Acid erosion and restorative dentistry – is prevention better than cure?

Peter J Nixon, **Mital Patel** and **Paul A Brunton** discuss the factors involved in acid erosion, strategies available for prevention and treatment options for restoring acid worn dentition

Acid erosion is defined as the dissolution of dental hard tissues as a result of a chemical etching process by acids not involving bacteria (Imfeld, 1996). In 1993, the prevalence of erosion was reported for the first time in a survey of Children's Dental Health in the UK (O'Brien, 1993) but, due to the difficulty in diagnosing erosion as the sole cause, the term tooth surface loss was used in the subsequent 2003 survey. In the 2003 survey, 53% of five-year-olds and a third of 12-15 year olds showed signs of some form of tooth surface loss (Children's dental health in the UK).

This was similar to the 1993 findings with a 1-5% increase. The lingual surfaces were the most commonly worn sites and, in children and adolescents, dental erosion is thought to be the most common form of tooth surface loss with some elements of abrasion and attrition also present. In 15 year olds the number of teeth showing tooth surface loss into dentine and pulp on the lingual surfaces increased from 2% in 1993 to 5% in 2003 (Children's dental health in the UK). The Adult Dental Health Survey in 1998 also showed that two thirds of adults examined had signs of tooth surface loss into dentine on their anterior teeth and this was shown to increase with age. It is clear that tooth surface loss is highly prevalent and a growing problem with more adults retaining their natural teeth. The recent Steele report (2009) has highlighted that dental care should be evidence based and aimed at prevention.

This paper aims to discuss the factors involved in acid erosion, strategies available for prevention and treatment options for restoring the acid worn dentition.

Aims and objectives

To discuss the factors involved in acid erosion, strategies available for prevention and treatment options for restoring the acid worn dentition

Expected outcomes

Correctly answering the questions on page 98 will demonstrate you understand the factors involved in acid erosion, strategies available for prevention and treatment options for restoring the acid worn dentition.

Verifiable CPD hours: 1

Acid erosion

Acid erosion is caused by acids derived from either extrinsic or intrinsic sources but not from bacteria within the intra-oral flora. Table 1 (Scheutzel, 1996; Dugmore, Rock, 2004; Bishop, Deans, 1996; Smith, Robb, 1989) and Table 2 (Zero, 1996) outline the source of both intrinsic and extrinsic acids commonly associated with erosive tooth surface loss. Dietary acid is possibly the biggest aetiological factor associated with erosive tooth surface loss.

As well as the tooth being exposed to acid, there are several other factors that may influence acid erosion. Most in vitro studies only look at the erosive potential of the acids against the tooth and do not take into account other factors that may modify the erosive process. These modifying factors, described by Meurman and Cate (1996) and Lussi and Jaeggi (2008), include:

- Chemical properties of the acid (acid type, pH, titratable acidity and calcium chelation properties)
- Frequency of acid attack, time and method of contact between acid and tooth
- Presence of other ingredients such as calcium, phosphate and fluoride within food and drink
- Structure and composition of the enamel and dentine
- Formation of the salivary pellicle and its thickness
- Composition, flow rate and buffering capacity of saliva.

There is an ongoing debate in the literature over the importance of pH (Shaw, Smith, 1999) and titratable acidity (Hemingway et al, 2006) of the acid in terms of determining its erosive potential. pH is the measure of hydrogen ion concentration whereas titratable acidity is a measure of the amount of alkali or buffer such as saliva required to bring the pH of an acid up to a neutral. Hemingway et al (2006) suggested that the method of consumption may determine which is more important. If the acidic solution is held in the mouth then the composition of the solution will

Figure 1: Cupping lesions caused by a combination of attrition and erosion

Figure 2: Indirect restorations incorporating features to help retain a removable prosthesis

Figure 3: An example of full arch crowns required to restore a dentition extensively damaged by erosion

change with time, in which case titratable acidity will be more important. If the acidic solution is removed from the oral cavity relatively quickly then the chemical composition is unlikely to change, in which case the pH will be more important in determining erosive potential.

