International Journal of Applied Dental Sciences 2019; 5(2): 28-36

ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2019; 5(2): 28-36

www.oraljournal.com
Received: 13-02-2019
Accepted: 16-03-2019

Dr. B Santhiya
Post Graduate, Department of Public Health Dentistry, Government Dental College and Research Institute, Bangalore, Karnataka, India

Dr. Manjunath P Puranik
Professor and Head, Department of Public Health Dentistry, Government Dental College and Research Institute, Bangalore, Karnataka, India

Dr. Uma SR
Assistant professor, Department of Public Health Dentistry, Government Dental College and Research Institute, Bangalore, Karnataka, India

Correspondence
Dr. B Santhiya
Post Graduate, Department of Public Health Dentistry, Government Dental College and Research Institute, Bangalore, Karnataka, India

Risk factors, assessment and management of dental erosion in dental setting- A literature review

Dr. B Santhiya, Dr. Manjunath P Puranik and Dr. Uma SR

Abstract
The purpose of this review was to provide insight into risk factors and risk assessment of dental erosion and suggest appropriate preventive measures in dental practice. Literature search of eligible articles in English language published before 18th February 2018, was carried out to include all the old and recent published articles in various on-line databases such as PubMed, Medline, Google scholar, Scopus, Wiley Science Library using appropriate keywords (dental erosion, risk factors, risk assessment, prevention). Total of 625 articles were retrieved. All the eligible articles relevant to this present study were reviewed and compiled. As there is a change in lifestyle, the total amount and frequency of consumption of acidic foods and drinks have also changed leading to increase in dental erosion. There are different predisposing factors and aetiologies to this erosive condition. The interplay of chemical, biological and behavioral factors is crucial and helps explain why some individuals exhibit more erosion than others, even if they are exposed to the same acid challenge in their diets. Hence comprehensive knowledge of the different risk factors is a prerequisite to initiate adequate preventive (non-interventive) and, if necessary, therapeutic (interventive) measures.

Keywords: dental erosion, prevention, risk factors, risk assessment

1. Introduction
Tooth wear is a common problem but most often left untreated [1]. Tooth wear is the loss of dental hard tissue, due to various forms of physical and chemical impacts not involving bacteria and excluding trauma [2].
Wear is, strictly speaking, intentional or unintentional attrition or abrasion and is caused by human activity. Unintentional modifications include dietary, parafunctional, occupational, traumatic, and habitual dental marks, as well as erosion. Intentional modifications include deliberate extractions, fillings, decorations and early dentistry [3].
The presence of tooth wear might become more noticeable nowadays and in future, due to the current substantial decline in dental caries. This occurrence could be due to increased dental awareness and people becoming more interested in keeping their dentition healthy for a longer time which could be exposed to wear [1].
Erosive tooth wear, has for many years been a condition of little interest to clinical dental practice or dental public health. There are different predisposing factors and aetiologies to this erosive condition [4].
As there is a change in lifestyle, high consumption of acidic foods and drinks have also changed, and an apparent increase in prevalence of various gastro-intestinal diseases, and especially eating disorders leading to increase in dental erosion [5].
This overview provides insight into etymology, epidemiology, classification, etiology, mechanism of dental erosion, clinical features, diagnosis, risk factors and its assessment and management and prevention of dental erosion.

2. Methodology
Literature search of eligible articles in English language published before 18th February 2018, was carried out to include all the old and recent published articles in various on-line databases such as PubMed, Medline, Google scholar, Scopus, Wiley Science Library using appropriate keywords (dental erosion, risk factors, risk assessment, prevention). Total of 625 articles were retrieved. All the eligible articles relevant to this present study were reviewed and compiled.

3. Etymology

Erosion is derived from the Latin verb *erodere, erosi. erosum* (to gnaw, to corrode), describes the process of gradual destruction of the surface of something usually by electrolytic or chemical processes. The clinical term dental erosion or *erosiodentium*is used to describe the physical result of a pathologic, chronic, localized, painless loss of dental hard tissue, chemically etched away from the tooth surface by acid and/or chelation without bacterial involvement [6].

4. Definitions

The pathologic chronic loss of dental hard tissues due to the chemical influence of extrinsic and intrinsic acids without bacterial involvement [6].

Progressive and irreversible loss of dental hard tissue caused by a chemical process of acid dissolution that does not involve bacteria [2].

Irreversible loss of dental hard tissue by a chemical process that does not involve bacteria [7].

Progressive loss of calcified dental tissue by chemical processes not associated with bacterial action [8].

5. Epidemiology

In anthropology and archaeology, it has been assumed for several decades that teeth provide interesting material for observation. Tooth wear is of particular interest in the study of relationships between man, his environment and his pattern of subsistence [9].

As lifestyles have changed through the decades, the total amount and frequency of consumption of acidic foods and drinks have also changed. Soft drink consumption in the USA increased by 300% in 20 years, and serving sizes increased from 185g in the 1950s to 340g in the 1960s and to 570g in the late 1990s. Around the year 1995, between 56 and 85% of children at school in the USA consumed at least one soft drink daily with the highest amounts ingested by adolescent males. There is some evidence that the presence of dental erosion is growing steadily [10].

Additionally, a growing interest in dental erosion among dental practitioners gives the impression that the prevalence of erosive dental defects is increasing [6].

Hence, erosive tooth wear is becoming increasingly significant in the management of the long-term health of the dentition [10].

Reports have published the high incidence of dental erosion related to frequent consumption of highly acidic beverages, sucking or chewing of highly acidic fruit-flavoured sweets and gums, and other culturally influenced diets [8]. Scientific interest in dental erosion has considerably increased in recent years [6].

