enamel erosion.

Of particular concern (since it can be modified) is soft drink consumption of children and young adults, which often results in widespread dental erosion. Data demonstrates a seven-fold increase in the consumption of soft drinks between 1950 and 1990, with consumption highest in younger age-groups. It has been reported that as much as one-fifth of the added fermentable sugars in the diet of 11-12 year old children is consumed in the form of soft drinks and 42% of fruit drinks are consumed by children aged 2 to 9 years. Of greater concern perhaps, is the reported observation that eating patterns established in childhood persist into adulthood. Although some school districts have taken steps to ban the sale of such beverages in schools, excessive consumption continues to be a major problem in this age group.

pH studies have confirmed that virtually all soft drinks have low pH values. This may be due to acids in the component fruit juices or may be as a result of acids added during manufacture. Acids may be added for two main reasons, first to balance the sweetness of the drink and secondly, to inhibit the growth of micro-organisms and prolong shelf life.

The three acids most commonly used as additives to soft drinks and fruit juices are phosphoric, citric and malic acids. Phosphoric acid (0.0055 M) is the ingredient which contributes to the unique tangy taste of "Coke type" soft drinks and has a pH of around 2.5 – well below the critical pH of enamel. Citric and malic acids are flavor enhancers, citric being found naturally in citrus fruits, blackcurrants, strawberries and raspberries and malic acid found in apples, cherries, plums and peaches. Even the so-called "diet" drinks have similarly low pH values as they contain these same agents. These are all strong acids in comparison with the organic acids produced by cariogenic oral *Strep viridans*.

The issue of soft drinks and dental health has assumed political importance in some European countries and has led to the addition of fluoride (at 15ppm), calcium and phosphate to reduce the titratable acidity of fruit drinks and thereby reduce their erosive

potential. It has been suggested that reducing the length of time that soft drinks linger in the mouth by using a straw to help reduce drink- tooth contact, by avoiding holding or swishing the drink around the mouth or by dilution of fruit drinks have not been shown to decrease their erosive potential (CSFII survey results).

It should be borne in mind that erosion is a disease of enamel dissolution that can occur in the absence of fermentable carbohydrates. Certainly the presence of sugar, high fructose corn syrup or fructose provides additional substrate for bacterial acid production which further contributes to the tooth destruction through caries development.

### **Foods That May Cause Erosion**

Although some fresh fruits such as lemons, limes, apples, plums and oranges have a low pH, their consumption has not been linked to erosion unless they are consumed in a specific manner (such as continual sucking of lime or lemon segments as is often done in Latin American countries). In fact, many commonly consumed foodstuffs (e.g. vinegar and pickles, yoghurt, cider, dry wine and beer and some herbal teas) have low pH but are not generally consumed in a quantity, frequency or manner which routinely poses a threat to dental tissues.

### **Eating Disorders and Erosion**

Approximately 70 million individual's worldwide struggle with eating disorders. Five to ten million adolescent girls and women and approximately one million boys and men in the US are affected. Eating disorders have been diagnosed in children as young as three years old and in adults as old as ninety. However, the typical age of onset is from 12-18 years of age. It is estimated that currently 11% of high school students have been diagnosed with some sort of eating disorder.

The eating disorders most commonly associated with dental erosion are *Bulimia nervosa* and *Anorexia nervosa*. *Bulimia nervosa* is characterized by a persistent preoccupation with body weight and shape and periods of uncontrolled binge eating when large amounts of food are rapidly consumed, followed by some form of purging (self-induced vomiting) to prevent weight gain. *Anorexia nervosa* is characterized by extreme weight loss from a self-imposed and severe restriction of foods and fluids, and self-induced vomiting. It is not uncommon for an individual diagnosed with one of these conditions to exhibit behaviors usually seen in the other condition from time to time.

*Bulimia nervosa* is more common than *anorexia*, affecting 2% of US adolescent girls (14/100,000). The most commonly associated dental finding is *perimylolysis* - a condition characterized by a loss of enamel and dentin on the lingual surfaces of the teeth due to the chemical and mechanical effects resulting from regurgitation of gastric contents and activated by movements of the tongue. This is characteristically seen on the lingual surfaces of the anterior maxillary teeth – HOWEVER IT IS NOT IN ITSELF DIAGNOSTIC OF BULIMIA. No characteristic caries pattern is observed, however the margins of existing restorations may appear "proud." Patients may report thermal sensitivity, chipping of incisal surfaces, anterior open bite, and compensatory over eruption of opposing teeth (loss of vertical dimension). In common with all eating disorders, secrecy and denial are hallmarks. Additional significant clinical findings needed to support a diagnosis of *Bulimia nervosa* include calluses on the dorsum of the dominant hand (due to repeatedly pushing fingers

down the throat to induce vomiting – the so-called Russell's or Crisp's sign), salivary gland enlargement (especially involving the parotid glands) and reports of frequent sore throats.