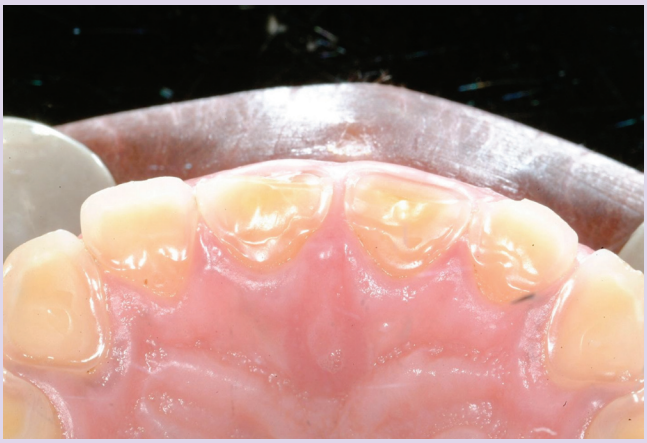
With respect to enamel hydroxyapatite, calcium and phosphate saturation play an important role in acid erosion. A solution supersaturated with calcium and phosphate will decrease or inhibit the dissolution of enamel regardless of the erosive potential of the acid. On the other hand, a solution under saturated (with respect to calcium and phosphate) is likely to increase the dissolution of enamel until equilibrium is reached. The pH at the point when the solution becomes under saturated and dissolution of the enamel structure starts to occur is known as the critical pH. For enamel this can vary, depending on buffering capacity of saliva and saturation of the solution with respect to calcium and phosphate, but is usually around 5.5. Several authors have modified acidic foodstuffs and drinks to increase the bioavailability of calcium and phosphate and have shown a decrease in erosive potential (Hughes et al, 1999; Hooper et al, 2004). Yoghurt is another example of where the pH of the acidic content is low but due to high calcium and phosphate content the erosive potential is next to nothing (Lussim, Jaeggi, 2008).

Fluoride ions may also offer some protection against erosion through re-mineralisation of the enamel to form fluorapatite. There is good evidence to support this concept when considering fluoride treatment in the prevention of caries (Walsh et al, 2010) but the evidence for the use of fluoride to re-mineralise the eroded tooth surface is not as strong. Both caries and acid erosion involve demineralisation, however, demineralisation during the carious process is much slower and the acidic challenge is also weaker, therefore, there may be more time for fluoride to work. Attin et al (1998) found that in vitro topical application of fluoride had some positive effect in preventing tooth surface loss and as fluoride concentration increased the wear resistance also increased. Epidemiological studies have also shown that water fluoridation, along with regular use of fluoride toothpaste twice daily, decreases erosive tooth surface loss in children.

Several acids have calcium-chelating properties, which is the ability to bind to calcium. This can increase the erosive potential via two mechanisms. Firstly, it can bind directly to calcium in the enamel surface and cause dissolution of the tooth as the acidic solution becomes under saturated with respect to calcium-acid complex. Secondly, it can bind to free calcium in solution and decrease the level of calcium saturation with respect to enamel resulting in dissolution of the tooth (Meurman, Cate, 1996).

The outer surface of the tooth is most resistant to acid erosion and once this has been lost erosion can progress rapidly. The structure of the mineralised portion of the enamel is predominantly made up of hydroxyapatite but also has impurities, which alters the solubility of the tooth (ten Cate, Featherstone, 1991). These impurities are made up of mainly sodium, magnesium and carbonate, and increase in quantity as you move away from the surface towards the amelo-dentinal junction, making the tooth more prone to erosion (Eanes, 1979). The outer surface of enamel also has an aprismatic layer of enamel, which is thought to be more resistant to acid erosion compared to the deeper prismatic layer (Meurman, Cate, 1996). Acid erosion in dentine starts

Case study one



Figures 1 and 2: Pre-operative intra-oral views of a 41-year-old male patient, showing extensive tooth tissue loss caused by a habit of swilling fizzy drinks around the upper anterior teeth during the day

Figures 3 and 4: Surgical crown lengthening surgery was required to increase the tooth tissue available for bonding

Figures 5 and 6: Direct composite restorations built-up on the upper anterior teeth to create posterior disclusion

Figures 7 and 8: Final views at nine-month review visit show the re-established posterior occlusion

within dentinal tubules where the peritubular dentine starts to dissolve and subsequently moves to dissolution of the intertubular dentine. This results in enlarged dentinal tubules and if the erosive attack is rapid so that there is little time for tertiary dentine deposition this can result in sensitivity (Meurmann, Drysdale, Frank, 1991).

Following an acidic challenge there is a significant drop in pH to below the critical level. This results in stimulation of the salivary glands to produce more saliva and increases the flow rate. The saliva counteracts the acidic challenge by (Meurman, Cate, 1996; Lussi, Jaeggi, 2008):

- Dilution and clearance of the acidic solution from the mouth
- Neutralisation and buffering of the acid (in both resting and stimulated saliva bicarbonate and phosphate are the main salivary buffers (Lilienthal, 1955)
- Keeping the solution super saturated with respect to calcium and phosphate ions in order to slow down acid erosion.

