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UK National Clinical Guidelines in Paediatric Dentistry: diagnosis, prevention and management of dental erosion

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This revised Clinical Guideline in Paediatric Dentistry replaces the previously published ninth guideline (Shaw L, O'Sullivan E. *Int J Paediatr Dent* 2000; **10**: 356–365). The process of guideline production began in 1994, resulting in first publication in 1997. Each guideline has been circulated widely for consultation to all UK consultants in paediatric dentistry, council members of the British Society of Paediatric Dentistry (BSPD), and to people of related specialities recognized to have expertise in the subject. The final version of this guideline is produced from a combination of this input and thorough review of the published literature. In the case of the present guideline, an internationally recognized expert in the field was invited to be a co-author (AM). The intention is to encourage improvement in clinical practice and to stimulate research and clinical audit in areas where scientific evidence is inadequate. Evidence underlying recommendations is scored according to the SIGN classification and guidelines should be read in this context. Further details regarding the process of paediatric dentistry guideline production in the UK is described in the *Int J Paediatr Dent* 1997; **7**: 267–268.

Background to updated guideline

For the identification of studies included or considered for this review, detailed search strategies were developed for each database searched. These were based on the search strategy developed for MEDLINE but revised appropriately for each database.

Language: the search attempted to identify all relevant studies irrespective of language. No non-English language references were used in the final guideline.

Reference list searching: the reference lists of review articles and standard clinical textbooks were checked for additional studies. The reference lists of included studies were also checked for additional studies.

Hand searching: the following journals were identified as being important to be hand searched for this review: *British Dental Journal, International Journal of Paediatric Dentistry and Community Dentistry and Oral Epidemiology.*

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Introduction

Tooth wear is recognized as a major problem in both children and adults. The triad of erosion, attrition and abrasion has been known for many years but the contribution of erosion to tooth wear may be increasing. Dental erosion is the irreversible loss of dental hard tissue due to a chemical process of acid dissolution but not involving bacterial plaque acid, and not directly associated with mechanical or traumatic factors, or with dental caries. Attrition may be defined as direct tooth-to-tooth contact wear, whilst particles moving across and contacting the tooth surface results in abrasion. Erosion usually co-exists with attrition and/or abrasion, but one of these factors may be more significant than the others, making differential diagnosis difficult.

(B) Epidemiological studies over the past 10 years, both in the UK and abroad, have elucidated the prevalence of dental erosion[1]. Prevalence data from cross-sectional UK studies indicate that dental erosion increases between different age cohorts of young people over time (Table 1)[2–14].

This guideline aims to assist the dentist diagnose, prevent and manage erosion in children, adolescents and adults. This may be

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Table 1. Prevalence studies.

Author	Year of publication (not year of actual survey)	Age of subjects	Sample size	% with exposed dentine	% with palatal/ occulsal/labial dentine exposed	Teeth included	Surfaces
O'Brien *et al.*[2]	1994	5	{17 061}		24	$U1^y$ incisors	Lab/Pal
		12/14			2	$U2^y$ incisors	Lab/Pal
Millward et al[3]	1994	4–5	178	48		All 1^y teeth	All
Milosevic et al [4]	1994	14	1035	30%	8	All 2^y teeth	All
Jones & Nunn [5]	1995	3	135	17		$U1^y$ incisors	Lab/Pal
Hinds & Gregory[6]	1995	1½–4½	1496	–	8	$U1^y$ incisors	Lab/Pal
Smith & Robb[7]	1996	<26–>65	1007	26% with extensive TW		All 2^y teeth	All
Bartlett et al[8]	1998	11–14	210	–	2	All 2^y teeth	All
Williams et al[9]	1999	14	525	11	1	$U2^y$ incisors	Lab/Pal
Walker et al[10]	2000	4–6	363		19	$U1^y$ or 2^y	Lab/Pal
		7–10	500		18	incisors s	Occ
		11–14	518		3	First 1^y or 2^y	
		15–18	345		5	molars	
Al-Dlaigan et al[1]	2001	14	418	52		All 2^y teeth	All
Dugmore & Rock[12]	2004	12	1753	3		Incisors & first molars	Lab/Pal Buc/Occ/Lab
Bardsley et al[13]	2004	14	2351	53	10	All anterior teeth & occ of first molars	Lab/Inc/Pal
Chadwick & Pendry[14]	2004	5	{12698}		22	$U1^y$ incisors	Lab/Pal
		12/15			5	$U2^y$ incisors	Lab/Pal

U = upper; 1^y = primary; 2^y = permanent; Lab = labial; Pal = palatal; Occ = occlusal; Buc = buccal; Inc = incisal.

complex and require interdisciplinary long-term management and liaison with physicians.

