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The role of erosion in tooth wear: aetiology, prevention and management

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Tooth wear is a universal experience. The cause is usually a combination of erosion, attrition and abrasion. Attrition usually presents with flattened incisal and occlusal tooth surfaces which accurately inter-digitate. Erosion from dietary or gastric acids forms smooth lesions which typically appear as cupped occlusal/ incisal and concave buccal/facial surfaces. When combined with attrition or abrasion, acids have the potential to cause significant wear. Wear reduces the thickness of enamel exposing the underlying dentine and changing the colour from the white of enamel to yellow of dentine. Acids causing erosion originate from the stomach or from the diet. Gastric acid is associated with reflux disease and eating disorders. The frequency of acidic foods and drinks and how they are consumed is important in dietary erosion. The progression of tooth wear is recognised to be slow with periods of activity and inactivity. Although restorations can be indicated, prevention and monitoring remain important strategies in maintaining the life of the teeth.

Keywords: Abrasion, erosion, attrition, abfraction, tooth wear, prevention, management

Tooth wear is a multifactorial condition leading to the loss of enamel and dentine[1]. There is good clinical consensus on the definitions of erosion, attrition and abrasion. Erosion is the dissolution of teeth by acids, attrition is the wear of tooth against tooth and abrasion is the wear of teeth from other factors[2,3]. There is less agreement about how to interpret the clinical presentation of tooth wear and relate this to the cause[4].

In many European countries the role of acid erosion has been recognised to be the most important component of tooth wear, whereas in other countries attrition is still considered to be the predominant cause[5-8]. This apparent dichotomy can be confusing. Even within the same geographical region there are differences in the understanding of tooth wear. For instance, a cervical wear lesion is considered by some to be erosive[9], others to be abrasive or abfractive[7] or a combination as shown in *Figure 1*[10]. One study reported similar levels of erosive tooth wear on subjects seen in dental schools in the UK and USA[6]. This seems contrary to the perception that erosion is more common in Europe than in North America. The reason for this apparent difference might be because European dentists are recognising acids as a cause of tooth wear more than their North American colleagues. These differences in the understanding and terminology of tooth wear between the continents have an impact both on epidemiological studies and on case by case assessments in everyday clinical practice.

Clinical presentation

The clinical appearance of the various sub-types of tooth wear can vary. Attrition in its purest form is typified by flattened occlusal surfaces which almost appear as if someone has filed the teeth with sandpaper (*Figure 2*). The degree of wear in both arches is normally equal and the teeth closely fit together. The presence of hypertrophic masseter muscles is another warning sign of the impact of bruxism. When erosion and attrition are combined the appearance alters with some cupping or undermining of the occlusal surfaces (*Figure 1*). The dentine being less mineralised than enamel appears to wear preferentially, resulting in occlusal cupping or depressions. When erosion is the dominant factor, the buccal and lingual surfaces of the upper incisors appear smooth and shiny with a generalised loss of anatomy (*Figure 3*). On the palatal surfaces of the

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Figure 1. This figure shows a combined lesion. There is occlusal cupping from acid erosion and buccal wear particularly along the cervical margin. The patient was experiencing pain from the mesial lesion above the cervical margin and not from the occlusal surfaces.

Figure 2. A typical appearance of bruxism with flattened incisal and occlusal surfaces

Figure 3. This unusual presentation of erosion shows that the occlusal and buccal surfaces have been eroded leaving an anterior open bite. The only occlusal contact is between the molars showing that the wear on the anterior teeth is not attrition.

Figure 4. A typical appearance of palatal erosion. The dentine has been eroded by acids leaving a halo of enamel surrounding the lesion. The remnants of the enamel provide a convenient tissue to bond to with adhesive materials.

Figure 5. This figure shows that erosion, abrasion and attrition are active. The interdigitation of the upper and lower incisors illustrates the role of attrition whereas the cervical wear lesions show that erosion and abrasion are also important

upper incisors the exposed dentine is smooth often with a halo of enamel surrounding the lesion[11] (*Figure 4*). This particular pattern is often associated with gastric causes or retention of acidic drinks, such as some carbonated beverages (soda pop), fruit juices, or wine, in the palatal vault[12]. Abrasion occurring on its own is unusual. It might be caused by biting or chewing objects between the teeth for example tobacco pipes, nails or pens. However, by far in the most common presentation of tooth wear is the result of a combined lesion involving erosion and abrasion. Acids weaken the outer 3-5 microns of mineralised tissue and increase the susceptibility of the enamel and dentine to abrasion from tooth brushing with or without toothpaste[13].