A reduced salivary flow rate (Jarvinen, Rytomaa, Heinonen, 1991) and decreased buffering capacity (Gudmundsson et al, 1995) has been noticed in patients with acid erosion and are considered to be important risk factors (Piangprach et al, 2009). This is commonly seen in patients who suffer from xerostomia or drug induced dry mouth. Following an acidic challenge, it can take saliva two to 10 minutes to raise the pH above the critical pH, depending on the site within the mouth (Azrak et al, 2008; Millward et al, 1997). This indicates that saliva may offer a different level of protection in different parts of the mouth. One reason for this is anatomical variations such as the presence of the tongue and cheeks, which either prevent saliva reaching the tooth surface or allow pooling of saliva.

Before the acid can cause dissolution of enamel it also has to diffuse through the acquired salivary pellicle. This is an organic bacteria-free film made up of several salivary proteins, which acts as another barrier to decrease the erosive challenge on the tooth (Lussi, Jaeggi, 2008). Amaechi et al (1999) showed that the thickness of the salivary pellicle can vary at different sites in the mouth and the amount of erosion present on teeth was inversely proportional to the thickness of the salivary pellicle present. Any procedure that causes removal of the pellicle or reduction in its thickness may, therefore, increase the risk of acid erosion.

The above mentioned chemical and biological factors, combined with patients' dietary habits and behavioral factors, makes acid erosion a very complex and difficult problem to manage.

The rest of this paper aims to highlight management strategies available in the treatment of erosive tooth surface loss.

Management strategies for erosion

- Accurate diagnosis and successful monitoring of condition
- Prevention
- Control acids
- Cessation or modification of acid consumption from extrinsic sources
- Dietary advice
- Control of intrinsic acid liberation
- Liaison with GMP
- Offer lifestyle advice
- Institute or correct medication
- Preventive products
- Regular introduction of fluoride ions into the mouth
- Building a protective layer on the pellicle
- Restorative intervention
- Plastic restorations
- Crown lengthening surgery
- Partial and full coverage in-direct restorations
- Removable prostheses.

Case study two

Figures 1, 2 and 3: Following surgical crown lengthening, dentine bonded crowns were provided to restore the upper anterior teeth for this patient who suffered with attrition and erosion of gastric origin

Diagnosis and monitoring

Accurate diagnosis, patient education and monitoring are of central importance in the management of erosive toothwear (Diagnosis and prevention of dental erosion, 2000). Although erosion may be seen in isolation, toothwear is commonly multi-factorial in its aetiology, with two or more combinations of attrition, erosion, abrasion and abfraction often seen together.

A detailed history of symptoms and careful questioning about potential sources of acid are useful in diagnosing erosion. Identifying the source of acid can be difficult to ascertain and can require sensitive questioning. If the source of acid can be established, then the appropriate advice or referral can be given.

Symptoms such as sensitivity tend to suggest wear progressing at a high rate. The patients' opinion of the aesthetics of their dentition and functional difficulties can also indicate whether restorative intervention is likely to be required. Signs of a significantly erosive element to tooth surface loss found on clinical examination include:

- Cupped-out defects (see Figure 1)
- Rounded dental contours with a loss of anatomical features
- Increased translucency and chipping on incisal edges
- Previous restorations seen to be proud of tooth tissue.

Evidence of staining is a useful observation as its presence may indicate tooth wear that has been present for a period of time or that is progressing slowly.

Monitoring of erosive tooth wear is indicated to assess the rate of tooth surface loss. The methods available to do this include indices, photographs, study models and silicone impressions. The most commonly used index for measuring the wear of teeth is the Smith and Knight tooth wear index (Smith, Knight, 1984). However, despite the usefulness of this index for research, it is not sensitive enough for monitoring purposes. Photographs and models are often recorded for monitoring tooth wear and can be useful and easy to store. The use of silicone matrices either made on previous models or in the mouth can be a helpful tool to visualise the amount of tooth tissue lost over a given period of time. The index must cover some of the alveolus or palate (in order to be consistently repositioned

in the mouth) and sectioned to allow the teeth to be visualised. Any gap between the tooth and silicone index at a future recall visit indicates a loss of further tooth tissue.

Preventive intervention

The key to treating patients once a diagnosis of erosive tooth surface loss has been made is to educate and advise on the condition and its prevention. This is aimed at controlling the rate of progression and, therefore, limiting the operative intervention that is required. It is of key importance to identify early evidence of tooth surface loss and intervene with the preventive aspects of care in order to reduce the number of individuals requiring extensive operative intervention.