Erosion was first included in the UK children's' dental health survey in 1993 and is repeated periodically. The prevalence of erosion was seen to have increased from the time of the children's dental health survey in 1993 to the study of 4- to 18-year-olds in 1996/1997.[11] European studies reported 50% prevalence of dental erosion in preschool children, 24- 60% in school aged children, 82% in 18- 88 years [12].

The median prevalence of dental erosion is 34.1 percent of children (interquartile range 27.4) and 31.8 percent of adults (interquartile range 18.7). In studies that reported prevalence of dental erosion in different age groups, there is a clear trend of increasing prevalence with age in children and adults [13].

Dental erosion has been considered a common condition limited to developed countries [13]. Even if the prevalence rates vary substantially, it is evident that dental erosion is a common finding in populations from all over the world, especially among children and adolescents [14].

Countries have reported varied prevalence of dental erosion in various age groups [14]

1. 1.5-7 years- Saudi Arabia (34%), UK (8 -30%), India (30%), Ireland (21%), Germany and Sweden (13%) and china (1%) [14].
2. 11-19 years- UK (2-53%), Saudi Arabia (16-26%), Sweden (12-22%), Iceland (1-6%), Turkey (28%) [14].
3. 22-50 years- UK (77%), Switzerland (11-19%) [14]

There was a trend towards a higher prevalence of erosion in children aged between 3.5 and 4.5 years, and in those who consumed carbonated drinks on most days, compared with toddlers consuming these drinks less often [10]. The progression of erosion seems to be greater in older adults (52–56 years) compared to younger (32–36 years) and has a skewed distribution. The group with high erosion progression was found to have four or more dietary acid intakes per day, a low buffering capacity of their stimulated saliva and used a hard bristle toothbrush [13].

Prevalence data indicated that females (35.5%) had somewhat more erosive tooth wear than males (28.1%).[15] Girls had a higher frequency of consumption of fruits and succade than boys, while boys drank more sport drinks than girls with DE [16].

In the second half of the 20th century, incidence of eating disorders (ED) and GERD progressively increased. In many countries there is growing evidence of a considerable increase in consumption of potentially erosive drinks and increased prevalence of GERD. Prevalence of dental erosions in children (2-16years) with GERD was reported as 17-87% [17].

Studies found a median prevalence of 24% for tooth erosion in patients with gastro esophageal reflux disease (GERD) and a median prevalence of 32.5% for GERD in adult patients who had tooth erosion [18].

The prevalence of dental erosion is higher in bulimic patients than in non-bulimic controls. Dental erosion in bulimic patients is most likely associated with oral retention of regurgitated gastric contents [13].

Data from 13 analytical studies reported 34.1% of dental erosion associated with carbonated drinks, acidic fruit juices, confectionary, milk, yogurt [19].

Environmental and occupational factors may contribute to dental erosion in selected populations, including swimmers, workers in an environment with acidic industrial vapors and professional wine tasters [13]. As per literature battery, galvanizing and associated workers are at higher risk of dental erosion. There is limited data about the prevalence of dental erosion among competitive swimmers [15].

6. Nomenclature and classification of erosion

Since the early reports on tooth erosion published in 1892 by DARBY, in 1907 by MILLER and in 1923 by PICKERILL many differing nomenclatures and classifications have been used in the dental literature, describing erosive lesions of the teeth. Thus, nomenclature and classification were based on etiology, clinical severity, activity of progression and localization of erosion [6].

6.I. Classification based on etiology [6]

Tooth erosion is classified according to the anamnesis (case history taking). The acids producing tooth destruction may be of exogenous, endogenous or unknown origin.

a). Extrinsic erosion is the result of exogenous acids.

The two types of extrinsic erosion are Industrial, due to exposure of the teeth to atmospheric acids- e.g dynamite factory workers due to atmospheric exposure to sulfuric and nitric acids.
Dietary, due to demineralizing foods such as citrus fruits and acid beverages that have a pH between 2.0 and 3.5.

b). Intrinsic erosion is the result of endogenous acid. This is gastric acid contacting the teeth during recurrent vomiting, regurgitation or reflux or due to eating disorders of psychosomatic origin.

c). Idiopathic erosion is the result of acids of unknown origin, i.e. an erosion-like pathology where neither tests nor anamnesis are capable of providing an etiologic explanation [6].

6.2 Classification based on clinical severity [20]
Class I- Superficial lesions-involving enamel only
Class II- Localized lesions-involving dentin for less than one third of the surface.
Class III- Generalized lesions-involving dentin for more than one third of the surface
a. Facial surfaces
b. Lingual and palatal surfaces
c. Incisal and occlusal surfaces
d. Severe multi surface involvement [20].

6.3 Classification based on pathogenic activity [6]
Mannerberg distinguished two types of erosion according to activity, namely

Manifest erosion - i.e. an actively progressing erosion, is clinically diagnosed by its enamel border zones. These are thin where they meet the exposed dentin.

Latent or inactive erosion - which, through a change in the etiologic factor, are no longer subject to further decalcification, have prominent thick enamel borders.

6.4 Localization of erosion – Perimolysis [6]
Chronic regurgitation, often leads to a typical distribution of erosion within the dental arches and on the teeth. This clinical finding has been termed perimolysis or perimylolysis. Corresponding with the path of the regurgitated hydrochloric gastric acid over the dorsum of the tongue, along the palatal surfaces of the maxillary teeth, and over the occlusal surfaces into the mandibular vestibulum, perimolysis affects the maxillary and mandibular teeth in different ways. While affecting the palatal and occlusal surfaces of all teeth in the maxilla, the erosion is confined to the buccal and occlusal surfaces of premolars and molars only in the mandible [6].

