IN BRIEF

- Prevention is a fundamental element of clinical practice. This is the first in a series of papers which will review and update the evidence base for preventive action in general dental practice.
- One important, but underdeveloped area of prevention is smoking cessation. Smoking and tobacco use adversely affects oral health in a variety of ways. The dental profession and their teams have a potentially important role to play in helping smokers to quit.
- This paper aims to review the practical steps that the dental team can implement in smoking cessation activities within the clinical dental setting.

1

Prevention. Part 1: Smoking cessation advice within the general dental practice

R. G. Watt[1] and B. Daly[2]; Series Editor E. J. Kay[3]

Smoking remains the largest single preventable cause of death and disability in the UK and costs the NHS £1.7 billion each year.[1] More than 120,000 people die prematurely due to smoking related diseases. Worldwide smoking is the single most important public health problem. The detrimental effects of smoking and tobacco use on oral health are well recognised. Oral cancers and pre-cancers, periodontal diseases and poor wound healing are the most significant and serious effects of smoking on the mouth.[2,3] In addition, staining of the teeth, soft tissue changes and halitosis are aesthetic and social impacts of smoking directly related to oral health.

PREVENTION

1. Smoking cessation advice
2. Dietary advice
3. Prevention of tooth wear
4. Toothbrushing advice
5. Patients requiring osseointegrated oral implant treatment
6. Older dentate patient
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Recently published evidence-based guidelines on smoking cessation have highlighted the important role that health professionals can play in helping smokers to stop successfully.[4] Systematic reviews of many randomised controlled trials have shown the effectiveness of smoking cessation advice provided by general medical practitioners. On the recognised hierarchy of evidence, these would be classified as Type 1 evidence. Relatively few well designed studies have been undertaken to assess the effectiveness of dental professionals in smoking cessation activities although the success rates achieved are comparable with studies in other primary care settings.[5,6] Indeed factors such as access to smokers, level of training, experience and commitment are more important in determining success than professional discipline.[7]

Although many dentists express positive attitudes to becoming actively involved in smoking cessation activities with their patients, few routinely assist smokers to stop.[8,9] This paper aims to outline ways in which dental practitioners and their teams can support smokers to effectively quit. Very limited time is required when assistance and support is provided in a standardised way to those smokers interested and willing to stop. Involvement in smoking cessation provides an opportunity for dentists to become engaged in an interesting, relevant and important area of prevention.

WHO SMOKES ANYMORE?

In the UK around 28% of the adult population smoke, that is over 13 million smokers.[10] Although the overall rate of smoking has declined steadily since the 1940s, smoking is now increasingly restricted to the more disadvantaged sections of society. For example, in 1996, 12% of men in professional occupations smoked compared with 40% of men in unskilled manual jobs.[11] Although dental attendance is inversely related to deprivation, many smokers will be seen by general dental practitioners.

Across many parts of the developed world concern has been expressed about the continuing problem of teenage smokers, especially amongst young women. The vast majority of adult smokers start during their adolescence. Once started, although many smokers report a desire to give up, they will become addicted to nicotine and will spend years struggling to break the habit.

TIME FOR ACTION

Based upon a systematic review of the scientific evidence, a smoking cessation protocol has been published and updated to encourage health professionals, including dentists to become more actively involved in smoking prevention.[4,11] The 4 A's model is a straightforward and quick means of identifying smokers who want to stop and how best to help them achieve their goal (Fig. 1).

Advice and support provided in a clinical setting will be most effective with patients who are interested and keen to make a quit attempt. Pressurising 'contented' smokers will most often achieve very little. It is essential to tailor advice and support to smokers who are ready and willing to change their behaviour. The use of appro-

Table 1 Questioning techniques and styles

- Use both closed and open questions, as appropriate, depending on what information you require
- Give patients time to answer your questions – don't rush them!
- Encourage patients to speak openly and honestly
- Take care not to be seen as nagging or judgemental – this achieves nothing
- Sum up any information given to you to check you have understood what has been said

priate questioning techniques is therefore very important (Table 1).

The different steps in the 4 A's model will now be outlined.

Ask

All patients should have their smoking status checked at the start of each course of treatment. A simple and quick system should be devised to record smoking details in the patient's clinical notes. This information should be kept up to date as possible. The following questions can be used within a standard medical history to assess whether the patient smokes, their level of nicotine addiction and their motivation to stop.

Are you a smoker?
How many cigarettes do you smoke each day?
How soon after waking up in the morning do you have your first cigarette?
Have you ever tried to stop smoking?
Are you interested in stopping now?

Patients who report smoking more than 20 cigarettes per day and who have their first cigarette within 30 minutes of waking up in the morning are likely to be heavily dependent upon nicotine and will require more specialised and intensive support. These individuals are best referred to the local specialist services for help.

Advise

All smokers and those using other forms of tobacco should be advised of the value of stopping. The advice should be clear, firm and personally relevant. Although most people are aware of the harmful effects of smoking in relation to lung cancer and heart disease, fewer people know about the detrimental effects of smoking on their oral health.[12] This provides a unique opportunity for dentists and members of the team to highlight the dangers of smoking in what could be considered an appropriate setting, the dental surgery. Scarring patients with frightening images of diseased organs may not be effective for many people. Instead a range of reasons for stopping smoking could be highlighted, some directly related to oral health, others more general (Table 2). Consider what is likely to be most significant and relevant to the patient. For example, stained teeth, halitosis and soft tissue changes in the mouth may be especially pertinent to young people. The early effects of tobacco use on the mouth are visible and reversible and may be a useful means of motivating smokers on the benefits of stopping. All smokers however will have their own good reasons for stopping.

Assist

If during the first two stages a smoker expresses a desire to quit, help and support should be offered. For those smokers not ready or willing to give up at this point, it is best raising the issue again at a later stage to check if they have changed their opinions. Putting pressure or nagging smokers who are not ready to quit can be counterproductive and a waste of your and their time.

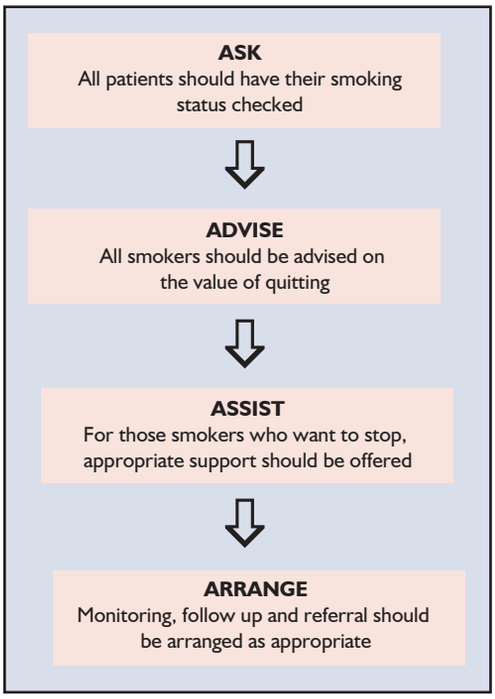

Fig. 1 The four A's approach to smoking cessation

Assistance for those wishing to quit should focus on the following points:

- Negotiate a quit date – smokers need time to prepare
- Review past experiences of quitting – identify what helped and hindered progress in the past
- Identify any potential problems ahead and plan how these can be dealt with
- Stress the importance of enlisting the support of friends, family and colleagues – their assistance is essential
- Explore the value of using nicotine replacement therapy and Bupropion (Zyban) (see below for further details)
- Give details of telephone support lines which can provide on going support and encouragement (see the box on the adjacent page for a list of useful phone numbers)

Arrange

Monitoring progress is an essential part of successful cessation. Arranging a follow up is therefore very important. Evidence indicates that ideally patients should be initially seen 1-2 weeks after their quit date. This may fit in with a subsequent dental appointment for on going treatment or a visit to the hygienist. At this early stage people need support and encouragement. Congratulate patients who have managed not to smoke over this period. Praise and encouragement can help motivate and maintain patients determination to succeed.