The ability to identify early changes in oral soft and hard tissue associated with eating disorders places the trained dental professional in a unique position to identify and manage the resulting oral lesions. Perhaps even more importantly, this allows them to refer the patient to the multidisciplinary team of psychiatrists, nutritionists, and other professionals required to successfully treat patients with these potentially fatal disorders.

A dental history should include an index for the longitudinal assessment of the progression and severity of hard tissue lesions. Many indices have been proposed over time, however for an index to be effective it must allow objective assessment of both the extent and severity of the lesion, be easy to use and reproduce, have been scientifically validated and, most importantly, must be sensitive enough to detect changes in the lesions over time for longitudinal assessment. Erosion Indices will be discussed in detail later in this presentation.

A careful review of oral hygiene practices is also necessary since vigorous horizontal tooth brushing may result in severe abrasion that is markedly enhanced by the coexistence of erosion. Dental treatment planning must be directed towards both managing existing erosion lesions and preventing further damage to oral tissues in a proven and effective manner. However, comprehensive cosmetic restorative dental care will have the best prognosis if it is performed after psychiatric management has terminated the destructive behaviors. In this way the dental practitioner becomes critical to the recovery and long-term management of the eating-disorder patient.

### **Other Medical Conditions Associated With Erosion**

Other conditions such as Gastroesophageal Reflux Disease (GERd), alcoholism, Sjogren's syndrome and prior radiation to head and neck region should first be ruled out in attempting a differential diagnosis of erosion resulting from self-induced vomiting.

Gastroesophageal reflux disease (GERd) was first described in the literature in 1933. This is a condition where stomach contents (food and gastric acid) frequently "regurgitate" into the esophagus and may subsequently pass into the oral cavity. Several mechanisms have been proposed to explain this condition including transient spontaneous or inappropriate relaxations of the sphincter, transient increase in intra-abdominal or intragastric pressure, or a functional abnormality of the lower oesophageal sphincter. A preliminary diagnosis can be made on the basis of clinical signs and symptoms (heartburn, retrosternal discomfort, epigastric pain, dysphagia and odynophagia - pain on swallowing), however a definitive diagnosis may require confirmation of an esophageal pH of less than four for >5% of a 24 hour period by ambulatory pH monitoring, or by endoscopy. Some refluxers can be "silent" with no clinical symptoms of disease other than dental erosion so establishing a correct diagnosis in these patients may literally change their lives. Management of GERd includes lifestyle modifications and pharmacologic therapy, while refractory disease requires surgery. If the GERd is nocturnal, dental erosion can be controlled by the use of a mouthguard containing a sodium bicarbonate paste.

The symptoms of GERd are different in children and can often present a diagnostic challenge. Many parents report that children with this condition experience pain, irritability, constant or sudden crying, frequent spitting-up or vomiting more than one hour after eating and not outgrowing the spitting-up stage. They also frequently report that pediatric GERd

patients have poor sleep habits with frequent waking episodes, have an intolerance of certain foods, demonstrate poor weight gain or even weight loss, have swallowing, gagging or choking problems; respiratory and ear problems, bad breath and of course, tooth enamel erosion. It has been found that neurologically impaired children have significantly higher levels of gastro-oesophageal reflux than "healthy" children. Unlike tooth decay, erosion typically causes lesions that are wide and shallow.

### **Illegal Drug Use**

Use of the club drug Ecstasy (3,4-methylenedioxymethamphetamine or MDMA) has been linked to cases of dental erosion. The use of this drug among young adolescents in the US is alarming with 3.0% of 12th graders, 2.6% of 10th graders, and 1.7% of 8th graders having used *Ecstasy* in the past year (2005 *Monitoring the Future* survey). In a recently reported study, xerostomia was reported by 93% of Ecstasy users while 89% stated that they clenched or ground their teeth after taking the drug. Acidic soft drinks were consumed by 93% of the users with a mean of three cans per "trip," presumably in response to the dehydration brought on by the increased physical activity this drug promotes.

Street methamphetamine is referred to by many names, such as "speed," "meth," and "chalk." Methamphetamine hydrochloride, clear chunky crystals resembling ice, which can be inhaled by smoking, is referred to as "ice," "crystal," "glass," and "tina." According to the 2004 National Survey on Drug Use and Health (NSDUH) 11.7 million Americans age 12 and older had tried methamphetamine at least once in their lifetimes (5.2% of the population), with the majority of past-year users between 18 and 34 years of age. Methamphetamines are taken orally or intranasally (snorting the powder), by intravenous injection, or by smoking.