The case in *Figure 5* illustrates the multifactorial nature of tooth wear. The teeth inter-digitate indicating that attrition is occurring. But there are also areas

of cupping along the incisal edges where the opposing teeth cannot touch and this indicates that erosion is also active. The cervical areas are worn which might suggest abrasion or erosion. Recognising the relative importance of the aetiology is crucial as prevention by control of aetrologic and predisposing factors is an essential part of any treatment regime. If attrition is suspected as the cause, occlusal splints might be appropriate but not if erosion is also active. In *Figure 3* attrition cannot be active as the anterior teeth cannot occlude due to an anterior open bite caused by erosion. In this case the sole cause is acids.

Pathogenesis

Erosion is generally considered in Europe to be the most prevalent cause of tooth wear. The source of the acid can either be gastric (intrinsic) or dietary (extrinsic) acids. Dietary acids are a common part of modern diets, particularly the fruit acids. There is strong evidence to suggest that the manner in which the acid food or drink is consumed is more important than the overall quantity. Holding, swilling or retaining acidic drinks and foods in the mouth prolongs the acid exposure on the teeth increasing the risk of erosion[14,15]. These destructive habits are characterised by holding soda pop in the mouth allowing it to bathe teeth, or swishing between the teeth to 'de-carbonate' the drink for several minutes before swallowing. Some individuals report only consuming a small amount, for example one can (approx 0.3L) each day, but sipping small quantities frequently throughout the day. Therefore, the first stage in management should be to identify the frequency of acidic intake and assess how it is consumed. It should also be remembered that dietary habits change over months or years. Therefore, the appearance of the wear could be historical, particularly if a previous dentist has given dietary and drinking modification advice.

Saliva can provide some protective benefits, particularly through acid clearance and neutralisation. The buffering by saliva of dietary acids is much quicker in the erosive than in the carious process[14,16]. In caries, bacteria in plaque metabolise sugars for up to 60 minutes after the consumption[17] whereas in erosion the acid clearance from the oral cavity occurs in only a few minutes[14,15]. This difference between the two processes means that the pathogenesis also differs. Acid erosion occurs as discrete episodes and is the reason why dietary habits are so damaging. The tooth surface continually changes as the acid partially dissolves the outer layer of enamel or dentine which then becomes more susceptible to abrasion or attrition. Whereas, caries is a sub-surface event involving a calcium rich plaque layer providing a source of mineral ions to remineralise the surface of the tooth[18]. This process passes from stages of demineralisation to remineralisation depending upon the availability and frequency of dietary sugars[19].

The other major source of acid originates from the stomach. The movement of the gastric acid from the stomach to the oesophagus can cause irritation of the mucosal lining. This frequently presents as heartburn and is so common that up to 60% of people will suffer from it at some point in their lives[20]. However, it is relatively unusual for gastric acid to migrate to the mouth but when it does the potential for damage is considerable[21]. Reflux past the upper oesophageal sphincter has been shown to increase the risk for erosion in the mouth[22-24]. The refluxed acid typically dissolves the palatal surfaces of the upper incisor (*Figure 4*). A similar appearance is formed in patients with eating disorders. Anorexia, bulimia nervosa and rumination have all been closely associated with palatal dental erosion[25,26]. Rumination is a condition when patients eat their food, swallow and then physically increase and decrease their diaphragmatic pressure and voluntarily regurgitate the food mixed with gastric acid into their mouths. Although first recognised in patients in long term care facilities it is also common in those patients with a similar psychological background as patients with eating disorders[27]. Patients with these signs and symptoms should not only receive dental care to protect their oral health, but a referral to a physician to assess their medical condition should be considered.

Screening for tooth wear

All patients should be considered to be at risk of developing tooth wear and examination should routinely involve looking for the clinical signs. The assessment of the severity of tooth wear is subjective both from the patient's and dentist's perspective. Deciding at what stage tooth wear requires restoration is challenging for the dentist. It will partly be dependant on the patient's wishes and partly on the dentist's assessment.

Tooth wear indices or scores have been used to assist this clinical decision. These indices grade the severity of wear over a 3 or 4 scale and involve assessing all the surfaces of the teeth (occlusal, buccal/facial, lingual/palatal and cervical). But they are designed for epidemiological studies and lack adaptability for individual patient assessments. To complicate matters, tooth wear is age related and estimating an acceptable level of wear for an individual at their age is open to bias[28]. The term pathological tooth wear is used to define an unacceptable level of wear for a particular age group. They are relatively easy to judge for severe wear in the young but the difficulty arises when an assessment is needed for less extreme circumstances. In these situations the decision on whether the tooth wear is pathological or not depends not only on the severity but also on the patient's needs.