7. Etiology
Dental erosion is multi factorial and includes the effect of exogenous material forced over tooth substances, the impact of tensile and compressive forces during tooth flexure, the action of opposing teeth, and the chemical dissolution of tooth mineral [2]
It has long been recognized that demineralization of dental enamel will occur once the oral environmental pH reaches the critical threshold of 5.5. Acids of bacterial origin cause caries, while extrinsic and intrinsic acids cause dental erosion [13].
A multitude of factors may modify the erosion process, such as saliva, oral hygiene practices, and presence or absence of fluoride. Also, the salivary pellicle does protect the teeth from erosion, the thickness of acquired salivary pellicle varies within the dental arches, which may also be responsible for the site-specificity of dental erosion [21].
Erosions advancing along with poor oral hygiene are often characterized by the presence of chalky spots and streak-shaped marks in the thin enamel surrounding the lesions [6].
Erosive lesions may also be aggravated by demastication, especially in lactovegetarian patients, by attrition of incisal edges and cusps or possibly by abfraction at the cementoenamel junction. A clinical *ex-postfacto* differential diagnosis between chemical and mechanical etiology is consequently often difficult, as the pathogenesis of any individual case may well be multifactorial [6].
Another link of erosion is the association with caries, more frequently observed since the increased usage of acid- and sugar-containing sport drinks during exercise and due to mouth breathing, there is less salivary clearance of acids and carbohydrates. In cases of true erosion, the tooth enamel is demineralized by direct contact with acids, while caries is a disease that occurs by the action of acids produced by plaque biofilm micro-organisms [6].

7.1 Causes of extrinsic erosion [13]
- Dietary citrus fruits
- Fruit juices
- Carbonated beverages
- Vinegar and pickles
- Medicines
- Ascorbic acid
- HCl replacement therapy
- Frequent acetylsalicylic acid use
- Some iron tonics, cough suppressant syrups, antiseptic mouth rinses.
- Occupational wine assessment
- Acid vapors (battery workshops)
- Recreational- improperly chlorinated large swimming pools.

7.2 Sources of extrinsic erosion [13]
Exogenous acids- Acidic beverages - Soft drinks, including carbonated beverages, fruit juices, wine and sport drinks, are almost exclusively acidic (pH<4.0) in nature in order to maintain a fresh and fizzy mouthfeel and to prevent rapid growth of bacteria. These beverages, when in contact with the tooth, will reduce the pH at the tooth surface to a level below the critical value of 5.5 for enamel demineralization.

Acidic foods and dietary ingredients- Apples, cranberry sauce, apricots, fruit jams/jellies, blueberries, Italian salad dressing, cherries, ketchup, grapes, mayonnaise, raspberries, fermented vegetables, strawberries, etc.

Other sources of exogenous acids- Acidic medications such as those containing vitamin C and aspirin may cause erosion when used in a manner resulting in sustained contact between tooth surfaces and the medication. Habitual use of mood-enhancing drugs such as ecstasy may also increase the risk for erosive tooth wear [13].

7.3 Causes of endogenous erosion [22]
- Anatomical defects e.g. hiatus hernia, deficient gastroesophageal sphincter, esophageal diverticulosis
- Psychological problems e.g. anorexia nervosa/ bulimia,

severe alcoholism, severe stress
- Medication for some severe health problems chemotherapy, severe asthma, or other drugs severely irritating the gastric mucosa
- Side effect of some cytostatic drugs
- Associated with peptic ulcer or uremia
- Prolonged nausea during pregnancy [22]
- Gastro-esophageal reflux disease (GERD), bulimia and rumination are the main conditions associated with the backflow of gastric juice to the mouth.[13]

7.4 Sources of intrinsic acids [13]

- The source of intrinsic acids in the oral cavity is mostly from the backflow of the gastric contents through the esophageal tract. Gastric juice consists mainly of hydrochloric acid, produced by the parietal cells in the stomach. The presence of the highly acidic gastric juice (pH 1.0-3.0) in the oral cavity may lead to dental erosion [13].

8. Mechanism of Action

When an acidic solution comes in contact with enamel, it has to diffuse first through the acquired pellicle, and only thereafter can it interact with enamel. The acquired pellicle is an organic film, free of bacteria, covering oral hard and soft tissues. On the surface of enamel, the hydrogen ion component of the acid will start to dissolve the enamel crystal. First, the prism sheath area and then the prism core are dissolved, leaving the well-known honey comb appearance. Thereafter, fresh, unionized acid will eventually diffuse into the inter prismatic areas of enamel and dissolve further mineral in the region underneath the surface. This will lead to an outflow of ions (dissolution) and subsequently to a local pH rise in the tooth substance immediately below and in the liquid surface layer adjacent to the enamel surface. The events in dentine are, in principle, the same but are even more complex [22].

When acidic substances enter the mouth, salivary glands will reflectively increase secretion and saliva flow will accelerate to clear the acids from the oral cavity. Since human saliva contains bicarbonates and urea, it rapidly neutralizes the acidic remnants and returns the oral pH to normal which is known as the buffering capacity of saliva, an important mechanism for oral pH regulation [13].

The effect of erosive agents in the human mouth may depend on many factors not yet elucidated, but erosion is certainly in some way influenced by salivary flow rate and buffer capacity as well as by the pellicle formed by salivary mucins [6]. When saliva flow rate is reduced, its clearance and buffering capacity will be negatively impacted, resulting in abnormal acid retention in the mouth, which, in turn, may contribute to dental erosion. Saliva flow rate and buffering capacity are therefore important etiological factors for erosion [13].