Dental erosion is also known to be a hazard of methamphetamine manufacturing. The primary compound used is anhydrous ammonia, but the process includes other very corrosive substances, such as red phosphorus, lithium from batteries, and muriatic acid. Oral and intranasal use of methamphetamine cause enamel problems because the substance drains into the posterior nasal pharynx, then to the back of the throat and bathes the teeth with corrosive substances. Extensive erosive enamel in relatively young people should raise the question of whether methamphetamine manufacture or use is contributory. The observed syndrome known as "meth mouth" includes rampant tooth decay attributed to lack of a user's concern about oral hygiene combined with drug induced dry mouth, teeth grinding and a craving for carbohydrates and sweets. Methamphetamine abuse is also associated with a greatly increased prevalence of bruxism.

### **Chlorinated Swimming Pools**

Erosion lesions were first reported in swimmers as early as 1982 in association with frequent swimming in chlorinated swimming pools. On closer investigation, studies suggest that in many instances this was associated with incidents involving over-chlorination. Swimming athletes might benefit from the use of a personal mouth guard with sodium bicarbonate or fluoride rinsing after swimming.

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## Other Causes of Tooth Structure Loss

### **Introduction**

In addition to erosion, there are other forms of non-caries destructive processes that result in a loss of tooth structure. These processes include *abrasion*, *attrition*, *bruxism* and *resorption*. Destruction of tooth structure is almost never caused by a single process, as they often co-exist.

### **Abrasion**

*Abrasion* is the process of wearing down or rubbing away by means of friction. Dentally this usually occurs as a result of scrupulous or even compulsive oral hygiene practices. It is commonly seen in eating disorders, and is particularly harmful if the enamel is already compromised by erosion. *Abrasion* lesions are usually found first on the labial surfaces on the maxillary canine and premolar teeth; however it can progress to involve the labial surfaces of all the teeth. Lesions tend to be broad based and shallow, involving the gingival portion of the labial and facial surfaces. In these cases advise correct brushing and flossing with a fluoride dentifrice (but not immediately following purging), using a soft brush and low or non-abrasive paste.

### **Attrition**

Dental *attrition* is wear produced by tooth-on-tooth contact between neighboring teeth and opposing teeth, and produces wear facets on the occlusal surface or at the contact points between teeth. Tooth wear occurs as a result of normal function, however *bruxism* can greatly enhance this wear due greater forces being employed over longer periods of time. *Attrition* will be accelerated where the tooth structure has already been compromised by erosion.

There are also non-masticatory behaviors that can be associated with specific patterns of dental wear. These behaviors must be practiced repeatedly over a long period of time to leave permanent marks on the teeth. A commonly seen example of such wear is the notching of the labial edges of incisor teeth in individuals who routinely use their teeth to cut lengths of sewing thread. Cultural practices may sometimes affect the appearance of teeth. The use of labrets (an ornament worn in a perforation of the lip) among Alaskan and Pacific Northwest natives is indicated by polished or worn labial and buccal surfaces. Dental mutilation is practiced by many different ethnic groups and may involve the removal of one or more teeth, removal of parts of specific teeth through filling or chipping, or modification of crown surfaces through distinctive incising and drilling often involving the upper incisors and signifying development of maturity.

The clinical appearance that suggests attrition includes matching wear on occluding surfaces; the appearance of shiny facets on amalgam contacts and fracture of cusps or restorations.

## **Bruxism**

A major cause of tooth loss by attrition is by dental parafunction, the most common being *bruxism*. It is thought to affect 55-95% of adults and 15% of children. Although it may be *nocturnal* and/or *diurnal*, both manifestations entail forceful contact between the biting surfaces of mandibular and maxillary dentitions. When the teeth are brought together in grinding and tapping, the contact involves movements of the lower jaw and unpleasant sounds which can often awaken others. Chewing delivers a force of about 175 pounds per square inch (psi) to posterior teeth. With *bruxism* the force can be in excess of 300 psi (since there is no food to absorb force). In children *bruxism* may suggest the existence of systemic factors such as intestinal parasites (i.e. pinworms), anal pruritis, nutritional deficiencies, allergies, or endocrine disorders. It may be more common in Down's syndrome and children with AD/HD. Many therapies have been tried including exercise, drugs, splints, wakeful EMG and equilibration therapy (occlusal adjustment), however these rarely work. Stress reduction works but may be hard to achieve. Fortunately, *bruxism* in children usually resolves spontaneously. In one study, for example, 126 children between the ages of 6 and 9 were diagnosed with *bruxism*. Five years later, upon re-examination, only 17 children retained the bruxing habit.