Those patients who have smoked since their

Heirarchy of evidence

Type 1
Systematic review of at least one randomised controlled trial (RCT)
Type 2
At least one RCT
Type 3
Non-randomised intervention studies
Type 4
Observational studies
Type 5
Traditional reviews, expert opinion

Table 2 Potential reasons for quitting smoking

- Reduce risk of halitosis
- Improve appearance – less staining on teeth, better skin texture
- Save money
- Feel better and more energetic
- Break dependence on tobacco
- Reduced risk of cancers and heart disease
- Better periodontal health – greater chance of retaining teeth for life
- Reduced risk of oral cancers
- Improved success with surgical treatments

quit date need your support and encouragement too. Most smokers make several attempts to stop before finally succeeding. Through sensitive questioning it is important to find out what happened and any lessons that can be drawn from the experience. This will help them in future attempts to predict possible problems and increase their confidence to succeed.

Some smokers who are heavily dependent on nicotine may require more specialist and intensive support to quit. Across the country specialist smoking cessation services have been established to provide assistance to these individuals. Dentists can refer patients to these services, details of which should be available with the local Primary Care Trust or Health Promotion Service.

IMPORTANT AIDS TO SUCCESS

A range of factors make quitting smoking a difficult task for many people. One of the most important problems is the powerfully addictive nature of nicotine. Nicotine replacement therapy (NRT) can help people cope better with their cravings for nicotine, particularly moderate smokers. The use of NRT doubles a persons cessation success rate. A range of NRT products are available including patches, gums, nasal sprays, inhalators and microtabs. Recently a NRT lozenge product has also been launched. The choice of product largely depends on personal preference. NRT products have recently been made available on prescription which has helped improve access by reducing their cost, which was previously a significant barrier to their use especially amongst low income smokers.

Bupropion (Zyban), although originally developed as an anti-depressant in the US has now been licensed as a pharmaceutical treatment for tobacco dependence. A meta analysis of published trials demonstrate that the drug improves 12 month abstinence rates and reduces the severity of withdrawal symptoms.[13] The drug is available on prescription through GPs and specialist smoking clinics.

SMOKING CESSATION WORKS

The evidence base demonstrating the value of smoking cessation in primary care settings is very strong, based upon the findings of a number of randomised clinical trials.[4] Very brief advice lasting less than 3 minutes given by a health professional will help an additional 2% of smokers to successfully stop smoking each year. With more intensive support lasting up to 10 minutes, plus NRT, an additional 6% of smokers will quit.

A quit rate of 2% or even 6% may seem rather insignificant. However when translated into a population estimate, between 63,000 and 190,000 people may quit smoking each year in the UK if all general dental practitioners routinely offered smoking cessation advice based on the 4 A's model to those seeking dental care.[11] Such an impressive achievement for the dental profession can be achieved through the routine adoption of a straightforward and relatively quick protocol.

MOVING THE AGENDA FORWARDS

A range of barriers have been reported by dentists to explain the low level of routine involvement in smoking cessation activities within dental practices despite positive attitudes.[6,9,14–16] The main barriers include time and cost pressures, lack of knowledge and confidence, concerns over impact on dentist-patient relationship, doubts of the effectiveness of interventions and lack of resources for use in dental settings. How can these barriers be overcome? Table 3 outlines a variety of factors to facilitate future action.

Table 3 Facilitators for action with smoking cessation

- Reimbursement – introduction of smoking cessation fee item into GDS payment schedule
- Professional development – expansion of training opportunities in a range of topics from communication skills to knowledge of smoking treatments
- Team working – delegation of roles and responsibilities and development of team approach
- Improved communication – between staff on roles and responsibilities, with patients on relevance of oral health and smoking, and with history taking and clinical note keeping
- Multi-disciplinary working – referral of cases to specialist support when required
- Resource development – need for relevant materials for history taking and support materials for patients
- Research – need for improved evidence base on effectiveness of smoking cessation within dental settings

CONCLUSION

Smoking is the single most important public health challenge facing the NHS. The continued toll of suffering, disease and premature death resulting from tobacco use requires effective and concerted action. The government launched a national anti-smoking strategy in 1998 to co-ordinate action across the health service and beyond.[17] Dental professionals have been identified as having an important role to play in supporting smokers who desire to quit. Evidence- based guidelines provide a clear way forward for all health professionals to become engaged in this important area of prevention.[4,7] A reduction in smoking levels would improve both general and oral health,

Between 63,000 and 190,000 people may quit smoking each year in the UK if all GDPs routinely offered smoking cessation advice

Telephone support lines

Quitline
0800 00 2200
NHS Smoking Helpline
0800 169 0169
NHS Pregnancy Smoking Helpline
0800 169 9169

and would help to reduce widening inequalities across the population.

RECOMMENDATIONS ON SMOKING CESSATION WITHIN DENTAL SURGERIES

1. Tobacco use is a recognised risk factor for a host of conditions including a range of oral diseases (Type 1 Evidence).
2. Dental professionals should establish the smoking status of their patients on a regular basis (Type 3 Evidence).
3. Dental professionals should advise all smokers to stop and emphasise the oral health benefits of quitting (Type 3 Evidence).
4. Smokers who are interested and motivated to quit should be given appropriate assistance by dental professionals (Type 3 Evidence).
5. Smokers attempting to quit should be monitored and supported. Dental professionals should refer heavy smokers or those with complex needs to specialist smoking cessation services (Type 3 Evidence).

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IN BRIEF

- Nutrition plays a central role in the aetiology of a range of chronic conditions. It is essential that any dietary advice given to promote oral health is in accordance with general nutritional messages.
- Although few high quality studies have successfully altered the diet to promote oral health, evidence-based guidelines in other areas of nutrition provide a useful guide to providing dietary support in a clinical dental setting.
- The aim of this paper is to review the evidence linking diet to oral health and to outline the steps involved in providing dietary advice and support to dental patients.

2

VERIFIABLE CPD PAPER

Prevention. Part 2: Dietary advice in the dental surgery

R. G. Watt[1] and P. McGlone[2]; Series Editor E. J. Kay[3]

Oral health is directly related to diet and nutrition. Dental caries remains the most significant dental public health problem in the UK and concerns have been expressed over the potentially rising prevalence of erosion. Both these conditions are linked to dietary factors. The dental professional and their teams therefore have a role to play in supporting their patients in adopting appropriate dietary habits.

PREVENTION

1. Smoking cessation advice
2. **Dietary advice**
3. Prevention of tooth wear
4. Toothbrushing advice
5. Patients requiring osseointegrated oral implant treatment
6. Older dentate patient
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Reviews of oral health education and promotion interventions have highlighted the limited number of high quality studies aimed at altering diet to promote oral health.[1-5] However better quality evidence from randomised controlled trials with other primary health care professionals have highlighted the impact of dietary advice on changing dietary patterns.[6] Evidence-based guidelines now outline ways of helping patients improve their diets. This paper will provide an overview of the importance of diet on oral health and outline practical steps that can be taken within primary dental care settings to promote healthier eating patterns. The provision of dietary advice in dental practices also provides an ideal opportunity to involve and develop a team approach to patient care.

EVIDENCE ON DIET AND ORAL HEALTH

A great deal of research has been undertaken over many years into the relationship between diet and oral health. Although the totality of evidence is clear with an international scientific consensus, media coverage still frequently highlights the findings of controversial and isolated studies. As health professionals, dentists should base any advice they provide to their patients on the scientific consensus view.

Many different terms have been used to name and classify sugars. This has caused a degree of confusion amongst both the general public and health professionals. In recognition of this an expert Government committee (COMA) have recommended a revised naming system which has now become the standard classification of sugars in the UK.[7] The COMA classification is based upon where the sugar molecules are located within the food or drink structure. Intrinsic sugars are found inside the cell structure of certain unprocessed food stuffs, the most important being whole fruits and vegetables (containing mainly fructose, glucose and sucrose). Extrinsic sugars, in contrast are found outside of the cells of the food and drink. There are two types of extrinsic sugars, milk extrinsic sugars and non milk extrinsic sugars (NMES). The extrinsic milk sugars include lactose found in dairy products such as milk and milk products. NMES are found in table sugar, confectionery, soft drinks, biscuits, honey and fruit juice.