Control of extrinsic acids is primarily achieved through dietary advice. The effect of excessive consumption of acidic drinks and foods should not be underestimated, as it is a common source of powerful acids. Acid attack that is spread throughout the day is particularly damaging and can lead to rapid and extensive damage to the dental tissues (see case study one). Advice is generally to reduce the consumption of damaging drinks and foodstuffs and confine them to mealtimes when salivary flow is at its greatest (Milosevic, O'Sullivan, 2006). Patients with erosion due to fizzy drinks should be advised to avoid rinsing the fluid around the teeth and that drinking through a straw positioned towards the back of the mouth can reduce contact with teeth.

In patients for whom erosion is largely due to intrinsic acids, control can be helped greatly through liaison with the general medical practitioner. Patients suffering from conditions related to frequent vomiting are often suffering from a medical complaint and have additional health problems in combination with their dental needs. Treatment with a medical professional may well result in an improvement of not only the dental condition but also address medical requirements. In terms of dental advice, it is helpful to inform patients prone to vomiting of the usefulness of rinsing the mouth with water after vomiting and the importance of not brushing the teeth at this point, which is likely to result in further damage by super-imposing an abrasive action on the softened tooth surfaces.

For many patients, the source of intrinsic acid is gastro-oesophageal reflux. For this group, acids may be controlled through a combination of medication, lifestyle or dietary advice. A variety of medications can be prescribed for gastro-oesophageal reflux and act to decrease the production of gastric acid. Dietary advice may include avoiding food close to bedtime, taking time over meals and avoiding overindulgence with food and alcohol.

Restorative treatment for erosive tooth wear

Restorative treatment may be indicated for cases in which the dentition requires restoration in order to preserve or restore function, for aesthetic reasons or to control symptoms. The point at which restoration is needed varies in different cases and individuals. The complexity of treatment required also varies depending on the severity of the condition, the occlusal scheme and patient related factors.

Intrinsic acid (reflux of gastric acid)	Common causes
	Increased pressure on stomach from pregnancy, obesity or increased gastric volume from over eating or eating late at night
	Voluntary repeated induced vomiting often associated with eating disorders, such as bulimia nervosa and anorexia nervosa
	Rumination syndrome – reflux of swallowed food for further mastication
	Gastro-oesophageal reflux disease (GORD). It is associated with: • Hiatus hernia (weakening of lower oesophageal sphincter) • GI tract disturbances (duodenal ulcer, chronic constipation) • Chronic alcoholism.
	A side effect to certain medication may induce vomiting or decrease buffering capacity of saliva due to drug induced xerostomia
	Vomiting caused by chemotherapy and radiotherapy treatment for cancer
	Voluntary regurgitation in athletes to maintain body weight e.g. race jockey

Table 1: Sources of intrinsic acid

Direct restorations

Localised erosive tooth surface without loss of space

Early treatment of erosive tooth surface loss can be relatively simple, particularly when space is available for restoration within the existing occlusal scheme. In contrast to tooth wear caused by attrition, space may well be available for restoration placement in cases of dental erosion. Space tends to be available in areas that do not have occlusal contact or in 'cup-shaped' defects, typically seen in mild to moderate erosion (Figure 1).

This situation is commonly seen in young patients and children, as well as adults. In younger age groups, direct composite restorations are almost always preferable to other forms of restorative intervention due to greater conservation of tooth tissue. Such lesions do not have an inherently retentive shape if restoration is indicated, are ideally treated conservatively with simple adhesive restorations. Composite restorations, bonded with a

Extrinsic acids	Common causes:
Alcohol	Wine, beer, alco-pops, cider
Soft drinks	Fruit juices Flavored water Carbonated drinks (NB: carbonic acid is weak acid and itself does not cause erosion, it is other acids in soft drinks such as citric acid that cause erosion) Fruit flavored teas/Chinese teas/herbal teas Sports/energy drinks e.g. Lucozade sport, Red Bull, Maxim
Mouthwashes	Certain mouthwashes have low pH values e.g. Listerine, Peroxyl
Food stuff	Pickles Fruits e.g. oranges and lemons Vinegar-based foods Yoghurt-based foods
Medication	Vitamin C, iron tablets
Environmental	Chlorine from swimming pools
Occupational	Working in acid environment

Table 2: Sources of extrinsic acids

compatible dentine adhesive system, are ideal in such circumstances after cleaning the area with pumice or light surface roughening with a slow-speed bur. Glass-ionomer restorations are best avoided in erosion cases as they have a tendency to dissolve in acidic environments (Aliping-McKenzie, Linden, Nicolson, 2004).