*Bruxism* can coexist with erosion, but the lesions are only related on occluding surfaces, where *bruxism* will enhance the loss of tooth structure if it has already been compromised by erosion.

## **Resorption**

This refers to the biological breakdown of tissue previously synthesized by the body. In the dental context may be seen when there has been a breakdown of cement or dentin by cementoclasts. These lesions may appear supragingivally following a loss of gingival attachment. Therefore, resorption should be considered in a differential diagnosis of possible erosion lesions of the dental root surface.

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## Clinical Signs and Symptoms of Erosion

### **Mild Erosion**

In its early stages, erosion is characterized by a loss of enamel surface characteristics (lines and ridges) leading to a “polished” appearance, the development of opacities and or white spots, and the thinning of the enamel exposing the dentin color. It is not usually associated with pain or sensitivity, and frequently first diagnosed at routine dental exam (Figure 1.).



**Figure 1 - Mild to moderate erosion demonstrating a loss of occlusal enamel on the first permanent molar and a generalized thinning of the facial enamel.**

(Image generously provided by: **Dr. F. Thomas McIver**, Professor of Pediatric Dentistry, School of Dentistry, UNC Chapel Hill.)

### **Moderate Erosion**

This stage is characterized by a flattening of the bicuspid and molar cusps with a consequent loss of vertical dimension. There may be a progression of existing cervical lesions and cupping and/or grooves of the occlusal surfaces. The tooth may appear translucent due to the general thinning of the enamel. If the dentin is exposed it will be associated with increased sensitivity or pain (Figure 2.).

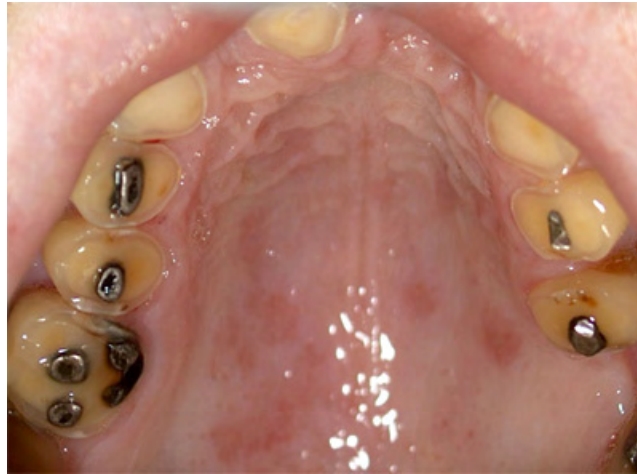


**Figure 2 - Moderate erosion with “cupping” of the occlusal surface and thinning of the occlusal enamel.**

(Image generously provided by: **Dr. F. Thomas McIver**, Professor of Pediatric Dentistry, School of Dentistry, UNC Chapel Hill.)

### **Advanced Erosion**

By this advanced stage the loss of enamel has been so great that existing restorations appear to stand “proud” of the surrounding tooth structure (Figure 3.). The amalgam restorations commonly appear “clean” and untarnished, and even when the enamel loss is widespread (Figure 4.) the preservation of enamel "cuff" in the gingival crevice is common. If the erosion progresses slowly there will be time for deposition of tertiary dentin causing a narrowing of pulp chamber. If the process is rapidly progressing it may result in exposure of the pulp through thinned occlusal enamel.



**Figure 3 - Advanced erosion demonstrating severe palatal tissue loss and amalgam restorations standing “proud” of exposed surface.**



**Figure 4 - Advanced erosion with severe occlusal tissue loss and “polished” amalgam restorations.**

(Images generously provided by: **Dr. F. Thomas McIver**, Professor of Pediatric Dentistry, School of Dentistry, UNC Chapel Hill.)

## Host Modifying Factors

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The most important host modifying factors that influence the extent and severity of the erosion lesions that develop in an individual are salivary flow rates and composition, tooth structure and dental anatomy and occlusion.

Of these factors saliva is undoubtedly the most important, with many different protective functions including dilution and oral clearance; formation of the acquired pellicle by the adsorption of salivary proteins and glycoproteins, which have the ability to protect the enamel surface from demineralization; buffering of dietary acids; and maintenance of a calcium and phosphate supersaturated solution on the tooth that is necessary for remineralization. As the flow rate increases so does the level of bicarbonate ion (necessary for the buffering of dietary acids). Little erosion is seen to occur where there is pooling of saliva (such as in the lower incisor region).