9. Risk Factors

There are different predisposing factors of the erosive condition. The interplay of biological, chemical and behavioral factors is crucial and helps explain why some individuals exhibit more erosion than others, even if they are exposed to the same acid challenge in their diets. Comprehensive knowledge of the different risk factors is a prerequisite to initiate adequate preventive (non-interventive) and, if necessary, therapeutic (interventive) measures [22]. The risk factors are discussed as follows:

- Biological Factors
- Chemical Factors
- Behavioral Factors

9.1 Biological factors: each one constitutes a primary criterion [22]

- Saliva: flow rate, composition, buffering capacity, stimulation capacity
- Acquired pellicle: diffusion-limiting properties and thickness
- Tooth composition and structure (e.g. fluoride content as FHAP or CaF2-like particles)
- Dental anatomy and occlusion
- Anatomy of oral soft tissues in relationship to the teeth
- Physiological soft tissue movements [22]

A very important biological parameter is saliva. Several salivary protective mechanisms come into play during an erosive challenge: dilution and clearance of an erosive agent from the mouth, neutralization and buffering of acids, and slowing down the rate of enamel dissolution through the common ion effect by salivary calcium and phosphate [23].

Patients taking medication such as - Vitamin C, aspirin A, amphetamine-like drugs, tranquilizers [22] can also present decreased saliva output, as well as those who have received radiation therapy for neck and head cancer, diseases - gastroesophageal reflux esophagitis/gastritis/peptic ulcer, eating disorders (anorexia, bulimia), regurgitation more than twice daily [22, 23].

9.2 Chemical factors: each one constitutes a primary criterion

- pH and buffering capacity of the product
- Type of acid (pKa values)
- Adhesion of the product to the dental surface
- Chelating properties of the product
- Calcium concentration
- Phosphate concentration
- Fluoride concentration [22]

The calcium and phosphate content of a foodstuff or beverage are important factors for the erosive potential as they influence the concentration gradient within the local environment of the tooth surface [23].

It has been shown that addition of calcium to a low-pH blackcurrant juice drink reduces the erosive effect of the drink [24]. Several Ca-enriched orange juices and sports drinks hardly soften the enamel surface. The pH of Yoghurt is 4.0, yet it has hardly any erosive effect due to its high calcium and phosphate content [23].

Erosive potential of an acidic drink or foodstuff is not exclusively dependent on its pH value but is also strongly influenced by its mineral content, its titratable acidity (‘the buffering capacity’) and by the calcium-chelation properties. The pH value, calcium, phosphate and fluoride contentof a drink or foodstuff determine the degree of saturation with respect to the tooth mineral, which is the driving force for dissolution [23].

Acids such as citric acids have double actions and may be very damaging to the tooth surface [23]. Citric acid dissolves enamel more readily than other acids, since in addition to the effect of its acidity, it forms a complex calcium citrate [6]. Up to 32% of the calcium in saliva can be complexed by citrate at concentrations common in fruit juices, thus reducing the super-saturation of saliva and increasing the driving force for dissolution with respect to tooth minerals. Saliva takes longer time to neutralize the acids in the drinks containing organic

acids with high buffering capacity, but will reduce the titratable acidity. But dilution will also reduce concentrations of Ca and P (if present), which have a protective effect [23].

Theoretically, fluoride has some protective effect in a drink with a pH higher than that indicated by the saturation curve of fluorapatite at given Ca and P concentrations.[23] The addition of fluoride to acid solutions and beverages has been shown to decrease the amount of erosion in animal models. Topical application with high concentration fluoride varnish or solution was effective in inhibiting enamel softening by a carbonated cola beverage *in vitro* [25].

9.3 Behavioural factors: each one constitutes a secondary criterion

- Eating and drinking habits
- Healthier lifestyle: diets high in acidic fruits and vegetables
- Excessive consumption of acidic foods and drinks
- Night-time baby bottle feeding with acidic beverages
- Oral hygiene practices
- Airborne acidic contaminates of the working environment (industrial acids), or acidic water of swimming pools, a side effect of chlorination using chlorine gas [22].

During and after an erosive challenge, behavioural factors play a role in modifying the extent of tooth wear. The manner that dietary acids are introduced into the mouth will affect which teeth are contacted by the erosive challenge and possibly the clearance pattern [23].

Studies in children and adults have shown that number of servings per day is associated with the presence and the progression of erosion when other risk factors exist. High erosion was associated with a method of drinking whereby the drink was kept in the mouth for a longer period [23].

Health-conscious individuals also tend to have better than average oral hygiene. While good oral hygiene is of proven value in the prevention of periodontal disease and dental caries, frequent tooth brushing with abrasive oral hygiene products may enhance dental erosion. At the other end of the spectrum, an unhealthy lifestyle may also be associated with dental erosion. Alcoholics may be at particular risk for dental erosion and tooth wear [23].

9.4 Other factors affecting erosion

1. Illegal or prescription drug use and severe dehydration following extreme exercise (e.g. rowers, jockeys, boxers) or to achieve weight loss, are risk factors that affect teeth only while the condition or its effect lasts. However some other risk factors may be long lasting, e.g., radiation damage to salivary glands or Sjogren's Syndrome or on-going medication for some incurable conditions [4].
2. Maturity of enamel with its increased resistance to acidic dissolution has been shown to reduce susceptibility to caries. However, there is no evidence that it will protect against erosive acids. Interproximal surfaces rarely become eroded, whereas those surfaces most exposed to natural and physical cleaning are most susceptible [4].

9.5 High risk groups for erosion

- During early childhood erosions are usually associated with chronic gastric reflux and prolonged contact of sweet, acidic drinks –syrups [4].
- With teenagers and young adults, excessive consumption of soft drinks, including diet soft drinks, is a common cause of erosion [4].
- Advanced erosion usually affects the elderly due to reduced saliva production, dry mouth, ageing process and possibly poly-pharmacy [4].
- Those who exercise extensively, distance swimmers using swimming pools, wine assessors, citrus orchardists, chronic asthma sufferers and vegetarians with advanced erosion, resulting from excessive consumption of berries and fruits [4].