Table 1 summaries the evidence on diet and oral health based upon expert scientific reviews.[7,8]

Based upon the available evidence, consensus recommendations advocate the following points:[7,8,10,11]

- The frequency and amount of NMES should be reduced. NMES consumption should be restricted to mealtimes when possible.
- Limit consumption of NMES to a maximum of four times a day
- NMES should provide no more than 10% of total energy in the diet and not exceed 60 g per day per person
- Consumption of intrinsic sugars and starchy

Table 1 Consensus view on diet and oral health

- The influence of the diet is more important after the teeth have erupted. The pre-eruptive effect of diet on oral health is minimal.
- Non milk extrinsic sugars (NMES) are highly cariogenic.
- Frequency of eating/drinking NMES is important in caries development. However, frequency of intake and amount consumed are closely correlated.
- Intrinsic sugars eg fresh fruits and vegetables and cooked staple starchy foods such as rice and potatoes are of low cariogenicity. Milk extrinsic sugars eg milk are virtually non cariogenic.
- Alternative or non-sugar sweeteners (bulk and intense) are non-cariogenic.
- Frequent consumption of acidic drinks may be linked to the development of dental erosion

Modified from Rugg-Gunn[9]

Table 2 Eight guidelines for a healthy diet

1. Enjoy your food
2. Eat a variety of different foods
3. Eat the right amount to be a healthy weight
4. Eat plenty of foods rich in starch and fibre
5. Eat plenty of fruit and vegetables
6. Don't eat too many foods that contain a lot of fat
7. Don't have sugary foods and drinks too often
8. If you drink alcohol, drink sensibly.

Health Education Authority, 1997[12]

As health professionals, dentists should base any dietary advice they provide to their patients on the scientific consensus view

foods should be increased to five pieces/portions of fruit/vegetable per day.

It is essential that any dietary advice provided by dental health professionals is in accordance with general nutritional recommendations for good health (Table 2).[12,13] Oral health advice on diet must therefore not result in any increases in, for example, saturated fat intakes. In the past, well meaning oral health advice on reducing sugary snacks often resulted in an increase in fatty snacks such as crisps.

OVERVIEW OF SUGARS CONSUMPTION

Sugar has played a prominent role in British economic and political history for many centuries. In recent decades the pattern of eating in the UK has changed radically in response to wider social changes across society. From a peak in consumption in the 1950s following relaxation of war-time rationing, sugar consumption has gradually reduced. However a radical change has taken place in the pattern of consumption. There has been a large reduction in consumption of visible or table sugar (added to tea/coffee, breakfast cereals etc) and instead an increase in hidden sugars consumed in processed or manufactured foods and drinks.[14] These changes have important implications for preventive actions to promote health. Table 3 lists the sugars contents of certain popular foods and drinks.[14]

The majority of the UK population consume more NMES than the recommended 60 g/day, although many want to reduce their intakes, often to lose weight. Particular concern focuses on the high levels of consumption amongst pre-school children, adolescents and older people. A range of barriers prevent individuals from changing what they eat (Table 4). Indeed certain groups in society have limited control over what they chose to eat. It is important for health professionals to be aware of the factors influencing their patients' dietary patterns. Taking a detailed history, setting realistic goals and monitoring any change are all essential steps in supporting patients in altering their eating habits.

EVIDENCE ON DIETARY INTERVENTIONS IN PRIMARY CARE

Very few well designed dietary interventions have been undertaken within primary dental care settings to demonstrate the effectiveness of different interventions.[1–5] This does not mean that there is no point in dentists providing dietary advice. Instead it highlights the need for better quality research into this area. Population-based interventions have shown that sugar consumption can be substantially reduced through the introduction of policy guidelines.[15] This demonstrates that sugar consumption is amenable to change given appropriate support.

A larger body of research has been undertaken to change dietary risk factors for systemic conditions such as cardiovascular disease and stroke. In a meta analysis of studies aimed at reducing dietary risk factors through advice in primary care settings, modest dietary changes were achieved which were estimated would result in a 14% reduction in CHD incidence and a 9% reduction in the incidence of stroke.[6] A systematic review of dietary interventions in primary care has highlighted characteristics of effective dietary interventions (Table 5).[16]

The challenge for the dental profession is how to translate these general guidelines into action that will facilitate a reduction in NMES consumption. The following section will outline practical steps dental practitioners and their team members can adopt to support patients adopt healthier eating patterns.

STEPS IN DIETARY COUNSELLING

Based upon evidence-based guidelines,[16] a six step model can be followed to ensure that

Table 3 NMES content of popular foods and drinks

Food/Drink item	Percent NMES	Grams per serving
Coca cola regular	10.5	35.0
Ribena regular	14.0	40.0
Lucozade regular	17.9	61.8
Sunny Delight	9.8	49.0
Nestle Kit Kat	60.2	29.3
Fruit Pastilles	82.9	46.1
Kellogg's Frosties	38.0	11.2
Quaker Sugar Puffs	49.0	14.7
McVitie's Jaffa Cakes	52.0	13.0

dietary counselling is provided in a systematic and comprehensive fashion for those patients who need preventive support (Fig. 1). A clear and detailed account of each step is provided by Rugg-Gunn, and Nunn.[17]

Step 1: Identify higher risk patients

All patients should routinely be given appropriate dietary advice to maintain their oral health. For most patients this will involve a brief mention of any relevant dietary information following their clinical examination. Visual information in the form of leaflets and posters may provide reinforcement and help raise awareness of the importance of maintaining a healthy diet. For example, posters highlighting the sugar contents of popular foods and drinks may stimulate interest and motivation.

Patients with a high caries experience or evidence of erosion will require a more detailed level of support. This may apply to certain groups in particular such as pre-school children, adolescents, individuals on long-term medication and dentate older people. In addition people living in poverty may be at high risk of diet related oral health problems. Any individual at high risk of developing further oral disease should have a dietary history undertaken to determine the nature of the potential dietary problem.

Step 2: Take a dietary history

A detailed assessment of nutrient intakes is a complex, time-consuming and skilful task. Within primary dental care settings the purpose of conducting a dietary assessment is not to establish precise nutrient intakes, instead it is designed for the collection of dietary information most relevant to oral health. The key information required for this purpose is the following:

- Establishing the number of intakes per day and how many of these were snacks.
- Identifying the number of intakes that contained NMES
- Assessing whether any intakes containing NMES were taken within 1 hour of bedtime.

The most effective and feasible manner of collecting this information is through a 3-day dietary record. For three consecutive days, one of which must be on a weekend, patients are required to keep an account of all their food and drink intakes. This account should include the following information:

- Time of food or drink intake and whether eaten away from home
- Description of type of intake
- Assessment of amount of intake
- Time of going to bed

To undertake this task patients need to be very motivated and have a clear understanding of the purpose of the activity. Precise instructions on how to complete the dietary record should be given, both verbally and in a written format and the patient should be given the opportunity to ask any questions. Honesty, focus and motivation are required by the patient to complete the task accurately to avoid excessive reporting bias.

Information gathered and analysed from the diet record will provide a picture of any dietary issues that may be linked to the patient's oral health problems. Appropriate goals and an action plan can then be developed.

Step 3: Set goals

A reduction in the amount and frequency of NMES consumption is the ultimate aim of dietary advice to promote good oral health. Setting goals which are realistic (can they be achieved?), appropriate (do they take into account the individual's circumstances?) and measurable (can progress be gauged over a relatively short time frame?) are important.