Several drugs currently have earned US FDA approval for the treatment of low saliva production (*xerostomia*) including *Salagen* (pilocarpine hydrochloride) (MGI Pharma Inc.); *Evoxac* (cevimeline hydrochloride) (Daiichi pharmaceuticals) and *Ethyol* (amifostine) which is indicated to reduce the incidence of moderate to severe xerostomia in patients undergoing post-operative radiation treatment for head and neck cancer. These MAY have applications in the future for the prevention or control of erosion (especially cases of idiopathic erosion) but are not yet recommended in its management. Chewing sugar-free gum will stimulate salivary flow and may offer some protection to enamel particularly after self-induced vomiting episodes. However, since chewing gum may cause increased gastric secretions it should not be suggested for those with a history of gastric reflux. Also, if a patient with dental erosion is taking medications known to cause xerostomia, it might be prudent to ask their physician to try to seek alternatives that are not associated with this unwanted side effect.

Although it appears likely that decreased salivary flow rates and buffering capacity can contribute to dental erosion the importance of qualitative differences in saliva is less clearly understood, especially in relation to destruction of enamel by erosion.

## The Use of an Erosion Index and the Monitoring of Erosion in the Dental Office

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In adults, a rapid diagnosis of erosion is often difficult to make, as it may be hard to distinguish between erosion, abrasion and attrition. Frequently one condition exacerbates the other.

The *Smith and Knight [1984] Tooth Wear Index* is a standard epidemiological index that uses loss of tooth tissue (measured in mm), and the presence of secondary dentine as guides to the amount of tooth surface loss.

The index specifically designed for measuring erosion in children was developed by O'Brien (1994) and used in the UK Child Dental Health Survey of 1993. This index assesses area and depth of enamel and dentin loss of maxillary incisor teeth only. It was designed for use in epidemiological data collection and so had to be easily mastered. The differences in the assessed grades are gross however, measuring loss of enamel, and associated exposed dentin or exposed pulp and not allowing for accurate determination of the more subtle changes that may need to be followed over time in an individual patient. Further, it does not allow for examination of posterior teeth or of the lower arch.

In the dental office the best way to monitor the progression of erosion in adults and children alike is to make serial study casts of the dentition at recall visits. Since erosion tends to be cyclic in nature, demonstrating periods of active tooth destruction followed by periods of inactivity it may be necessary to monitor a patient's condition over many years to accurately determine the disease progression.

## Management and Treatment of Erosion

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The most important rules in the management and treatment of erosion are:

- Treat the pain
- Treat the causative condition (this may require referral to a physician)
- Apply preventative strategies to prevent the worsening of erosion lesions
- Monitor the progression of tooth wear with study casts and photographs
- Consider provisional or temporary treatment until the erosion is controlled and stabilized
- Perform definitive restorative treatment

## Preventive and Provisional Care

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Advise patients not to brush their teeth immediately after drinking an acid drink, after self-induced vomiting or after a reflux episode. This is the time when the enamel is weakened and therefore most vulnerable to abrasion. Instead, following episodes of demineralization, what is needed is a way to drive the precipitation/dissolution equation to the left (encouraging precipitation). One way to encourage this is to chew sugar-free chewing gum thus providing calcium and phosphate ions from the stimulated saliva to remineralize the demineralized enamel. Other ways to accomplish remineralization include rinsing with antacid (sugar free with sodium bicarbonate) or milk.

Remineralization in the presence of high fluoride is even more desirable. Recommend that the patient uses a topical fluorides rinse, not acidulated phosphate fluoride gels (low pH) or 0.4% Stannous Fluoride in methylcellulose and glycerin base (it stains). In patients with a history of coexisting *bruxism* and *erosion*, nocturnal mouthguards to treat the *bruxism* can be used as fluoride carriers for neutral sodium fluoride gels. Duraphat fluoride varnish may also be useful but data on this product in the management of erosion lesions is limited.

Always recommend that patients with erosion lesions use only a low abrasion or non-abrasive dentifrice. In cases of slight to mild hypersensitivity, desensitizing toothpastes containing either strontium (chloride or acetate) or potassium (chloride or nitrate) may be useful. The mode of action of these agents remains unclear and studies have reported conflicting results when comparing their efficacy to that of control toothpastes.

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# Restorative Treatment of Erosion Lesions

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## **Introduction**

Consider restorative treatment if the structural integrity of the tooth is threatened or to restore loss of vertical dimension; where there is a risk of tooth fracture; to relieve hypersensitivity; to avoid pulpal exposure and to improve esthetics (main patient complaints).