10. Clinical Features

Erosive lesions have to be distinguished from attrition and abrasion. The latter are often flat, have glossy areas with distinct margins and corresponding features at the antagonistic teeth. The most commonly reported areas with this condition are occlusal surfaces [23].

10.1 Symptoms of dental erosion range from no symptoms through sensitivity to severe pain associated with pulp exposure [26].

10.2 Signs of erosion range from slight loss of tooth surface characteristics to extensive loss of tissue with pulp exposure and abscess formation.

- In enamel, early signs of erosion include: rounding of sharp angles, dentine cupping or scooping, thinning of enamel
- In the more advanced stages, further changes in the morphology; result in developing a concavity in enamel, the width of which clearly exceeds its depth.
- Further progression of occlusal erosion leads to a rounding of the cusps. Any restorations present may appear to be above the tooth surface.
- In severe cases signs become more exaggerated leading to eventual total loss of enamel.
- On exposed root surfaces, early erosion presents itself as a detectable softening of the surface and is indistinguishable from root caries. Erosive demineralization of the root cementum and dentine appears to progress more rapidly than during caries process. With time, following repeated erosive episodes, the cementum/dentine becomes very soft, is easily damaged by brushing, coarse foods or dental scaling and polishing and becomes very sensitive.

However, the demineralized collagen, if it remains well hydrated by saliva and is not physically damaged, can be readily remineralized with fluoride and can regain almost its original profile and hardness [26].

Characteristics of dental erosion associated with different causative factors given in Table 1 [26]

General erosive patterns given in Table 2 [27]

11. Indices used in the measurement of erosion

For epidemiological purpose, an index with high detection capability and reliability is most important. The earliest indices shared common, arbitrary criteria, relying on descriptive terms such as slight, mild, moderate, severe and extensive. Restarski *et al.*, (1945) developed a six point grading system to evaluate the severity of erosive destruction observed on the lingual surfaces of rat and puppy molars, but concerns were raised with regards to reproducibility [28].

Eccles, 1978 originally classified lesions broadly as early, small and advanced, with no strict criteria definitions, thus allowing wide interpretation. Later, the index was refined and expanded, with greater emphasis on the descriptive criteria. It was presented as a comprehensive qualitative index, grading

both severity and site of erosion due to non-industrial causes, and is considered as one of the cardinal indices from which others have evolved [28].

Greater accuracy was introduced by Xhonga and Valdmanis (1983) who divided erosions into four levels by measurement with a periodontal probe: none, minor (less than 2 mm), moderate (up to 3 mm) and severe (greater than 3 mm). They further differentiated types of erosion by morphological descriptions, such as wedge, saucer, groove and atypical. They did not address the problem of inter- or intra-examiner variability [28].

A popular tooth wear index used is the one proposed by Smith and Knight [1984] [29]. In this index, four sections of each tooth (i.e., buccal/labial, palatal/lingual, cervical and incisal/occlusal) are examined visually and recorded separately, scoring each surface, ranging from 0 (no loss of enamel surface characteristics) to 4 (complete loss of enamel and pulp exposure). This index is arguably more relevant for adults and the required details prove lengthy to record. An important aspect of this index is that it measures tooth wear irrespective of aetiology and hence is not exclusively designed for diagnosis of erosion [29].

Many other indices have been proposed for measuring erosive tooth wear which have their roots in the indices of Eccles [1979] and Smith and Knight [1984]. Linkosalo and Markkanen [1985] utilised a qualitative index with listed diagnostic criteria to confirm lesions as erosive and a four-scale grading of severity, relating to involvement of dentine. Lussi *et al*. [1991] modified Linkosalo and Markkanen [1985] criteria to create an erosive index that has been used widely by European workers to score the facial, lingual and occlusal surfaces of all teeth except the third molars.[28] This index, which also is an extension of Smith and Knight index, separates the grading of erosion between the facial and the oral and occlusal surfaces. As erosion, attrition and abrasion are difficult to distinguish from one another in their initial stages, only the lesions that are considered to be definitely a result of an acidic challenge are classified above grade 0. For the facial surfaces, grade 1 is loss of enamel, grade 2 is involvement of dentine for less that one half of the tooth surface, and grade 3 is involvement of dentine for more than half of the tooth surface. However, this index fails to record the initial signs of dental erosion [29].

O'Brien [1993] reported the use of a partial recording system for measuring erosion in children in UK children's dental health surveys, where only the facial and lingual surfaces of the primary and permanent maxillary incisor teeth were scored for erosion. Again, the criteria were mostly qualitative and descriptive, with a broad attempt made to quantify the area involved [28].

O'Sullivan [2000] proposed an index for the measurement of erosion specifically in children. The index was qualitative with a broad attempt at quantification noting whether less or more than half of the surface was affected. Every tooth was examined and assigned a three-digit score relating to the site of erosion, severity (grade 0–5) and area of surface affected [28].

Bardsely *et al*. [2004] pioneered a new, simplified version of TWI when carrying out epidemiological studies on large numbers of adolescents in North West England [28].

A basic erosive wear examination (BEWE) scoring system is a partial scoring system recording the most severely affected surface in a sextant and the cumulative score guides the management of the condition for the practitioner. The four level score grades the appearance or severity of wear on the teeth from no surface loss (0), initial loss of enamel surface texture (1), distinct defect, hard tissue loss (dentine) less than 50% of the surface area (2) or hard tissue loss more than 50% of the surface area (3).The result of the BEWE is not only a measure of the severity of the condition for scientific purposes but, when transferred into risk levels, also a possible guide towards management [30].