A simplified index based on that of Smith and Knight[29] has been proposed[30]. This system defines wear on four levels; no wear, enamel exposure and mild and

Figure 6. The surfaces of these teeth are stain free and clean indicating that the erosion is active

Figure 7. The upper incisors are stained indicating that the erosion may be inactive

Figure 8. The amalgam restoration is no longer supported on the palatal wall. Acids have eroded the palatal cusp leaving the restoration proud.

severe dentine exposure. Clinically, this can be further simplified to mild, moderate and severe tooth wear. For example, *Figure 1* shows the wear of a young person. This might be assessed as being mild and not requiring restorative treatment. In *Figure 2*, the patient is aged 35 years and the classification would be severe. However, if the person had been 70 or 80 like the patient in *Figure 5* the wear would be classified as moderate. The classification for a middle aged person of 50 years old seen in *Figure 4* would be severe. These examples illustrate that the classification is not only dependant upon the severity of the wear but also the age of the patient.

Prevalence

Virtually all the studies reporting the prevalence of tooth wear do so retrospectively. The implication of these studies suggests that tooth wear is common and affects all age groups[31]. A study of 391 randomly selected people in Switzerland from two age groups (26-30 and 46-50 years old) reported frequent and severe erosion on all tooth surfaces. On the facial surfaces, 7.7% and 13.2% of patients showed at least one tooth with exposed dentine. On the occlusal surfaces dentine exposure occurred in 29.9% of the younger group and 42.6% of the older group.

There are only a few studies that have reported longitudinal data for the progression of tooth wear in enamel and dentine[32,33]. Only one study compared progression on individual tooth surfaces[34]. This study reported the results of tooth wear recorded on consecutive study casts taken from 34 patients over a 2-year period. All the subjects presented with tooth wear and were given preventive advice but the progression of wear was observed on only 7.3% of the surfaces. This evidence is often supported clinically when patient's rate of tooth wear appears to remain static over long periods of monitoring. However, for some patients the tooth wear occurs over short periods of time. For instance, in young adolescents with dentine exposure on the palatal surfaces of the upper incisors the damage will have occurred in the period following eruption. This damage can occur in only a few years. But once dietary advice and prevention is implemented the rate of wear rapidly decreases. Why some patients suffer from rapid wear is not known.

Recognising how the appearance of teeth change with tooth wear can be helpful in assessing the activity. Smooth and clean surfaces suggest that the process is active whereas stained teeth (*Figures 6* and *7*) suggest inactivity[1,35]. The tooth surface in an active lesion would be constantly changing so producing a clean unstained surface. If the erosion becomes inactive there is then sufficient time for the stain to be taken up onto the tooth surface. Other indicators for activity of tooth wear include the erosion of the tooth around an existing restoration. The restoration is resistant to acid and so it remains unchanged but the tooth is gradually dissolved leaving the restoration proud (*Figure 8*). These markers

can be used to monitor tooth wear. However, the most effective way to monitor wear is to compare dated study casts to the clinical condition of the teeth over time. This can be used as part of a preventive regime.

Another important indicator for progression is dentine hypersensitivity. This can present in different ways in different parts of the mouth. The palatal surfaces of upper incisors shown in *Figure 4* were not sensitive. Possibly because as the tooth was eroded by acids the combination of abrasion (from the tongue, tooth brushing or toothpaste) created a smear layer blocking the dentinal tubules. However, in other parts of the patient's mouth sensitivity is often present indicating that erosion is active. In the same Swiss study quoted before, on average, 34.8% of all patients reported tooth hypersensitivity but 84.6% of those with tooth wear (as measured by wedge-shaped defects) reported hypersensitivity. It is therefore important to examine all tooth surfaces and when erosion is noted in one area the effects might also be present elsewhere. The treatment for dentine hypersensitivity would involve elimination of acidic food and drinks, which are responsible for eroding the tooth, and a de-sensitising toothpaste ideally with a low abrasivity for pain relief.

If tooth wear is accepted to be a relatively slow process, for many patients there is no immediate need to restore the tooth particularly if progression is the patient's main concern. In addition, restorations will eventually fail. Composite restorations for instance have a longevity that approaches 3-5 years[36-38], whereas crowns may last nearer to 10 years[39]. For a young patient, the provision of extensive and destructive restorations is unlikely to survive their life time. A more long term approach involving prevention and monitoring is an equally important outcome[40].