Soft drinks, confectionery, and biscuits and

Table 4: Barriers to reducing NMES intakes

Individual level

- Lack of motivation to change — enjoy taste of sugary foods and drinks
- Lack of confidence to change — previous attempts have failed
- Lack of information — not clear which foods contain sugars
- Lack of skills — unable to prepare and cook healthier foods

Social level

- Peer group pressures — everyone else eats chocolate at coffee time
- Lack of time — too busy to cook
- Family pressures — husband and children will not eat vegetables
- Cultural food beliefs — sugar is needed for energy

Environmental level

- Healthier choices too costly — high costs of healthier snack foods and drinks
- Limited choices available — tuck shops only stocks soft drinks and confectionery
- Advertising pressures — children demand latest gimmick food as seen on television

Table 5 Evidence-based dietary guidelines

- Interventions should be developed from behavioural theory and should incorporate well defined goals. Information alone has only a limited impact
- Personal contact is important in motivating and monitoring change. A detailed history is required to ascertain all relevant background information
- Interventions should be tailored to individual's personal circumstances and ability to change
- Provision of feedback on dietary changes are important
- Multiple contacts over a period of time are more likely to achieve desired goals
- Encouragement and support from family and friends is essential to motivate and maintain change

Roe *et al.*[16]

Fig. 1 Six step dietary counselling model

Step 1: Identify higher risk patients
Step 2: Take detailed dietary history
Step 3: Set goals
Step 4: Develop action plan
Step 5: Monitor and review
Step 6: Refer if necessary

As in any other area of clinical practice, providing dietary advice to patients is likely to be more effective when the whole dental team is actively involved

cakes are the main sources of NMES for the majority of the population. Setting goals to reduce the consumption of these items is most likely to achieve an effect on overall NMES levels. A phased programme of reduction may help patients through a gradual alteration in their taste thresholds. Any goals need to be agreed and understood by the patient. Imposing goals on someone achieves very little.

Step 4: Develop action plan

To successfully meet agreed goals requires the development and implementation of an action plan. Dietary interventions which are tailored to the circumstances and needs of the individual are more likely to achieve desired outcomes.[18] Reviewing any past experiences in changing eating patterns may reveal useful information on ways of addressing barriers to achieving sustained changes. For example, many people report the difficulties of coping with stress and excessive pressures without resorting to chocolate or sweet eating. Discussing alternatives ways of dealing with stress could be very important.

Eating is a social activity influenced by a wide range of factors. Patients therefore need to enlist the support of their family and friends. Reflecting on the information gathered in the dietary history may identify particular times of the day when NMES are more likely to be consumed, for example, coffee breaks. Suggesting ways of altering these routines may make a real difference. Providing practical advice on alternative foods and snacks which will help reduce NMES intakes are really important (Table 6).

Table 6 Suggested foods and snacks

- Fresh fruit
- Raw vegetables
- Breadsticks
- Crackers
- Rice cakes
- Crumpets
- Currant buns, scones or teabreads
- Plain popcorn
- Savoury sandwiches, crispbreads, or pitta breads
- Water
- Milk (skimmed or semi-skimmed)
- Diluted fruit juices

Step 5: Monitor and review

With any attempt at changing behaviour, monitoring and reviewing progress is fundamentally important. There is no point spending time with a patient assessing their diet, agreeing goals and an action plan and then not seeing them again for year or so. Patients need on-going support and feedback to achieve sustained changes in their eating habits. Once an action plan has been agreed, reviewing progress within a few weeks would be ideal. Patients undergoing a course of dental treatment can have their progress assessed briefly at the end of a clinical appointment.

Step 6: Refer

In certain circumstances dietary problems may be identified which require expert guidance and support. For example, individuals who are on special diets, have a particular medical condition or have extreme dietary patterns are all beyond the expertise of dental professionals. In these cases it is best to refer the patient either to their general practitioner or a state registered dietitian for more detailed assistance. Conditions such as anorexia nervosa and bulimia may initially present with oral signs but require expert treatment and management.

TEAM APPROACH

As in any other area of clinical practice, providing dietary advice to patients is likely to be more effective when the whole dental team is actively involved.[4] Designating the appropriate roles and responsibilities of individual team members is a critical first step. Frequently due to pressures of time and in recognition of their clinical expertise, the primary role for dentists may be in the identification of patients who need dietary support and the overall co-ordination of future action. Through a detailed clinical history, dentists should be able to identify individuals who are at greatest risk from caries and erosion due to their dietary behaviour. Dentists have a professional responsibility to highlight the nature of the problem with the patient and the need for action. Delegation to appropriately trained dental nurses or hygienists for a more detailed dietary assessment and action planning may then be undertaken. Dentists however need to ensure that progress is fully monitored and reviewed at regular intervals.

CONCLUSION

Changing what people eat is not an easy task. Dentists and their team members have a responsibility however to promote and maintain the oral health of their patients. Taking a dietary history, setting appropriate and achievable goals, and developing an action plan will help patients in their attempts at controlling their sugars consumption. In addition to tailored dietary advice in the dental surgery, other public health measures aimed at the wider influences on dietary patterns are also needed to promote health and reduce inequalities across the population.

RECOMMENDATIONS: DIETARY ADVICE IN DENTAL SURGERY

1. Dietary advice should primarily aim to reduce the frequency and amount of sugary foods and drinks consumed and should be in accordance with general diet guidelines (Type 3 Evidence).
2. A dietary history should be taken to identify the pattern of sugars consumption in patients at risk of developing future caries (Type 3 Evidence).
3. Appropriate goals and an action plan should

be agreed with patients on the best means of reducing sugars consumption (Type 3 Evidence).

4. Progress with dietary changes should be monitored and reviewed. Any patients with special or complex dietary problems should be referred to their general practitioner or a state registered dietitian for detailed support (Type 3 Evidence).

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IN BRIEF

- The causes of tooth wear may be intrinsic or extrinsic and are usually chemical (acidic) or mechanical (frictional) in nature.
- Several factors may combine to cause tooth wear in any individual patient.
- Tooth wear, especially tooth erosion is an increasingly recognised clinical problem.
- Modifying the composition of soft drinks is an important concept in prevention that should be further developed.
- Although a conservative approach to restorative treatment seems justified, longitudinal clinical evaluations are needed.

3

VERIFIABLE CPD PAPER

Prevention. Part 3: Prevention of tooth wear

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Non-carious destruction of teeth has been observed in archaeological material from various parts of the world and clearly pre-dates the first appearance of dental caries. Attrition, abrasion and erosion are also described in the classic text of Pindborg[1] on the pathology of the dental hard tissues. Whilst the dental profession, at least in affluent parts of the world, was engaged in diagnosing, treating and later preventing dental caries these other causes of tooth destruction were largely ignored.

PREVENTION

1. Smoking cessation advice
2. Dietary advice
3. **Prevention of tooth wear**
4. Toothbrushing advice
5. Patients requiring osseointegrated oral implant treatment
6. Older dentate patient
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Striking clinical examples of attrition were seen in patients with bruxism. Abrasion was attributed to tooth brushing or occasionally to habits such as chewing on a pipe stem. Erosion was seen in patients with symptoms of gastric reflux[2,3] and later was recognised in patients with anorexia[4] or bulimia[5] or in patients with unusual dietary habits.[6] In some cases erosion has been recognised as an occupational disease where workers have been exposed to acidic fumes, for example in factories making batteries.[7,8] It is also recognised among wine-tasters[9] (Type 4,5).

Over the past 10–15 years, however, there has been a steady increase in reports of erosion seen especially in young adults, adolescents[10] (Fig. 1) and young children as noted particularly in the UK National survey.[11] The cause of this erosion has been largely linked to the high consumption of soft drinks, both fruit juice and carbonated drinks, by these age groups. This link has been made largely in Europe and the problem has received little attention in the literature coming from the USA[12,13] (Type 4).

Fig. 1 Clinical appearance of erosion on the palatal surface of upper incisor teeth in a patient who consumed daily large quantities of carbonated drinks

DIAGNOSIS AND SEVERITY

In order to prevent or reduce the non-carious destruction of tooth substance it is important first of all to:

1. Recognise that the problem is present
2. Grade its severity
3. Diagnose the likely cause or causes and,
4. Monitor progress of the disease in order to assess the success, if any, of preventive measures.