The indexes developed and used during the last 20 years are not comparable; a gold standard does not exist, and validation studies have not had the effect of identifying an index that could be used as a standard for assessing tooth erosion. Finally in the discussion, debate will be whether it is possible to involve erosion indexes into Health Indicator Sets and into International Classification of Diseases (ICD). One of the prospective targets ought to be the inclusion of indexes on dental health prevention especially of an internationally agreed "erosion index". These would be the Health for All Database of the WHO (HFA21), The European Community Health Indicator Set (ECHI), Country Databases on Oral Health and the inclusion of Dental Erosion into the International Classification of Diseases (ICD) and Health-Related Problems. ICD-10, exists two codes for Dental Diseases: "K02" for Caries and "K03" for "Other diseases of hard tissues of teeth" including with "K03.2-Erosion of teeth. Within a revision of the WHO Oral Health Surveys Basic Methods, new oral disease patterns, e.g. dental erosion, have to be taken into account [31].

According to WHO oral health survey 2013 Severity of dental erosion is recorded based on the tooth with the highest score of erosion. In addition, the number of teeth involved is recorded [8].

12. Diagnosis

Diagnosis of early forms of erosion is difficult, as it is accompanied by few signs and fewer if any symptoms. There is no device available in routine dental practice for the specific detection of dental erosion and its progression. It is possible to use disclosing agents to render dentine involvement visible [23]. The clinical examination should be done systematically using a simple but accurate index. The most important part is to recognize the condition and to describe its dimension and severity [30].

12.1 Erosion: Activity and risk assessment

Identify activity

Visual examination

Enamel surfaces that appear 'glazed' or 'silky' demonstrate evidence of current erosive activity. Active erosion will remove the surface smear layer from exposed dentine, opening the dentinal tubules and causing dentine hypersensitivity. If the dentition shows no evidence of plaque (especially when the mouth is in pristine condition) then this also is evidence of high erosive activity, as continuous exposure to acids will remove any evidence of biofilms in the oral cavity. Alternatively, it must be noted that in some cases erosion can be very mildly active over many years, and pristine oral conditions and dentine hypersensitivity may not be present [26].

Tactile examination

Scratch test: The scratch test uses a no. 12 scalpel blade to score a line across an affected tooth surface, before using a small amount of a low-viscosity resin composite or an addition-cured silicone to take an impression with a wooden tongue blade, which can be labelled with the patient's name

and date. Repeat the impression 1-4 weeks later and observe, using magnification, the rate of disappearance of the 'groove' in the impression [26].

Other methods: Serial color photographs (to compare changes in enamel translucency and shade from thinning of the enamel) and high-quality dental casts (to compare subtle changes in tooth morphology) over a much longer time period may be used. Further, examination of dental radiography, especially bitewings longitudinally taken, can provide information about the substance loss over time. For research purpose, computed controlled mapping or profilometric measurements using acid resistant markers are tools to monitor progression [23].
Techniques to evaluate erosion given in Table 3 [32]

12.2 Risk assessment
Thorough history of risk factors should be followed by investigation of plaque, saliva and Gastroenterologic investigation. The identification of the source of acid such as from dietary habits or the presence of GORD directs the clinician towards eliminating the aetiological agent(s)
The age of the patient also should be considered. Newly erupted teeth have enamel crystals containing high amounts of carbonated hydroxyapatite that will dissolve more readily in acids than 'matured' enamel, which has a higher percentage of fluorapatite and other minerals. Past and present fluoride experience must be considered as another risk factor [23].

Methods
- Assessment of systemic diseases and oral hygiene behavior through medical and dietary histories, symptoms of acid regurgitation.
- Assessment of Dietary liquids for daily quantity, method of drinking (drinking method - holding; and in short-sipping; long-sipping; gulping; nipping; and sucking) drinking speed, liquid temperature and time of day of consumption. Intake frequency of various foods, chewing, swallowing and sucking behaviors.
- Registration of plaque topography
- Salivary flow rate and microbial analyses (Streptococcus mutans, lactobacilli, and yeast counts), Buffering capacity by the Dentobuff method
- Colorimetric assessment for Ca, P concentration.
- Microtouch and Telemetric - pH registrations for intraoral sites
- Intra-oral and intra-esophageal pH monitoring for 24 hours
- Gastroenterological investigation [23]

13. Management of Dental Erosion
Accurate diagnosis of the condition and its causes along with patient's awareness is the first aspect in establishing the management program. Clinician must identify and eliminate the acidic aetiological agent(s) whether it is a dietary soft drink, a wine or a commonly consumed food such as pickled vegetables. GORD may require confirmation/intervention by referral to a medical practitioner**.**
There are four steps that are necessary in the management of erosion cases.
- Behavioural aspects of control
- Chemical control and protection
- Physical protection of the teeth
- Maintenance

13.1 Behavioural aspects
For exogenous erosion, the following useful alternatives should be suggested
- Drinking more water, particularly between meals;
- Limiting the frequency of acidic foods and drinks by restricting to main meals; finish with a small piece of cheese or a drink of milk;
- Substituting non-acidic alternatives instead of acidic drinks e.g. flavoured milk instead of all soft drinks and cordial;
- Consuming fruit juices, soft drinks and sports drinks through a straw;
- Rinsing the mouth immediately after the acidic attack, with water, milk or if possible 0.2% NaF mouthrinse (i.e., containing 900-1000 ppm F ion)
- Not brushing for at least 30 minutes after an attack, to permit some salivary stabilization of the tooth mineral structure.
- Swallowing Vitamin C tablets or solutions rather than chewing or swishing [33-35].

13.2 Chemical control and protection
- Use of ant-acid preparations to neutralize acids, especially from gastric reflux.
- Addition of calcium, magnesium, phosphates or fluoride ions to beverages to reduce their erosive potential [33, 35].
- Application of concentrated topical fluorides to teeth prior to an erosive challenge.