1. Aetiology

Ideally, the aetiology of erosion should be identified prior to patient management. This is not always possible because of the difficulty in gaining an accurate and contemporaneous relevant history or because the patient may withhold important information regarding lifestyle or behaviour. Nonetheless, the identification and reduction of risk factors will improve the success of management. It is important, therefore, to question each patient about their medical history and medication with particular reference to gastro-oesophageal reflux disease and vomiting. The dietary intake of acidic foodstuffs may be quite high in certain cases and careful questioning on the intake of specific items of food and drink is necessary (see Table 2). Dietary associations with erosion are present but weak. Future research may establish causal relationships and the influence of co-factors in the erosive process. *In vitro* studies have identified dietary factors with erosive potential but further research is needed to fully understand causal relationships and co-factors that increase the risk of erosion.

Table 2. Dietary items with erosive potential.

Beverages
Carbonated or fizzy drinks excluding ordinary unflavoured sparkling water
Pure fruit juice and cordials excluding Ribena Really Light® (GlaxoSmithKline, Breintford, UK)
Certain alcoholic drinks, e.g. alcopops, cider, white wine
Herbal teas
Foods
Fruits especially citrus, grapes, sour apples
Sauces, e.g. Ketchup, Brown Sauce
Snack foods, e.g. salt & vinegar crisps
Vinegar and pickled foods

1.1 Intrinsic acidic sources

These are of gastric acid origin and may be associated with significant palatal dental

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erosion. Gastric acid enters the mouth secondary to gastro-oesophageal reflux, vomiting or rumination.

1.1.1 **(B)** *Gastro-oesophageal reflux disease (GORD).* This is common with up to 7% of adults in the Western World affected daily and one third every few days. It is known to cause erosion in susceptible patients and should always be considered a possible cause for erosion in the presence of indigestion, heartburn or epigastric pain[15]. Dental erosion in relation to GORD is less of a problem in children. This may be due to a shorter history of GORD or that refluxing is limited to the oesophagus (Table 3)[16–18].

1.1.2 Vomiting. Vomiting may be spontaneous or self-induced and is often associated with an underlying medical condition. In children, cyclic vomiting syndrome is recognized to be linked with irritable bowel syndrome, motion sickness, migraine and epilepsy[19]. These prolonged bouts of vomiting, lasting weeks, can begin in pre-school children, occur throughout child development and reduce in frequency by adulthood. It is, therefore, self-limiting.

(C) Self-induced vomiting is the commonest form of purging and weight loss in the eating disorders of anorexia and bulimia nervosa. Teenage females are particularly prone to abnormal eating behaviours. Athletes including professional jockeys have also been reported to engage in this habit.

Table 3. Principal causes of gastro-oesophageal reflux.

Sphincter incompetence
Oesophagitis
Alcohol
Hitus hernia
Pregnancy
Diet
Drugs, e.g. Diazepam
Neuromuscular, e.g. cerebral palsy
Increased gastric pressure
Obesity
Pregnancy
Ascites
Increased gastric volume
After meals
Obstruction
Spasm

1.1.3 Rumination. **(C)** The ability to relax the lower oesophageal sphincter, reflux gastric contents into the mouth and re-swallow is uncommon but has been reported[20].

1.2 Extrinsic acidic sources

1.2.1 Drinks. **(B)** Much emphasis has been placed on healthy food and drink in recent years with evidence that dietary practices and habits have changed[21]. The consumption of soft drinks with erosive potential, particularly in young age groups, is significant[22,23]. Evidence linking dental erosion with soft drink consumption is now emerging[24]. Some alcoholic drinks, such as dry wine, cider and alcopops are also acidic[25–27]. Alcohol consumption is linked with gastric reflux and erosion may therefore be from intrinsic and extrinsic sources[28]. Carbonated beverages, fruit juices, including so-called smoothies, and fruit flavoured mineral waters, are tangy or refreshing because of the acidity. Carbonated mineral water (sparkling water) has negligible erosive potential.

1.2.2 Foods. **(B)** Fresh fruit, and in particular citrus fruit, have erosive potential as do foods pickled in vinegar. Less well known is the influence of covert acids in food stuffs that have been associated with erosion in teenagers e.g. brown sauce, crisps, ketchup, and vinaigrette[29].