Collectively the various manifestations of non-carious tooth destruction have been termed tooth wear which conveniently allows for discussion of the problem without the obligation to meet all the precise definitions of each manifestation of the condition. Indeed many patients present with tooth wear that is the result of several aetiological factors that do not fall conveniently into one or other of the categories, attrition, abrasion or erosion (Figs 2,3). Careful observation by the dentist or hygienist at a routine visit is still probably the most usual way for tooth wear to be seen. Tooth

Fig. 2 Erosion on the palatal surface of maxillary incisor teeth, note the 'step' in the dentine caused by abrasion in the dentine by the lower incisors

Fig. 3 Appearance of erosion in maxillary teeth of a teenage patient who consumed large quantities of carbonated drinks and also had a history of gastric reflux. Note the remains of incisal enamel at the gingival margin and erosion of the palatal cusps of the premolar and molar teeth

wear may be present in patients with gastro-oesophageal reflux disease (Figs 4-6), bulimia and anorexia. It is clearly important for doctors and nurses treating patients with these conditions to be aware of the possibility that the patient also has severe tooth wear.

Once diagnosed, it is important that the location of the tooth wear and its severity be recorded. Several indices are available for this, ranging from the relatively simple index of Eccles and Jenkins[14] (Type 4), that was designed for recording the severity of erosion, through the more detailed modification of the same index proposed by Lussi[15] and the detailed Tooth Wear Index of Smith and Knight[16] (Type 4) that is somewhat cumbersome to use at first but gives a good record of wear on each tooth surface enabling monitoring of the progression of tooth wear. It is also not limited to tooth erosion as are most of the other indices. In epidemiological studies the degree of inter- and intra- examiner variability in detecting and scoring tooth wear may be as great a problem as determining the aetiology. Careful calibration of examiners is helpful. For an individual practitioner, clinical experience may not be sufficient for his or her purposes and even a brief examination and second opinion by a colleague may help confirm the diagnosis, its severity and possible aetiology. Study casts are clearly a useful record of the status at any particular time and can be used to monitor progression of tooth wear. Computer-aided analysis of direct imaging of the affected teeth, impressions or study models are being developed but have not yet reached the stage of being a useful clinical tool for general practice [17,18] (Type 4). For routine clinical purposes, tooth wear should be recorded separately for the anterior and posterior teeth. The clinician should note the tooth wear as being: in enamel only; into dentine; or severely affecting the tooth or series of teeth for example as seen frequently in erosion of the palatal surfaces of four maxillary incisor teeth.

Frictional forces and acids cause tooth wear, singly or in combination. Although the presence of tooth wear may be obvious to the clinician, determining its cause can be difficult

AETIOLOGY AND HISTORY TAKING

Following diagnosis of the presence of tooth wear, the clinician should attempt to determine the main aetiological factors. This will partly be based on clinical experience: examination of wear-facets; restorations that stand proud of the surrounding enamel; loss of vertical dimension; and the pattern of tooth wear. For example, a pattern of tooth wear involving the palatal surface of maxillary molar teeth, buccal surfaces of mandibular molars and palatal wear of maxillary anterior teeth is strongly suggestive of erosion caused by gastric acid. Nevertheless, other factors may play a part in the overall clinical picture. If there is a loss of occlusal enamel in the molar teeth the consequent loss of vertical dimension may produce 'step-like' wear facets palatally on the maxillary anterior teeth (Fig. 2), especially if the enamel has also been lost on these surfaces (Figs 5-6). The patient may also show other signs of more severe bruxism. A particular diagnostic problem is the condition sometimes termed abfraction where cervical erosions occur in several teeth thought by some authors[19,20] (Type 4) to be caused by lateral occlusal forces acting in an acidic environment. These conditions may be found in a patient with bruxism who also has gastric reflux or who consumes acidic foods or beverages frequently.

Fig. 4 Clinical appearance of maxillary anterior teeth in a patient with gastric reflux disease — note the enamel at the palatal gingival margin and the approximal surfaces

Good history taking is essential to determine the consumption of carbonated drinks, fruit juices and other dietary factors that may contribute to the observed tooth wear.[15] Medication, particularly frequent use of asthma inhalers containing steroid[21,22] (Type4) or effervescent medications,[23] should be checked as they may contribute to tooth erosion. Habits, including tooth brushing, that could contribute to tooth

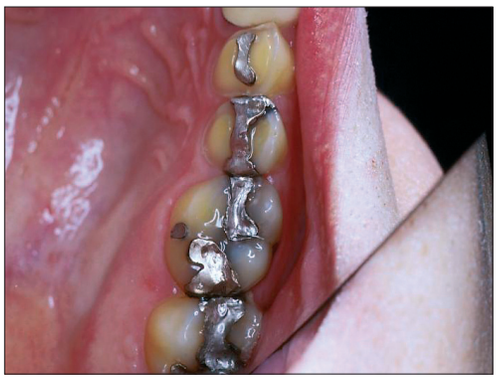

Fig. 5 Clinical appearance of maxillary posterior teeth in a patient with erosion and gastro-oesophageal reflux disease. The erosion is largely confined to the palatal aspects of these teeth

Fig. 6 Clinical appearance of mandibular posterior teeth in a patient with erosion and gastro-oesophageal reflux disease. The erosion is largely confined to the buccal aspects of these teeth

wear should be investigated with careful questions. It is important not to indicate that any blame for the clinical findings is being placed on the patient, otherwise a false history will be obtained. This is especially true when there are financial implications for the patient, for example the possibility of discretionary payments for necessary dental treatment, should the tooth wear be deemed not to be the 'fault' of the patient. The possibility of gastro-oesophageal reflux should be considered, not only bulimia and anorexia that patients are understandably reluctant to admit to, but also other possible causes of reflux including hiatus hernia.[24] It may be necessary for the dentist to refer the patient to a gastroenterologist for investigations including gastroscopy and 24-hour monitoring of oesophageal pH that is the 'gold standard' for diagnosis of gastro-oesophageal reflux disease.[25] Prompt diagnosis of reflux will in most cases lead to medication or possibly surgery to reduce reflux that will, in turn, remove the erosive challenge to the teeth (Type 4,5).

Tests of salivary function, particularly measuring salivary buffer capacity, may reveal contributing factors to tooth wear. There is no doubt that saliva plays an important role in the protection of enamel from erosion by acid, both by supplying the components of the acquired pellicle that coat the enamel surface and by promoting remineralisation of the enamel surface following acid attack. Clinical studies of the relationship between erosion and low salivary buffer capacity have, however, given conflicting results (Type 4).[25–27] Careful history taking and clinical examination bearing in mind a possible mixed aetiology of tooth wear and including questions on diet, reflux disease and functional habits should help the practitioner arrive at a correct diagnosis.

PREVENTION OF TOOTH WEAR

Preventing tooth wear is not the same as preventing caries. Dental caries is regarded as a disease that will affect most people in the world to some extent during their lifetime. This inevitability of caries developing, at least historically, was a strong stimulus to the development and promotion of preventive measures, especially those based on fluoride use and oral hygiene. Developed countries have experienced, by and large, higher prevalences of caries than less developed countries and their need for preventive measures has, therefore, been greater. Well-structured prevention programmes based on fluoride, organised dental examinations and regular recall and even financially subsidised treatments have become available that not only protect non-diseased teeth but also reduce the cariogenic challenge by removing the diseased tissue.

Tooth wear is a different and, in many ways, more difficult preventive problem. It has been regarded, until recently, as a problem for individual patients rather than being community based. With the high prevalences particularly of tooth erosion recorded in some surveys[11,28] (Type 4), it is arguable that this type of tooth wear at least has now achieved the status of a community-wide dental problem in several countries. Undoubtedly tooth wear that can be attributed to a coarse diet, to rituals such as filing down teeth and also to environmental factors can all be found in developing countries. Prevention of tooth wear in these circumstances calls for cultural and economic changes that lie outside the scope of this review.