13.3 Physical protection of teeth
Various remineralising products such as fluorides and casein-derived pastes containing CPP-ACP: casein phosphopeptide - amorphous calcium phosphate are very useful. The CPP-ACP act as an artificial pellicle allowing the calcium and phosphate ions to be released as soon as the pH drops. Low-dose 'continuous' fluoride exposure can be effective provided sufficient calcium and phosphate ions are available in the saliva [26, 34, 35].
Physical protection for primary and permanent teeth given in Table 4 [26, 34, 35].

13.4 Maintenance
Continuing monitoring for erosive damage is essential for some time after control has been achieved or restorations placed as endogenous erosion in particular has a habit of re-occurring. Recurrent dentinal sensitivity is a frequent useful indicator of continuing demineralization, particularly where exposed roots are involved; Methods which have been recommended for monitoring short term continuing loss of enamel structure (i.e. over six weeks to three months) are:

a) Place a small circle of unfilled resin on the lingual surface of vulnerable teeth. A 'lip' of lost enamel may be discernible by dental loupes around the area protected by the resin.[33]
b) Scratch test has to be performed. If the scratch diminishes or disappears over a one month period, active erosion is present [26].

Long term monitoring of continuing enamel loss is best achieved with repetitive impressions of vulnerable teeth, from which dies are formed. Assessment of loss of dimension with calipers will indicate that the erosion is still active [33, 35].

14. Conclusion
Dental erosion is a multifactorial condition. To date, there is

not one ideal index that can be used for epidemiological prevalence studies, clinical staging and monitoring, and it may be necessary to accept that one simple index does not yet exist to meet all requirements of both clinical and research teams.

When dental erosion is diagnosed, it is important to investigate and identify the acid source, and to determine if the process is ongoing. The aim of treatment should be towards eliminate the cause of acid exposure, and to minimize the effects of acid exposure where it is not possible to remove the acid source. Hence it is important to detect this condition as early as possible. It is fundamental to diagnose the possible risk factors such that preventive measures can be initiated. A modern preventive strategy needs training of dentists in early detection and monitoring of the process. Only with these capabilities can dentists comply with their responsibilities for providing adequate care for patients.

Table 1: Characteristics of dental erosion associated with different causative factors [26]

Form of erosion	Affected areas
General	Affected tooth surface is smooth and appears crazed
Drinking directly from a bottle/ sucking citrus fruits	Labial surfaces of the anterior teeth
Swishing acidic drinks before swallowing	Widespread tooth erosion involving multiple posterior tooth surfaces
Medication	Occlusal surfaces of the molars and palatal surfaces of the upper molars
Gastro-oesophageal reflux disease (GORD)	Occlusal surfaces of the molars or vomiting and palatal surfaces of the upper anteriors and premolars
Vomiting	Palatal surfaces of all the maxillary teeth
Rumination	Occlusal tooth surfaces
Occupational	Usually buccal surfaces of the upper and lower anterior teeth

Table 2: General erosive patterns It is important to search for a general pattern and not to over interpret one single sign.[27]

Characteristics	Erosion
Tooth surface affected	Predominantly smooth surfaces, rare on approximal surfaces
Location in the mouth	Anterior or posterior teeth, often bilateral, in areas with low plaque levels
Appearance	Surface smooth and appears glazed, if oral hygiene is very good the affected area may be yellowish (dentine showing through) and well-polished
Color	Similar to tooth color, may become yellowish as enamel becomes thinner, if dentine exposed becomes yellow and never stains.

Table 3: Techniques to evaluate erosion [32]

S.no	Techniques	Method of analysis
	***In-vitro* techniques**	
1	Scanning electron microscope	Qualitative
2	Surface profilometry	Qualitative
3	Non-contacting laser profilometer	Qualitative
4	Polarized light microscopy	Qualitative
5	Non-contact confocal laser scanning microscopy	Qualitative
6	Scanning acoustic microscope	Quantitative
7	Secondary ion mass spectroscopy	Semi-quantitative
8	Iodide permeability test	Semi-quantitative
9	Transverse microradiography	Quantitative
10	Contact X-ray microradiography	Quantitative
11	Ion chromatography	Quantitative
12	Microdensitometric scan	Semi-quantitative
	***In-vivo* techniques**	
13	Clinical examination and using photograph	Qualitative
14	Indices	Qualitative
15	Colorimetric procedures	Quantitative
	***In-vitro/in-vivo* techniques**	
16	Quantitative light-induced fluorescence	Semi-quantitative
17	Optical coherence tomography	Semi-quantitative
18	Atomic absorption spectroscopy	Quantitative
19	Digital pH meter	Quantitative
20	Micro indentation and nanoindentation	Quantitative
21	Ultrasonication and chemical analysis	Quantitative

Table 4: Physical protection for primary and permanent teeth [26, 34, 35]

Primary dentition	Permanent dentition
Small areas of erosion may be covered with composite resin if sensitive. Larger areas - composite crowns on anterior teeth and preformed metal crowns on posterior teeth.	Vulnerable surfaces-unfilled resin or GIC Severe loss of tooth structure- placement of protective adhesive restorations crowns.
Severe symptoms, extraction of the offending teeth may be necessary.	Active erosion cases- complex restorative work should be avoided. Nocturnal gastric reflux- Night guard with a lining of neutral fluoride gel