Prevention

In deciding upon a regime of prevention it is important to consider the aetiology of the wear process (*Table 1*). The first stage in any management is to diagnose the cause and then start preventive advice. There is evidence that fluoride may be effective in erosion and abrasion[41,42]. The possible role of fluoride may be to

Table 1 Check list for acid erosion

1. Diagnose the cause of the wear
   - Acid erosion – occlusal and incisal cupping, palatal wear on upper incisors, facial (buccal) changes on upper incisors
   - Bruxism – flat occlusal/incisal surfaces. Accurate inter-digitation of upper and lower teeth, masserteric hypertrophy
   - Abrasion – cervical wear lesions
   - Combination (the most common type) look for aspects from a, b and c
2. Check the diet for:
   - The frequency and amount of acidic foods and drinks
   - The presence of any drinking habits
   - Historical dietary habits
3. Check for gastric causes
   - Heartburn and other symptoms of reflux (epigastric pain, chronic cough, hoarseness)
   - Regurgitation
   - Rumination
   - Eating disorders
4. Classify the tooth wear into – mild, moderate or severe remembering the impact of age
5. Provide reasonable and achievable changes to the diet
   - Do not attempt to radically change dietary habits as research has shown this not to be particularly realistic
   - Attempt to modify dietary patterns. Reducing frequency of acidic intake and stopping any dietary habits
6. Consider adapting oral hygiene habits such as using low abrasivity toothpastes with fluoride
7. Monitor tooth wear with study casts remembering that tooth wear is a relatively slow process and does not always require restorations

harden the tooth surface and increase the resistance to acid dissolution rather than encouraging remineralisation. There may also be some potential for using resin based sealants or bonding agents to reduce the progression of erosion but this hypothesis needs further clinical investigation[43,44] and may have limitations on a public health basis. Providing a Michigan Splint or night guard (a hard acrylic maxillary night guard) would not be effective if the cause was erosion as these devices are generally used for someone with bruxism.

Restoration

The decision on whether to restore the worn dentition is dependant on the patient's needs, the severity of the wear and the potential for progression. From the studies on progression there is no evidence that mild or moderate wear will inevitably lead to severe wear[34]. But what factors are important in progression is not wholly understood. The factors influencing the decision on whether to treat will depend on cost, the patient's needs, influence of society and the complexity of treatment. Since tooth wear is an almost universal experience and the impact of erosion likely to be so important, prevention remains an essential and important component in its management.

When teeth wear, the alveolar bone and associated tissues adapt to the change with a process called alveolar compensation[45]. *Figure 9* shows that the worn upper anterior teeth have maintained occlusal contact with the lower incisors despite losing half their original length. The alveolar bone and soft tissues appear to have moved in an occlusal direction. The results of this wear process are short clinical crowns which cannot be restored conventionally without creating more vertical space. Dahl and other researchers proposed techniques to reverse this process to create the necessary space for crowns[46-48]. When the tooth wear is limited to the anterior region a Dahl appliance or Dahl effect can be used to treat the tooth wear[36,37] (*Figures 10* and *11*). But the restorations have a limited longevity and involve complex treatment.

Conclusion

Tooth wear is a multifactorial process. The impact of wear is usually progressive but can be slow. The wear results in shortened clinical crowns and in conjunction with alveolar compensation complicates treatment. Recognising the early signs of wear and erosion should stimulate the need for prevention in an endeavour to prolong the life of teeth. The presence of dentine hypersensitivity and unstained tooth surfaces is often the only clinical manifestation of active toothwear. Relief of symptoms can generally be gained by the daily use of a desensitising toothpaste, but control of the underlying cause is essential in any management[49].

Figure 9. The palatal surfaces of the upper incisors have been eroded and the lower incisors have apparently over-erupted to maintain contact. This produces short clinical crowns without any vertical space to restore them.

Figure 10. A Dahl appliance cemented to the teeth allows the posterior teeth to over-erupt and the anterior teeth to be intruded so creating sufficient vertical space for anterior crowns.

Figure 11. Once the Dahl appliance is removed after a few months sufficient vertical space has been created for conventional crowns without further need to reduce the incisal/occlusal surfaces of the upper teeth.

There is no doubt that for some patients, restorations are indicated but for others a preventive approach is equally appropriate. The use of a classification based on mild, moderate and severe wear can help with this decision making process. Mild tooth wear would involve dentine exposure on less than 1/3 of the tooth surface and may not require treatment. This level of wear is unlikely to result in the demise of the teeth in the lifetime of patient. Moderate wear with dentine exposed for greater than 2/3rd might require treatment but would depend upon what the patient required. Moderately worn teeth can be monitored for some time and may not need restorations. Severe wear would normally involve secondary dentine exposure and loss of tooth height. This level of wear might normally suggest treatment is indicated. The assessment can be varied for different age groups but remains subjective.

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