Although tooth wear is increasingly recognised to be a problem, it is difficult to predict which individuals will be affected and true prevention is therefore difficult to achieve. Much that can now be done is aimed at limiting further tooth wear in individuals already found to be affected by this condition. Population-based strategies of prevention, such as by widespread modification of the composition of soft drinks and educational campaigns to increase awareness of the causes of tooth wear may be possible but it is not likely that they will meet with the widespread acceptance that preventive strategies for caries have achieved. This is in part due to the age group perceived to be most at risk of developing erosion, teenagers and young adults, being rather resistant to the messages of health educators, at least when the message relates to reducing the consumption of erosive drinks that

Although tooth wear is now a community-wide problem, population-based preventive strategies will probably be less effective than for dental caries

are so much a part of the lifestyle of this age group. More can possibly be done with an at-risk strategy aimed at specific individuals with early signs of tooth wear or with known risk factors for tooth wear present, such as those taking medicines known to be erosive and patients with bulimia. For such a strategy to work collaboration between the dentist and other healthcare professionals is important.

PREVENTIVE STRATEGIES

Strategies for preventing tooth wear are largely based on the individual. Abrasion and attrition are disorders that are individual-based. Erosion has certain features, including its prevalence and relationship to diet, that make the disease problem somewhat similar to that of caries. Few, if any, population-based strategies that have been so successful in caries prevention have, however, been shown to have an effect on erosion. The perceived increase in the prevalence of tooth erosion has produced an upsurge of research into possible ways of preventing erosion whereas other forms of tooth wear have received less attention.

Fluoride

Fluoride is the mainstay of caries prevention and it was, therefore, natural for fluoride to be considered as a possible vehicle for preventing tooth erosion. In fact the literature contains conflicting reports about the benefits of fluoride in this respect. A number of animal and *in vitro* studies suggest that adding fluoride to potentially erosive drinks will reduce the erosive potential of these drinks.[29–31] Addition of fluoride to sports drinks has also been shown to reduce the erosive potential of these, otherwise highly erosive, drinks.[32] Amaechi *et al.*,[33] have shown that xylitol and fluoride have an additive effect in reducing the erosive potential of orange juice in *in vitro* studies. Larsen,[34] however, showed that the protective effect against erosion of fluoride added to soft drinks was minimal. Clearly some more research is required in this area to resolve these differences, perhaps through the development of agreed test systems to evaluate erosive potential. It is known that tooth brushing shortly after drinking an erosive beverage causes an increase in tooth wear. Topical fluoride appears to protect against this subsequent tooth wear following acid challenge.[35–37] This is especially helpful in reducing dentine wear in previously eroded teeth.[38] Fluoride, therefore, appears to have only a limited protective effect against erosive challenge *in vivo* (Type 4).

Modifying drinks to make them less erosive is still the most promising and realistic preventive measure against tooth erosion

Drink modification

Drink modification has been developing in recent years with varying success.[30] Addition of calcium lactate to Coca Cola® has been shown to reduce the erosive potential of this most international of erosive beverages[39] but this research does not appear to have been taken up by the manufacturer. Rather the reverse trend is seen with the marketing of drinks with added citric acid to drinks such as Pepsi Cola® and to several diet preparations of carbonated drinks. This increases the erosive potential of these drinks, at least when measured *in vitro*.[40] A successful attempt to reduce the erosive potential of soft drinks by the addition of calcium citrate-malate was reviewed by Grenby[30] but a later *in vivo* investigation by Rugg-Gunn *et al.*[41] found no difference in the amount of erosion seen in enamel slabs treated with plain or modified orange drinks. One of the potentially most important steps in soft drink modification has been the development and subsequent marketing of Ribena Tooth Kind.[42–44] This low pH blackcurrant drink has been modified with the addition of calcium and has been shown in *in situ* and *in vitro* studies to be less erosive than blackcurrant drinks without added calcium and also less erosive than orange juice. Considering the increasing prevalence of tooth erosion, especially in young children and teenagers and the strong association between consumption of acidic drinks and tooth erosion, it still seems logical to continue the development of drinks with low erosive potential. Drink modification has considerable potential in combating erosion but clinical trials are needed.

Diet modification is a difficult area in which to achieve successful disease prevention as experience from dental caries has shown. Nevertheless the strong links between dietary factors and tooth wear make it sensible for the dental team to at least try to get patients with tooth wear to modify their diet. Patients with tooth wear thought to be linked to dietary acids should be closely questioned about their dietary habits and modifications, suggested including reducing the frequency of consumption of these foods limiting consumption of fruit and fruit juices to mealtimes. Consuming hard cheese or milk products after drinking an erosive beverage may promote re-hardening of the enamel[45,46] (Type 4). This is probably also a useful method of neutralising acid in the mouth after a bout of reflux or vomiting but patient compliance is perhaps questionable. Chewing-gum containing carbamide (urea) has been shown to raise salivary pH rapidly[47] (Type 4). This may, therefore, reduce the erosive effect of acid in the mouth.

The pattern of drinking erosive beverages is thought to contribute to tooth erosion[48] (Type 4) especially when cola-type drinks are swished around the mouth before swallowing. Drinking through a straw has been shown to reduce the potential for tooth erosion from acidic drinks[49] (Type 4), especially on the palatal surfaces of the maxillary incisors that are most commonly affected in patients with erosion.

Abrasion caused by diet or tothbrushing is greater if the teeth have been recently exposed to dietary or gastric acid. It has been shown by Attin *et al.*[50] that resistance to this abrasion develops in the mouth but that at least 60 min should elapse after an acid challenge to the teeth before brushing. This is probably of particular significance for patients who have frequent

episodes of vomiting but it is also sensible for dentists to advise their patients not to brush shortly after consuming carbonated drinks. Similarly, mouthrinses with a low pH should not be recommended for prolonged use nor as pre-brushing rinses.[51] Remineralizing toothpaste (Enamelon™) has been shown to increase the hardness of acid-treated teeth significantly more than conventional fluoride toothpastes in *in vitro* studies.[52]

Saliva and pellicle are important factors in protection of tooth substance against acid attack. Amaechi *et al.*[33] and Johansson *et al.*[47] have shown that erosion is usually found in areas of the dental arches that are lacking in pellicle. Increasing salivary flow and hence accumulation of pellicle will, therefore, probably offer protection against erosion. Data from clinical trials are lacking, however, although Hall *et al.*[53] (Type 4) have demonstrated this protective effect of salivary pellicle in an *in-situ* model system. Increasing salivary flow and, consequently, buffer capacity should increase protection against erosion and promote remineralization. Sugar-free chewing gum and even fluoride-containing or carbamide-containing gum should be advised, particularly for adolescents who may be least willing to limit their consumption of acidic beverages. A number of preparations intended to promote salivation are available for patients including those with dry mouth symptoms who may not be willing to chew gum. Profylin™ (Prophylactor AB, Sweden) and Xerodent™ (Dumex-Alpharma, Denmark) lozenges are examples of such topical preparations and Xerodent™ has the added advantage of containing fluoride.

Gastric reflux

Reflux disease and vomiting are important causes of tooth erosion. Recognition of the erosion and presumptive diagnosis by the dentist should lead to appropriate referral for further investigation. Most often this will be to a gastroenterologist for gastroscopy and for 24-hour measurements of oesophageal pH. Medication to reduce gastric reflux and acid production includes drugs such as over-the-counter antacids or prescription drugs such as omeprazolum (Losec®) and ranitidinum (Asyran®). Should hiatus hernia be diagnosed then surgical intervention may be necessary. Diagnosis and treatment of the underlying condition is obviously a pre-requisite to stopping the progression of the tooth wear. In many cases of tooth wear associated with gastric disturbance, both attrition and erosion are seen. Because many individuals with erosion are young males, in our clinical experience at least, they are in the age group that is known to consume a lot of acidic drink but this is also the age group that is active in sport and training and may, for example experience gastric reflux as a consequence (Holbrook *et al.* unpublished findings, Type 4). Diagnosis of the tooth wear may be clear but determining the aetiological factors involved may, however, be difficult.[54] Should the dentist believe that the patient may have bulimia then referral to a psychiatrist may be indicated. This is often difficult and depends to a great extent on the rapport and trust that the dentist has built up with the patient. At the very least the dentist should convey his suspicion to the patient's general medical practitioner. Careful monitoring of the progress of the tooth wear over time, for example with study casts, is helpful both for the dentist and as an aid to increase patient cooperation. The use of fluoride and antacid medications as well as the protective effect of cheese should be emphasised and careful instruction on tooth brushing technique to minimise abrasion should be given (Type 5).[55]

Lifestyle changes

Lifestyle changes are particularly difficult to achieve, especially in the age groups that are frequently found to have tooth wear. Drinking carbonated beverages with a straw; eating a piece of cheese shortly afterwards; and taking antacids,[56] xylitol gum or xylitol-fluoride-containing lozenges[57] after exercise are not activities that fit in particularly well with the lifestyle of young people. Nevertheless the dental profession has the responsibility to inform patients of the problem and its consequences. The success of fluoride in preventing dental caries in populations that continue to consume sugar at high levels is not likely to be repeated with tooth erosion. Indeed the rise in awareness of tooth erosion, in Europe at least, has occurred as caries levels have rapidly declined. Whether or not modification of acidic drinks to make them less erosive will prove possible or even acceptable to manufacturers and public alike remains to be seen. Considerable financial sums are at stake for the industry and it seems unlikely that these will be risked without public demand or legislation.