1.2.3 Medication. A number of medications such as vitamin C, aspirin and some iron preparations are acidic[30]. Furthermore, many medications induce a dry mouth and some induce nausea and vomiting. This potential co-morbidity has not been investigated widely.

1.2.4 Lifestyle. Active lifestyles, leisure and fashion trends can be associated with greater risk of erosion[31,32]. The use of mood enhancing drugs such as ecstasy increases the risk of dental erosion/tooth wear[33,34].

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1.2.5 Environmental. Work related exposure to acids can result in dental erosion[35].

1.3 Predisposing factors

(B) Although the aetiology of erosion is acidic substances from a variety of sources, there are some individual factors that may predispose to erosion, or indeed be protective. Saliva rates, buffering capacity and differing clearance rates from various parts of the mouth may modify the severity and distribution of erosion[36].

2. Presentation and diagnosis

Although acid erosion may affect any surface, it predominates on the maxillary teeth. Few studies have investigated the site specificity of dental erosion but most reports indicate that the incisal, palatal and occlusal surfaces are commonly affected with buccal or labial surfaces also being involved. As enamel becomes thinner, chamfered ridges or ledges within enamel are visible and can be felt with a probe.

(C) Cusp tips may be cupped and incisal edges become grooved with discrete areas of exposed dentine, which increase in area as the erosion progresses. There may also be incisal chipping and teeth may appear darker as dentine is exposed. Patients complain of poor aesthetics once a significant volume of enamel and dentine becomes lost, resulting in shortened upper teeth and/or dentinal exposure. This is the common complaint on presentation rather than sensitivity or any functional difficulty. A diagnosis of dental erosion is made more difficult because of the triad of wear mechanisms and therefore careful history taking is important.

3. Management

Early diagnosis may stop the progress of erosion providing patients comply with dentists' advice. Careful examination of the most susceptible surfaces (upper labial and palatal aspects of all upper teeth, occlusal surfaces of the lower first molars) under good lighting and on dry teeth facilitates diagnosis.

(C) The main thrust of prevention is to change lifestyle and to record and monitor the erosion. A 'wait and see' philosophy is recommended especially if patients have no complaints regarding pain/sensitivity, function or aesthetics.

3.1 Patient information leaflets

These may be useful and allow the patient to 'go over' risk factors, behaviours etc in their own time. Some companies produce patient information leaflets or they can be made 'in house'.

3.2 Recording erosion

In children, study casts and photographs aid the monitoring of dental erosion. In adults, these methods are also satisfactory although safe storage of study casts can be problematic. A silicone putty impression of the worst affected area is more readily stored with the patient notes and may be a helpful tool to assess progression.

(C) At a subsequent recall appointment, the putty index is sectioned labio-palataly and placed over the teeth. Any gap between the putty index and the tooth surface indicates progress of the erosion/wear and possible poor compliance with lifestyle changes. In children, growth and dento-alveolar development will preclude accurate seating of a putty index at review. A recall interval of 1 year is reasonable.

Epidemiological indices such as the Tooth Wear Index are tools for population based surveys but are not really applicable to monitoring at the individual patient level[37]. Dentists who use epidemiological indices to monitor wear should be aware of the diagnostic criteria and the need to maintain good intra-examiner reproducibility.

3.3 Dietary analysis

It is recommended that patients keep a minimum 3-day diet diary to include a weekend, times of food/drink consumption and bedtime. This is then subject to analysis by the dental healthcare professional.

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3.4 Dietary counselling

(C) This must be tailored to the individual and is only possible after the diet has been thoroughly assessed. Specific points to emphasize are the limitation of acidic food and drinks to mealtimes. This is the time of maximum salivary flow and increased buffering capacity. Clear explanation of the difference between erosion and caries is often advisable as the public confuse these terms and believe them to be synonymous. This is especially relevant to artificially sweetened diet drinks, which can be as acidic as normal varieties. Chewing sugar free gum increases salivary flow and encourages tooth remineralization[38]. Finishing a meal with cheese or milk will neutralize intra-oral acid[39].

3.5 Behaviours

The habit of frothing or swishing drinks around the mouth is likely to increase the risk of dental erosion and it is advisable that drinks are consumed quickly or, if consumed slowly, a wide bore straw placed toward the back of the mouth is advisable in order to reduce contact of acidic fluid with the teeth[40,41].