15. References

1. Daly RW, Wan Bakar WZ, Husein A, Ismail NM, Amaechi BT. The study of tooth wear patterns and their associated aetiologies in adults in Kelantan, Malaysia. Arch Orofac Sci. 2010; 5(2):47-52.
2. Ganss C, Young A, Lussi A. Tooth wear and erosion: methodological issues in epidemiological and public health research and the future research agenda. Community Dent Health. 2011; 28(3):191-5.
3. Koçani F, Kamberi B, Dranqolli J, Luci K, Peja F, Dragusha E *et al*. Occlusal tooth wear in human sculls of antique period from Vendenis and Municipium Dardanorum DD, Kosovo. Open Journal of Stomatology. 2012; 2(1):1-11.
4. Linnett V, Seow WK. Dental erosion - a literature review. Pediatr Dent. 2001; 23(1):37-43.
5. Ten Cate JM, Imfeld T. Dental erosion, summary. Eur J Oral Sci. 1996; 104(2):241-4.
6. Imfeld T. Dental erosion. Definition, classification and links. Eur J Oral Sci. 1996; 104(2):151-5.
7. Shafer, Hine, Levy. Regressive Alterations of the Teeth, In: Rajendran R(ed). Textbook of Oral Pathology. 7th ed. New Delhi. Elsevier; 2012:p.573.
8. World Health Organization. Oral Health Surveys basic method. 5thed.Geneva: World Health Oraganisation. 2013, 52-53.
9. Esclassan R, Hadjouis D, Donat R, Passarrius O, Maret D, Vaysse F *et al*. Panorama of tooth wear during the medieval period. Anthropol Anz. 2015; 72(2):185-99.
10. Lussi A. Erosive tooth wear–a multifactorial condition of growing concern and increasing knowledge. Monogr Oral Sci. 2006; 20:1-8.
11. Nunn JH, Gordon PH, Morris AJ, Pine CM, Walker A. Dental erosion–changing prevalence? A review of British National childrens' surveys. Int J Paediatr Dent. 2003; 13(2):98-105.
12. O'sullivan E, Milosevic A. UK National Clinical Guidelines in Paediatric Dentistry: diagnosis, prevention and management of dental erosion. Int J Paediatr Dent. 2008; 18:29-38.
13. Yan-Fang Ren DD. Dental erosion: etiology, diagnosis and prevention. ADA: The academy of dental therapeutic and stomatology. 2011, 76-84.
14. Johansson AK, Omar R, Carlsson GE, Johansson A. Dental erosion and its growing importance in clinical practice: from past to present. Int J Dent. 2012, 1-17.
15. Wiegand A, Muller J, Werner C, Attin T. Prevalence of erosive tooth wear and associated risk factors in 2–7-year-old German kindergarten children. Oral Dis. 2006; 12(2):117-24.
16. Wang P, Lin HC, Chen JH, Liang HY. The prevalence of dental erosion and associated risk factors in 12-13-year-old school children in Southern China. BMC Public Health. 2010; 10(1):478-86.
17. Pace F, Pallotta S, Tonini M, Vakil N, Bianchi Porro G. Systematic review: gastro-oesophageal reflux disease and dental lesions. Aliment Pharmacol Ther. 2008; 27(12):1179-86.
18. Ranjitkar S, Kaidonis JA, Smales RJ. Gastroesophageal reflux disease and tooth erosion. Int J Dent. 2012, 1-10.
19. Salas MM, Nascimento GG, Vargas-Ferreira F, Tarquinio SB, Huysmans MC, Demarco FF. Diet influenced tooth erosion prevalence in children and adolescents: Results of a meta-analysis and meta-regression. J Dent. 2015; 43(8):865-75.
20. Eccles JD. Dental erosion of nonindustrial origin. A clinical survey and classification. J Prosthet Dent. 1979; 42(6):649-53.
21. Amaechi BT, Higham SM, Edgar WM, Milosevic A. Thickness of acquired salivary pellicle as a determinant of the sites of dental erosion. J Dent Res. 1999; 78(12):1821-8.
22. Lussi A, Jaeggi T, Zero D. The role of diet in the aetiology of dental erosion. Caries Res. 2004; 38(Suppl 1):34-44.
23. Lussi A, Jaggi T. Erosion-diagnosis and risk factors. Clin Oral Investig. 2008; 12(1):5-13.
24. West NX, Hughes JA, Parker DM, Moohan M, Addy M. Development of low erosive carbonated fruit drinks 2. Evaluation of an experimental carbonated black currant drink compared to a conventional carbonated drink. J Dent. 2003; 31(5):361-5.
25. Zero DT. Etiology of dental erosion–extrinsic factors. Eur J Oral Sci. 1996; 104(2):162-77.
26. Kaidonis JA. Oral diagnosis and treatment planning: part 4. Non-carious tooth surface loss and assessment of risk. Br Dent J. 2012; 213(4):155-61.
27. Moss SJ. Dental erosion. Int Dent J. 1998; 48(6):529-39.
28. Bardsley PF. The evolution of tooth wear indices. Clin Oral Investig. 2008; 12(1):15-9.
29. Taji S, Seow WK. A literature review of dental erosion in children. Aust Dent J. 2010; 55(4):358-67.
30. Bartlett D, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. Clin Oral Investig. 2008; 12(1):65-8.
31. Berg-Beckhoff G, Kutschmann M, Bardehle D. Methodological considerations concerning the development of oral dental erosion indexes: literature survey, validity and reliability. Clin Oral Investig. 2008; 12(1):51-8.
32. Joshi M, Joshi N, Kathariya R, Angadi P, Raikar S. Techniques to evaluate dental erosion: a systematic review of literature. J Clin Diagn Res. 2016; 10(10): ZE01- ZE07.
33. Meurman JH, Ten Cate JM. Pathogenesis and modifying factors of dental erosion. Eur J Oral Sci. 1996; 104(2):199-206.
34. Wang X, Lussi A. Assessment and management of dental erosion. Dental Clinics. 2010; 54(3):565-78.
35. Lussi A, Hellwig E. Risk assessment and causal preventive measures. Monogr Oral Sci. 2014; 25:220-229.