Restorative procedures

Restorative treatment of teeth affected by tooth wear is very expensive and not always covered by health services, even in Europe. There is also still a need for long-term studies on tooth wear, particularly into how erosion and related tooth wear progresses in young people. This makes authoritative recommendations on restorative measures impossible until further research has been completed. Various non-or minimally-invasive procedures have been tried in order to prevent further tooth wear but clearly extensive crown and bridge work is sometimes required. Lambrechts *et al.*[58] have reviewed the various therapeutic approaches and point out that the durability of crown and bridgework is only 15–20 years which should be borne in mind in the light of the age group frequently presenting in the dental surgery with tooth wear. Conservative approaches that may also offer a degree of protection/prevention against further wear are therefore urgently sought as are restorative techniques that do not involve further destruction of remaining tooth substance. Dentine-

Tooth wear may be an indication of underlying reflux disease or bulimia. Collaboration between medical and dental practitioners is important in treating such cases

bonding agents have been shown to be effective in reducing sensitivity and offering protection against further dissolution of erosive lesions[59,60] (Type 3). These should be applied and the patient monitored before any final decision is taken on restorative measures.[55]

Prevention of attrition and abrasion is not usually considered until the patient actually has signs of the problem. Diagnosis is usually more straightforward than with erosion except in cases where attrition or abrasion are superimposed on erosion when diagnosis can become problematical. Patients with bruxism may well need occlusal splints, at least to use at night, and restorative treatment is frequently necessary. Correction of tooth brushing technique and the use of less abrasive toothpaste should help reduce abrasion and habits that may lead to abrasion should be controlled. As with tooth erosion it is helpful to make study casts and to monitor progression of the tooth wear.

Restorative procedures that do not involve yet more destruction of tooth substance should be attempted. More research in this area is needed

CONCLUSION

A considerable increase in tooth wear has been observed in recent years. This is predominantly erosion though often complicated by other forms of tooth wear. Careful diagnosis and monitoring of progress are important and the underlying aetiological factors should be corrected wherever possible. The aetiology of tooth wear is often complex but individualised prevention can usually only be initiated once the disease has started. This is largely aimed at limiting progression of tooth wear in the affected individual. Population-based strategies are largely inappropriate in preventing tooth wear although modification of erosive drinks, medicines and foods may prove to be an acceptable future strategy for manufacturer and customer alike. Careful monitoring of patients following diagnosis of tooth wear, removal of causative factors and relatively simple dental treatments may enable the patient to avoid extensive restorative procedures.

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IN BRIEF

- Clinicians have an important role in advising patients about toothbrushing. By modifying this well accepted habit significant increases in health benefit can be gained.
- Caries reductions can be increased by increasing brushing frequency, using higher concentration fluoride formulations and limiting rinsing
- Periodontal disease can be controlled by teaching effective twice daily brushing, advising the correct design brush and toothpaste.

4

VERIFIABLE CPD PAPER

Prevention. Part 4: Toothbrushing : What advice should be given to patients?

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This paper examines and summarises the evidence to support the advice that GDPs should give their patients on toothbrushing. The strength of evidence is graded using a five-point hierarchical scale. Much of the evidence to support toothbrushing advice is relatively weak but the increasing number of high quality systematic reviews will gradually improve the strength of evidence to support effective programmes of preventive care. Clinicians can play an important role in maximising the benefits of toothbrushing with fluoride toothpaste for patients of all ages. This well-accepted health behaviour can, if implemented correctly, reduce the establishment and advance of the two major dental diseases.

PREVENTION

1. Smoking cessation advice
2. Dietary advice
3. Prevention of tooth wear
4. **Toothbrushing advice**
5. Patients requiring osseointegrated oral implant treatment
6. Older dentate patient
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Twice daily brushing with a fluoride toothpaste has been widely promoted by the profession for many years since it plays a pivotal role in the prevention and control of dental caries and periodontal diseases. Such behaviour, although self-reported, appears to be an integral part of many people's daily hygiene routine. In Great Britain 55% of children aged 1.5 to 4.5 years were reported to have their teeth brushed more than once a day[1] and in the UK 64% of 4 to18 year olds[2] and 74% of dentate adults claimed to brush their teeth twice a day.[3] Whilst it is generally accepted that such behaviour has been the most important contributor to the improvement in the dental health of the nation a sizeable proportion of the population still do not even claim to brush twice daily.

Contrary to the prevailing view that caries is under control the disease poses a potential threat throughout the lifetime of the individual. In a recent longitudinal study of 2,293 regularly attending adults, a total of 3,030 teeth (37% of those that received treatment during the 5 years) were treated for caries.[4] The increasing dentate elderly population are particularly vulnerable; 29% of dentate adults, aged 65+, had root caries with an average of 2.3 teeth affected.[5]

In the UK, the prevalence of plaque and periodontal disease also remains high;[3] 72 % of dentate adults and 33% of teeth had visible plaque and 54% of adults had pocketing greater than 3.5 mm. Although severe periodontal disease is relatively uncommon, with only 8% of dentate adults having loss of attachment of 6 mm or more, this increased to 31% in those aged 65 and over. It was concluded that if large numbers of teeth are to be retained into old age there is a need to improve the oral cleanliness of the majority of the UK population.[6]

A search was made to identify systematic reviews on the Cochrane Library, DARE and Medline. A further search of Medline using 'toothbrush*' as a free text term produced a vast list of publications too numerous to assess. A number of symposia which had reviewed relevant topics and provided consensus statements were sourced. The last search was conducted in June 2002. Using the data from these different sources we have made recommendations as to the advice dental professionals should give their patients about toothbrushing. The strength of evidence to support each recommendation will be indicated using the following hierarchy of evidence:

Type 1 Systematic review of at least one randomised controlled trial (RCT)
Type 2 At least one RCT
Type 3 Non-randomised intervention studies
Type 4 Observational studies
Type 5 Traditional reviews, expert opinion

Randomised controlled trials are accepted as the most robust study design but they may not be ethical or practical to undertake in certain areas. For example, observational studies have provided data on the reported frequency of

toothbrushing and rinsing behaviour and should not be undervalued.

CARIES

The role of oral hygiene

The ubiquitous use of fluoride toothpaste makes it difficult to distinguish whether the effect of toothbrushing on caries is the result of the mechanical removal of plaque or a measure of fluoride application.[7] Clearly the caries predilection sites, ie. occlusal pits and fissures and approximal surfaces are the most difficult to clean with toothbrush and toothpaste and traditional reviews (Type 5) of the literature have generally concluded that the effect of oral cleanliness *per se* on caries is equivocal.[8,9] Prior to the widespread availability of fluoride toothpastes, evidence of the relative importance of oral hygiene and fluoride was provided by a 3-year study (Type 2) in which two groups of children, aged 9–11 years, had supervised brushing with or without a fluoride toothpaste whilst a control group received no supervision.[10] Both the supervised brushing groups had significantly reduced plaque and gingivitis scores when compared with the control group but a significant reduction in dental caries was only observed in the fluoride toothpaste group. It is generally accepted that the decline in dental caries can be attributed, primarily, to fluoride toothpaste[11] and it would now be considered unethical to withhold the benefits of this from any group in a clinical trial.