3.6 GORD and vomiting

Many patients with GORD self-medicate with over-the-counter medicines. Dentists should refer, with their permission, to the patient's GMP or a gastroenterologist.

(B) Subjects with an eating disorder should receive appropriate medical help and psychological counselling although care is needed regarding the maintenance of confidentiality in teenage patients.

3.7 Oral hygiene, remineralization and desensitization

3.7.1 Fluoride mouth rinses, varnishes and desensitizing agents, are recommended to aid remineralization and decrease sensitivity[42,43].

3.7.2 High fluoride concentration toothpaste (caution in children under 6 years)[44].

(C) 3.7.3 Appropriate oral hygiene technique and low abrasive toothpaste[45].

3.7.4 Sugar free chewing gum to increase salivary flow and aid remineralization[38].

3.7.5 Dentine bonding agents applied to areas of exposed dentine[46].

4. Restorative treatment

Ideally, in both children and adults aetiological factors should be identified and brought under control. This may involve a period of monitoring as previously outlined before definitive restorative treatment is commenced. Clearly, the patient's desire to improve appearance and/or reduce sensitivity may hasten the start of interventional treatment.

4.1 Primary dentition

In the primary dentition, if the child is not experiencing any symptoms restorative treatment is not indicated. However, if teeth are sensitive, small areas of erosion may be covered with composite resin.

(C) Larger areas may require placement of composite crowns on anterior teeth and preformed metal crowns on posterior teeth. For severe symptoms, extraction of the offending teeth may be necessary.

4.2 Mixed dentition

In the mixed dentition stage, the permanent dentition should be treated conservatively by either long-term monitoring or the addition of dental composite resin to eroded surfaces. The adaptive capacity of the stomotognathic system during growth may be greater than in adulthood and thus restoration of the eroded occlusion including guiding surfaces has not resulted in reports of post-operative problems.

(C) Minimal space is required to bond composite resin without increasing the occlusal vertical dimension (OVD). Cupped and grooved surfaces can be restored to the

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enamel rim, which does not usually involve an increase in OVD. Dentine surfaces should be cleaned with pumice/water or slow speed rosehead burs prior to etching in order to remove the salivary pellicle and enhance bonding resin infiltration/penetration of sclerotic dentine. The poly-alkenoates or glass ionomers are themselves susceptible to acid erosion/dissolution and have no application in the eroding dentition[47].

4.3 Permanent dentition

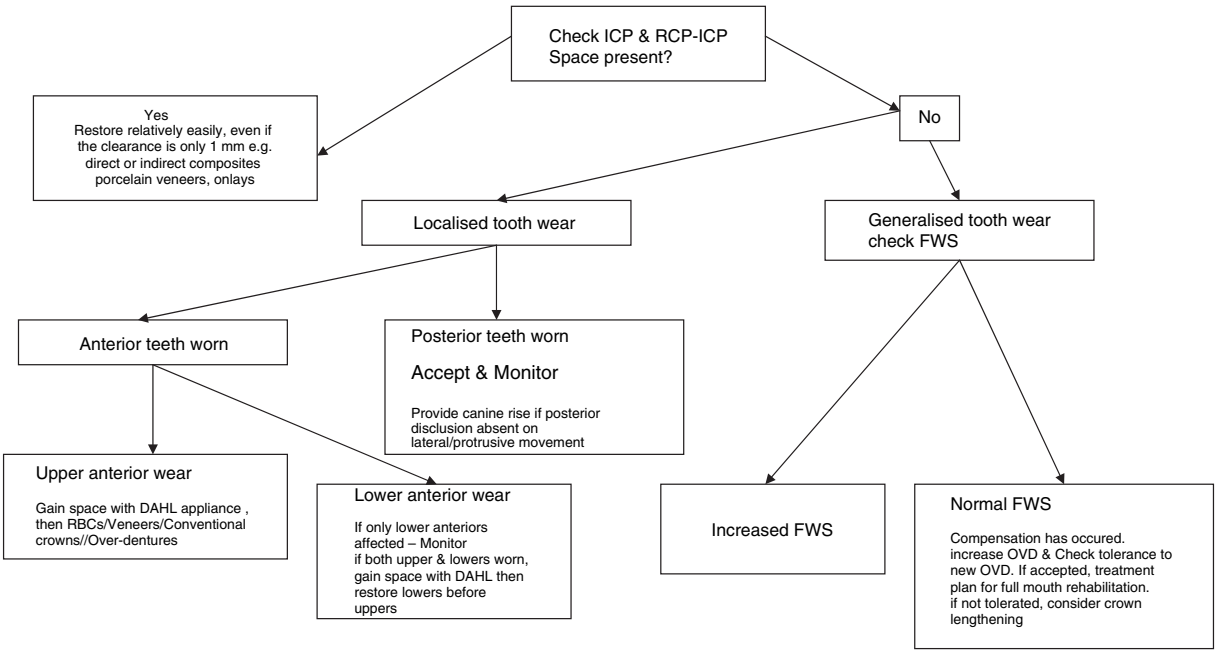
The management of erosion in the permanent dentition follows the guidance in the previous section.