Preferred treatment is dependent on the location and extent of erosion and should aim to protect the remaining tooth structure, stabilize the occlusion and control symptoms.

## **Treatment of Permanent Teeth**

In adults restorative definitive treatment can be accomplished using dentin bonding agents; glass ionomers or compomers; micro-filled composite resins or in cases of more extensive destruction, porcelain coverage and veneers or full coronal coverage to protect occlusion and maintain the vertical dimension.

### **Dentin bonding agents**

Semi-filled (around 50%) or nanofilled adhesive resins can be used by “direct” application to cover sensitive, exposed dentin. Although the thickness of the remaining smear layer does not appear to affect bond strength and they have a durable, wear-resistant coat retained by resin tags, they do not permit re-contouring of the eroded area. The latest type of bonding products have been single-solution agents (when applied to tooth) (etching, priming, bonding/sealing).

### **Nanotechnology**

Manufacturers claim that the filler particles in nanofilled resins can penetrate into the demineralized dentin and contribute to formation of the hybrid layer. Another purported advantage of their small size is that they do not contribute significantly to the adhesive's film thickness. Since the particles are smaller than the wavelength of visible light they result in greatly improved esthetics. Nanofilled composite resins have 20-75nm nanoclusters of filler (compare to 0.4-0.6microns for average microfilled). Fluoride releasing nanofilled bonding agents are available but have been found to be less effective on unground, unprepared, or uncut tooth surfaces.

### **Glass Ionomer/Compomer**

These are especially effective in cervical lesions where they are not subject to occlusal stress. The release of fluoride ions may help prevent recurrent caries. They demonstrate less polymerization shrinkage and subsequently less micro-leakage than traditional composite restorations. However, they are vulnerable to dissolution, resulting in increased wear and progressive loss of material. Although this may not be a factor in posterior teeth, they have poor esthetics compared to composite.

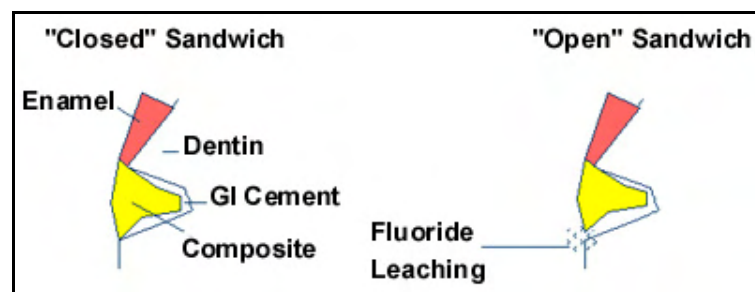
## Composite Resin

The conservative placement of plastic restorative materials in erosion lesions that will not be susceptible to high loads have excellent retention rates. Also composite resins are recommended when there is significant loss of tissue and a demand for excellent esthetics. Other than placing a bevel in the enamel margin with a flame shaped diamond bur, it requires little additional tooth structure to be removed, however its placement must be preceded with the use of a primer and a good dentin bonding agent. Composite resin offers the best color match (especially when used in bulk) and can be effectively used to mask stained, exposed dentin. Composites also demonstrate the highest resistance to microleakage and the highest chemical and microchemical adhesion to tooth enamel of any of the direct restorative materials however, deep, sclerotic lesions (++ peritubular dentin) require longer etch times than normal and result in less resin tag penetration.

Lesions involving the incisal aspect of the upper anterior teeth can be restored with composite resin and a more durable, stronger material such as yellow gold and nickel-chromium alloy used to restore the palatal surfaces.

## Composite Sandwich Technique

This technique is most useful when good esthetics (e.g. class V lesions) and fluoride release are required, and involves a glass ionomer cement "sandwiched" between the deepest portion of the lesion and a composite resin veneer. (Figure 5.). The difference between the "closed" and "open" sandwich techniques is that in the latter, the glass ionomer is exposed on one surface to the exterior and thus allows the leaching of fluoride ion. In the "closed" sandwich the glass ionomer is entirely covered by the composite resin so preventing surface leaching of fluoride.



**Figure 5 - The "Closed" and "Open" Sandwich Techniques**

Because of the cost and complexity of the remaining procedures, they should not be undertaken in any patient to treat erosion lesions unless the cause of erosion has been identified and addressed and the progression of the lesions has been stabilized.