Localised erosive tooth surface with loss of space

As wear becomes more significant or has progressed over a longer period of time, there is often a loss of inter-occlusal space in which to place restorations. This situation arises due to compensatory overeruption of the worn teeth and/or their antagonists. This situation is commonly seen in patients with localised anterior tooth wear. The preferential wear of the palatal aspects of upper anterior teeth is particularly commonly seen due to greater contact of this area during the consumption of erosive drinks or with gastric contents during vomiting.

Occasionally, space for restorations can be found by utilising the retruded axis position, as this results in a more posterior position for the mandible, thus creating space palatal to the upper anterior teeth. This is not possible in all cases and so space is often created by utilising the Dahl principle (Dahl, Krogstad, Karlsen, 1975). The original technique described by Dahl relied on a removable anterior bite-plane made of cobalt chromium (Darcar, Hemmings, 1997). Initially this bite plane results in posterior disclusion, but relies on the fact that the posterior teeth will gradually over-erupt and come back into contact over a period of months. Once the posterior teeth are in contact, the occlusion is stabilised and space has been created for palatal restoration.

More recently, this method of creating space has been modified firstly by bonding the appliance in position and then by using individual direct or indirect composite resin restorations instead of the cobalt chromium platform (Saha, Summerwill, 2004). Performing this technique with composite resin can be employed either as a provisional phase of treatment to create the space required for indirect restorations or, as is increasing the case, as definitive restorations (Redman, Hemmings, Good, 2003; Hemmings, Darbar, Vaughan, 2000) (see case study one).

Crown lengthening surgery

In cases where there is inadequate tooth tissue for the retention of restorations, crown lengthening surgery may be required. Despite modern adhesive bonding techniques allowing restorations to be retained on less tooth tissue than previously possible, crown lengthening surgery remains a useful tool in treatment of the worn dentition. As a result of gingival and osseous re-positioning, the amount of supra-gingival tissue can be greatly enhanced and enable fixed restorations to be provided (see case study one and two.)

Indirect restorations

Indirect restorations may be indicated for worn teeth in preference to direct restorations for a variety of reasons. Laboratory produced restorations may confer advantages in certain cases, such as improved aesthetics, better wear characteristics and enhanced integration with removable prostheses (Figure 2). However, indirect restorations tend to be less conservative of tooth tissue than direct techniques and so can limit future treatment options in a group of patients for whom tooth tissue loss is the primary concern.

Nonetheless, indirect restorations remain important in the treatment for erosion. Adhesively retained restorations such as dentine-bonded crowns, veneers and onlays can all help to reconcile conservation of tooth tissue with the need for indirect restorations (see case study two.)

In cases of localised erosion with loss of space, the immediate placement of indirect restorations using the Dahl principle has been reported. This technique allows rapid treatment but has the drawback of the restorations being difficult to adjust and, as a result, potential difficulties in controlling the tooth movements that occur (Saha, Summerwill, 2004).

In the most severe cases, there may be generalised erosion of teeth around the arch(es), with a consequent loss of occlusal height. Such cases may require full mouth rehabilitation at an increased occlusal vertical dimension (Ibbetson, Setchell, 1989). This type of treatment

necessitates careful planning, is time consuming to carry-out, expensive and often requires specialist treatment to control the change in occlusal scheme. This form of treatment should not be embarked upon lightly as it requires extensive and irreversible preparation of multiple teeth (Figure 3)

Removable prosthodontics

In cases where fixed restorations are not feasible or inappropriate, removable prosthodontics may be employed (Hemmings et al, 1995). This may involve the use of conventional partial dentures, onlay, overlay or conventional (partial or complete) overdentures. Although removable prosthodontics may be considered a simple option in comparison to full-mouth rehabilitation, these removable prostheses can be complex to construct and require expert technical support to produce.

Conclusions

Prevention is the key to success in the management of erosive tooth surface loss, just as it is in the treatment of other dental pathological processes such as caries and periodontal disease.

Intervention, in terms of preventive advice and monitoring, is required in all cases where erosion is diagnosed. Adopting this approach can reduce the need for extensive treatment and contribute to improving the prognosis for any restorative treatment that is provided. PD

References

For the full list of references to accompany this article, please email the editor at siobhan.lewney@fmc.co.uk.

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Comments to pd@fmc.co.uk

Peter J Nixon is a consultant in restorative dentistry at Leeds Dental Institute.
Mital Patel is a specialist registrar in restorative dentistry at Leeds Dental Institute.
Paul A Brunton is Professor of restorative dentistry at Leeds Dental Institute.