(C) Assessment of the space in intercuspal position (ICP) is essential. The bonding of composite resin is reversible, reduces any sensitivity and improves appearance. Eroded labial, buccal and palatal surfaces can be restored with composite, veneers or dentine bonded crowns. Cupped occlusal sites are very amenable to composite in-fill. A flow chart to aid treatment planning is shown in Fig. 1.

4.3.1 Palatal erosion of upper anterior teeth with no inter-occlusal space. The well-established management of this difficult restorative problem has been to provide a removable Dahl appliance[48]. This is, in effect, an anterior bite platform which provides a posterior open bite. It allows relative extrusion of posterior teeth and intrusion of anterior teeth in order to gain space for the restoration of shortened, eroded upper anterior teeth.

(B) Good patient understanding of the treatment is a prerequisite for success of this technique. Once space has been gained then restoration of the anterior teeth may be carried out by a variety of means. Clinical studies have supported the concept of restoring the worn upper anterior teeth at an increased OVD without the interim stage of a removable Dahl appliance as the restorations themselves have a Dahl effect[49]. Localized temporary increases in the occlusal vertical dimension are extremely well tolerated and have become entirely predictable as a treatment modality.

4.3.2 Generalized erosion. Generalized erosion of many surfaces may also result in mandibular over-closure, but in many cases compensatory over-eruption is likely to maintain the existing OVD. Evaluation of the FWS (Free Way Space) has also been recommended in



ICP = intercuspal position; RBC = resin bonded crown; FWS = free-way space; RFH = resting face height; OCV = oclusal vertical dimension

Fig. 1. Flow chart to aid treatment planning for tooth wear.

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order to determine the need or otherwise of encroaching upon it in order to restore the teeth.

(B) It is considered that in situations where the FWS is normal, management is more difficult. Restoration of worn teeth results in an increased OVD and the interim use of an acrylic appliance at the desired new OVD has been recommended. Clinical studies in adults have not reported any long term increase in temporomandibular dysfunction (TMD) or dental problems[50–53].

Restoration may be by way of conventional crown work or the application of adhesive technology such as composites or resin/dentine bonded crowns. Caution must be exercised in cases where full mouth rehabilitation is planned. Whereas application of bonding techniques is regarded as reversible involving minimal preparation, the preparation of multiple teeth for conventional crown-work requires great care in planning and execution.

Explanatory notes

1. Aetiology

1.1 Intrinsic acid sources

1.1.1 Gastro-oesophageal reflux disease. Reflux is the passive or effortless movement of regurgitated acid into the mouth. Vomiting involves a host of physiological events, co-ordinated in the medulla, resulting in the forceful propulsion of stomach and upper intestinal contents toward the mouth. Hypersalivation is a feature of both. Signs and symptoms associated with reflux are heartburn, retrosternal discomfort, epigastric pain and dysphasia.

(B) Symptoms are not, however, reliable indicators of the presence or absence of GORD. Patients may be symptom free despite continuation of reflux and are described as silent refluxers. These patients can remain undiagnosed. Nearly 25% of adult patients presenting with extensive palatal erosion had pathological GORD diagnosed by standard criteria but did not have any symptoms of reflux[15]. In silent reflux, therefore, dental erosion may be the only clinical sign that reflux is occurring. Excessive intake of alcohol, carbonated drinks and certain foods such as spicy food, and fatty food can provoke GORD. Neurologically impaired children have significantly higher levels of gastric reflux than healthy children with over 70% of children with cerebral palsy having abnormal reflux activity[16].

The following are indications for referral to gastroenterology: (i) if symptoms interfere with daily life; (ii) previous tests for GORD were either inconclusive or equivocal; (iii) if after elimination of dietary factors and after a period of review, erosion progresses; (iv) when there is no other obvious cause of erosion; and (v) severe erosion is present, which may be unilateral and affecting buccal surfaces.