## Veneers

Veneers can be composite or porcelain. Composite veneers may be placed in adolescents while waiting for complete tooth eruption. Porcelain should be used for the definitive restoration due to better esthetics and durability. Veneers can be used to replace significant

lost tooth facial surfaces, however, they are expensive, and not for upper palatal surfaces where metal coverage must be used. Palatal coverage can be problematic if there has been a significant loss of vertical space.

### Crowns and Other Fixed Partial Dentures

For permanent restoration of extensive defects; in cases of widespread perimolysis, or if there is a need to replace lost vertical dimension, gold overlays; partial or full coverage crowns or more extensive fixed partial dentures are preferred if there is a need for antagonistic occlusal reconstruction. If simultaneous treatment of both arches is required an occlusal analysis is necessary especially if using porcelain on the occlusal surfaces.

Prefabricated stainless steel crowns are an acceptable treatment in the permanent dentition as a temporary means of providing coverage to vulnerable surfaces until the erosion process is stabilized and permanent treatment can be rendered.

### Dental Implants

In patients where advanced erosion has left no recourse to extraction, tooth replacement with implants can be the best option for definitive treatment. The success of implants however depends upon the medical condition of the patient, the quality and quantity of the maxillary and/or mandibular bone, occlusion, number of units to be replaced and the proximity of the tooth to nerves and sinuses. Implants can be used to replace individual missing teeth or to replace multiple missing units. Alternatively they can function as supports for partial or full dentures.

### **Treatment of Primary Teeth**

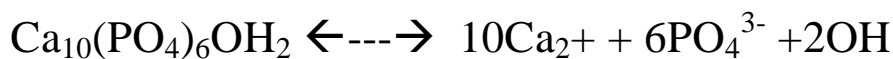
Treatment of erosion in the deciduous dentition is limited to glass ionomer cements, stainless steel crowns and, in the final instance, extractions. Glass ionomer cements can be useful for smaller lesions (especially if affecting the smooth surfaces of the teeth) and have the additional benefit of continued fluoride release. If the teeth become symptomatic, prefabricated stainless steel crowns may be the most appropriate management, or indeed they may be extracted. Because it is harder to achieve good enamel bonding in primary teeth (and considering the size, shape and depth of the erosion lesions and regions of the tooth where they occur) dentin bonding agents and composites restorations are rarely the treatment of choice.

1. Erosion occurs when the intraoral pH drops below 5.5 “ the Critical pH”
2. It is a microbiologically sterile process
3. The early signs of erosion are often difficult to diagnose
4. Definitive diagnosis may require long-term monitoring the progression of tooth wear with study casts and photographs
5. The causative condition must be treated before definitive dental restoration rendered
6. The number of children and adults with dental erosion presents a clinical challenge to the dental practitioner
7. Whether changes in risk factors such as altered eating patterns, increased consumption of acidic foods and beverages and various gastrointestinal and eating disorders factors are indeed resulting in a higher prevalence and incidence (on a population scale), of dental erosion or just better diagnosis has yet to be confirmed.

Please mark only one **best** answer to the following questions on the one page answer sheet. Return the answers by mailing or faxing the answer sheet or entering your answers on the form available on our website at <http://www.fice.com/>.

This test contains 15 questions. Please mark your answers in spaces numbered 1 through 15 on your answer sheet.

1. Which of the following techniques not \_\_\_ considered appropriate management for patients with erosion?
  - A. Advise patients not to brush their teeth immediately after drinking an acid drink, after self-induced vomiting or after a reflux episode
  - B. Encourage the use of sugar-free chewing gum
  - C. Advise rinsing with antacid
  - D. Advise brushing with 0.4% Stannous Fluoride in methylcellulose and glycerin base
  - E. Advise rinsing with milk
  
2. Which of the following statements are true?
  - A. Erosion results from demineralization by *Strep viridans*
  - B. Erosion is a microbiologically sterile process
  - C. Erosion causes bruxism, abrasion and attrition
  - D. Erosion is a disease of enamel dissolution that cannot occur in the absence of fermentable carbohydrates
  - A. Only statement A is true
  - B. Only statement B is true
  - C. Only statement C is true
  - D. Only statement D is true
  - E. None of the above statements are true
  
3. Which of the following is true in regard to the following equation?



- A. At low pH a higher concentration of ions is needed in the liquid phase surrounding crystallites to maintain saturation and so the driving force is towards dissolution.
- B. At low pH a lower concentration of ions is needed in the liquid phase to maintain saturation which leads to precipitation.
- C. At high pH this equation is in balance, with dissolution (to the right side of equation) occurring at the same rate as precipitation (to the left side of equation).

4. Which of the following are not true statements regarding the use of dentin bonding agents to treat erosion lesions?
- A. Dentin bonding agents can be used to cover sensitive, exposed dentin.
  - B. Dentin bonding agents do not permit re-contouring of the eroded area.
  - C. Dentin bonding agents that are nanofilled resins can penetrate into the demineralized dentin and contribute to formation of the hybrid layer.
  - D. The particles of nanofilled resins are smaller than the wavelength of visible light they result in greatly improved esthetics.
  - E. Fluoride releasing nanofilled bonding agents are more effective on unprepared tooth surfaces than non-fluoride releasing resins.
5. Which stage of erosion is characterized by flattening of the bicuspid and molar cusps with a consequent loss of vertical dimension and increased sensitivity or pain?
- A. Mild erosion
  - B. Moderate erosion
  - C. Advanced erosion
6. Which of the following is not considered a protective function of saliva?
- A. Dilution and oral clearance
  - B. Formation of the acquired pellicle by the adsorption of salivary proteins and glycoproteins
  - C. Supply of carbonate ions for enamel maturation
  - D. Buffering of dietary acids
  - E. Maintenance of a calcium and phosphate supersaturated solution on the tooth
7. What is the preferred order of procedures in the management and treatment of erosion?
- A. Monitor the progression of tooth wear with study casts and photographs, treat the pain, treat the causative condition
  - B. Treat the pain, treat the causative condition and apply preventative strategies
  - C. Perform definitive restorative treatment, monitor the progression of tooth wear with study casts and photographs
  - D. Consider provisional or temporary treatment until the erosion is controlled and stabilized, treat the pain
8. The success of implants to restore the dentition where advanced erosion has left no recourse to extraction, is not dependent upon...
- A. The medical condition of the patient
  - B. The quality and quantity of the maxillary and/or mandibular bone
  - C. The occlusion
  - D. Patient gender
  - E. The patient anatomy in particular, the proximity of the tooth to nerves and sinuses

9. Additional significant clinical findings in which condition include Russell's or Crisp's sign), salivary gland enlargement (especially involving the parotid glands) and reports of frequent sore throats?
- A. *Anorexia nervosa*
  - B. GERd
  - C. Illegal drug use
  - D. *Bulimia nervosa*
  - E. Bruxism
10. Which of the following is true regarding the restoration of teeth with advanced erosion?
- A. Stainless steel crowns can be used as a temporary means of providing until the erosion process is stabilized.
  - B. Where there is widespread perimolysis, lost vertical dimension should not be restored
  - C. Stainless steel crowns are preferred where there is a need for antagonistic occlusal reconstruction.
  - D. Stainless steel crowns can routinely be used in the treatment in the permanent dentition when cost prohibits the use of gold coverage.
  - E. Stainless steel crowns can only used to restore primary teeth.
11. Which of the following is not considered a high risk factor for the development of tooth erosion?
- A. Self-induced vomiting
  - B. GERd
  - C. Illegal drug use (especially amphetamines)
  - D. Bruxism
  - E. Sucking lemons
12. Which of the following is not a major factor to be considered in the treatment of *bruxism* in children?
- A. Treatment of intestinal parasites
  - B. Treatment of nutritional deficiencies
  - C. Treatment with occlusal splints
  - D. Treatment of allergies
  - E. Treatment of endocrine disorders

13. Which of the following statements are untrue regarding tooth erosion and *Bulimia nervosa*?

- A. *Bulimia nervosa* is more common than *Anorexia nervosa*
- B. Perimyololysis is caused by chemical and mechanical effects of regurgitated gastric contents and is characteristically seen on the lingual surfaces of the anterior maxillary teeth
- C. Perimyololysis is diagnostic in itself of *Bulimia nervosa*
- D. Patients may report thermal sensitivity, chipping of incisal surfaces, anterior open bite
- E. Patients often deny that they are suffering from *Bulimia nervosa*.

14. Which of the following statements regarding soft drinks are untrue?

- A. The three most common acids in soft drinks are phosphoric acid, citric acid and malic acid.
- B. Phosphoric acid (0.0055 M) has a pH of around 2.5
- C. The acids used as additives in soft drinks are weak acids in comparison with the organic acids produced by oral bacteria
- D. "Diet" drinks have similar pH values to non-diet drinks
- E. Dilution of fruit drinks has not been shown to decrease their erosive potential

15. The pathogenesis of dental erosion is considered to be multifactorial. Which of the following factors do not play an integral role in the development of erosion?

- A. The critical pH of enamel (5.5)
- B. Diet
- C. Frequency of low pH events
- D. Patient age
- E. Host modifying factors