1.1.2 Vomiting. Vomiting may be spontaneous or self-induced and may be associated with a variety of medical problems. The prevalence of eating disorders (anorexia and bulimia nervosa) appears to be rising. Although it is often relatively easy for dental personnel to recognize these disorders, initiation of medical help is a sensitive undertaking.

(B) In eating disorders, the frequency and duration of self-induced vomiting and the product of the two, the total number of vomiting episodes, were not linearly associated with the severity or number of eroded teeth[54].

1.2 Extrinsic acid sources

1.2.1 Drinks. Mean consumption figures of soft drinks can hide important facts. Soft drink intake is much higher in younger age groups: soft drinks have been reported to provide as much as one fifth of the added sugars in the diet of 11–12-year-old children and 42% of fruit drinks are consumed by children age between 2 and 9 years[55]. Titratable acidity and the pH of the drink are important in evaluating the drink's erosive potential.

(B) Frequency of, rather than total intake, may be critical in the erosive process. Drinks from a feeding bottle, used as a comforter, may be particularly harmful to infants

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with reported extreme dental destruction resulting from abuse of fruit juices[56]. It is apparent, therefore, that those most likely to show the effects of erosion in the dental tissues from excessive fruit juice intake are children. Patterns of dietary intake in early life may well continue into adult life. In 1995 it was projected that 12 to 25-year olds would be drinking 50% more soft drinks by 2000.

1.2.3 Medication. An early report highlighted the erosive potential of chewable vitamin C tablets as well as iron preparations[30]. It is unlikely that these are in widespread use amongst children and adult population groups.

1.2.4 Lifestyle. It is not just the total exposure to acidic substances that appears to have increased in recent years; there have also been changes in habits and general lifestyle. Undoubtedly there has been increased emphasis on a healthy diet and this involves a necessary increase in fruit and vegetable consumption. National campaigns for healthy eating have emphasized the importance of eating five pieces of fresh fruit or vegetables per day. More people are becoming vegetarian and this tends to be a more acidic diet. Lacto-vegetarians were reported to have significant dental erosion although the study has not been repeated in order to confirm this association[57].

The frequency of intake of food is changing with greater numbers of snacks being consumed and a reduction in the number of meals eaten at home. This is commonly known as 'grazing'. A habit of frothing up carbonated beverages in the mouth has also developed along with constant sipping from canned drinks.

Encouragement to take regular exercise is of benefit to general health but excessive and frequent consumption of acidic sports drinks is not to be recommended.

In a multi cultural society there will be different habits, various traditional drinks, varieties of food not necessarily indigenous to the UK and different methods of food preparation. Little is known about these influences on dental erosion.

Slaking palm with lime juice, betel nut chewing, crunching of chicken bones to savour the bone marrow have all been reported to increase the risk of tooth wear and erosion. Although not common amongst western cultures these habits will be common amongst other cultures that live in the western world. Dentists should be aware of these cultural differences and question patients about any habits that may increase the risk of tooth wear.

1.2.5 Environmental. In adults, extrinsic acid sources include environmental causes such as contact with acids as part of work or leisure activity. Although reports of dental erosion in battery workers, sheet metal workers, laboratory technicians, professional wine tasters and competitive swimmers have been made, environmental factors are probably not common risks for dental erosion[31,35,58].

3.0 Management

3.4 Dietary counselling

Counselling can only be given after thorough dietary analysis. It must be tailored to the individual on a positive basis to maximize compliance. Avoidance of acidic food and drink between meals, at bedtime and during the night is highly recommended. Although there is huge individual variation in salivary flow and buffering capacity it has been suggested that the use of chewing gum may help increase salivary flow and aid enamel remineralization[38]. Finishing a meal with milk or cheese is also useful as this will help bring the oral environment back to a neutral pH[39].

3.7 Oral hygiene, remineralization and desensitization

(B) Toothbrushing should be delayed for at least 20 min after an erosive attack and possibly up to 60 min because of the increased risk of abrasive wear on the softened/eroded surface[59,60.]

Patients with significant erosion and dentine exposure may complain of tooth sensitivity. It may also be an indication that the

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erosion is still active. The use of fluoride mouth rinses and varnishes are helpful but they must be used frequently and regularly. A high fluoride toothpaste may be helpful as long as it is not also highly abrasive. Other products such as specially formulated toothpastes for sensitive teeth or Tooth Mousse®, (GC UK Ltd, Newport Pognell, UK) may also be useful.

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