Conclusion: The evidence that brushing *per se* is important in the prevention and control of caries is equivocal.

Evidence: Type 5

FLUORIDE TOOTHPASTE

It is generally accepted that the beneficial effects of fluoride toothpaste on dental caries are due to the topical effect of fluoride once the teeth have erupted. In contrast, the risk of fluorosis is due to the unintentional swallowing of toothpaste during tooth development. The parents of children less than 7 years should be strongly advised to apply only a small amount of toothpaste (pea or smear) and encourage the child to spit out.

There is strong evidence that twice daily brushing with fluoride toothpaste is effective in reducing oral caries

A recent Cochrane Review (Type 1) concluded that the use of fluoride toothpaste is associated, on average, with a 24% reduction of dental caries in the permanent dentition of children and adolescents when compared with a non-fluoride toothpaste.[12] The effect of fluoride toothpaste on the deciduous dentition was limited to one study, which reported a reduction of 37% when compared with a non-fluoride toothpaste.

Frequency of brushing

The effectiveness of brushing twice daily with a fluoride toothpaste on caries is supported by data on reported behaviour (Type 4) obtained from surveys[1,3] and clinical trials.[13,14] For example, among children aged 3.5–4.5 years, 24% of those whose teeth were brushed more than once a day had caries experience compared with 38% of those whose teeth were brushed once a day and almost half (48%) of those whose teeth were brushed less often.[1] In clinical trials the 3-year caries increments in participants who reported brushing only once a day were 20–30% more than those who brushed twice a day.[13,14] Whilst these data need to be interpreted with some caution because of associations with other confounding factors, such as social class and sugar consumption, the weight and consistency of available evidence supports the recommendation that toothbrushing, with a fluoride toothpaste, should be performed twice daily.[15]

Recommendation: Brush twice daily with a fluoride toothpaste.

Evidence: (Type 4,5)

Fluoride concentration

In Europe, toothpastes containing a maximum fluoride concentration of 1500 ppm are on general sale as cosmetic products. Formulations with higher concentrations are available as prescription only medicines.

An extensive review (Type 5) of clinical trials of fluoride toothpastes indicated that fluoride concentration is an important determinant of anticaries efficacy.[16] Overall, the results suggest that within the range 1000 to 2500 ppm F each increase of 500 ppm F provides an additional 6% reduction in caries.[17]

Low fluoride toothpastes, containing less than 600 ppm F, are available for young children in the UK. A recent systematic review[18] concluded that toothpastes containing 250 ppm F were not as effective at preventing caries in the permanent dentition as toothpastes containing 1000 ppm F or more (Type 1). Clinical trials in pre-school children (Type 2) comparing 550 ppm F with 1055 ppm F[19]and 440 ppm F with 1450 ppm F[20] have demonstrated that toothpastes containing the lower concentrations of fluoride provide less protection than those containing higher concentrations.

A number of randomised clinical trials[21,22] have reported that toothpastes containing fluoride concentrations higher than 1500 ppm F provide greater protection than toothpastes containing conventional levels of fluoride. Such a high fluoride toothpaste, containing 2800 ppm F, has been launched recently as a prescription only toothpaste for high caries risk individuals over 16 years of age and particularly the elderly.

Recommendation: The appropriate fluoride concentration to recommend for an individual should be made after assessing their caries risk. This should involve an assessment of previous caries experience, the most powerful predictor of future caries[23,24] together with a consideration of family history and socio-economic status.

A low fluoride concentration toothpaste (< 600 ppm F) is appropriate for low caries risk children, less than 7 years of age, particularly if living in a fluoridated area.

A toothpaste containing a higher concentration of fluoride (1000-1450 ppm F) is appropriate for high caries risk children less than 7 years

of age with the proviso that the parent applies only a pea-sized amount or smear to the toothbrush.

A high fluoride toothpaste (1450 ppm F) can be recommended for all individuals 7 years of age or older.

A toothpaste containing 2800 ppm F is appropriate for high caries risk adults and the elderly.

Evidence: (Type 1, 2)

Rinsing behaviour

An important determinant of anticaries efficacy of a fluoride toothpaste is the rinsing behaviour after brushing. The volume of water used and the vigour of rinsing after toothbrushing affect the fluoride concentration in the mouth and caries experience.[25–27] Individuals should be advised not to rinse or to do so briefly with a small amount of water. Young children should be encouraged simply to spit out any excess toothpaste.

Recommendation: Discourage rinsing with large volumes of water. Encourage young children to spit out excess toothpaste.

Evidence: (Type 4,5)

Amount of toothpaste

Data concerning the effect that the amount of toothpaste has on efficacy is sparse. One clinical trial (Type 2) of dentifrices containing 1000, 1500 and 2500 ppm F reported that the fluoride concentration was more important than the amount of toothpaste applied.[28] Since very young children may swallow a large amount of toothpaste,[29,30] thereby increasing the risk of fluorosis, parents should supervise very young children and place only a small amount of toothpaste[31] (smear or pea size) on the brush. It is important to reinforce this advice since 31% of children aged 1.5 to 4.5 were reported to always brush their own teeth and 45% covered half the length of the brush or more.[1]

Recommendation: Toothbrushing by children should be supervised and only a smear or pea sized amount of toothpaste should be used.

Evidence: (Type 2,4,5)

When to brush

There is no evidence to indicate the relative anticaries benefits of brushing before or after eating meals. Recent surveys have reported that 61% of 1.5–4.5 year olds brush after breakfast and 52% last thing at night[1] for adults the values were 46% and 74% respectively.[3] However, recent evidence (Type 4) supports a recommendation that brushing with a fluoride toothpaste should take place just prior to going to bed; fluoride concentrations in saliva 12 hours after brushing last thing at night were comparable with those found 1–4 hours after brushing during the day.[32]

Recommendation: Brush last thing at night and on one other occasion.

Evidence: (Type 4,5)

Type of fluoride

There is some controversy regarding the comparative efficacy of the two major types of fluoride used in toothpastes; sodium fluoride (NaF) and sodium monofluorophosphate (MFP). A systematic review (Type 1) suggested that NaF was superior to MFP[33] but this was disputed.[34] If any difference does exist between these two species it is unlikely to be of any clinical significance. Toothpastes containing either fluoride species can be recommended with confidence.

The effectiveness of fluoride toothpaste is influenced by frequency, concentration and rinsing behaviour; frequency having the greatest impact

Table 1 The levels of evidence for recommendations for caries control

	Instructions	Evidence
Frequency of brushing	Brush twice a day with a fluoride toothpaste.	Type 4,5
Fluoride concentration	The choice of fluoride concentration should be based on the age and perceived caries risk of the individual and their exposure to other fluoride sources. A low fluoride concentration toothpaste (< 600 ppm F) is appropriate for low caries risk children, < 7 years of age, particularly if living in a fluoridated area. A high fluoride toothpaste (1450 ppm F) is appropriate for high caries risk, < 7 years of age, with the proviso that the parent applies only a pea sized amount or smear to the toothbrush. Such a concentration can be recommended to all individuals over 6 years of age. A toothpaste containing 2800 ppm F is appropriate for high caries risk adults and the elderly.	Type 1,2
Amount of toothpaste	Toothbrushing by children, < 7 years of age, should be supervised and only a pea sized amount or smear of toothpaste should be used.	Type 2,4,5
Rinsing behaviour	Discourage rinsing with large volumes of water. Encourage young children to spit out excess toothpaste.	Type 4,5
When to brush	Brush last thing at night and on one other occasion.	Type 4,5
Type of fluoride	Toothpastes containing sodium fluoride, sodium monofluorophosphate or stannous fluoride are clinically effective.	Type 1,5
Age to commence brushing	Advise parents/carers to begin brushing once the primary teeth have commenced eruption.	Type 4,5

Recommendation: Toothpastes containing sodium fluoride, sodium monofluorophosphate or a combination are clinically effective.

Evidence: (Type 1, 5)

Age to commence brushing

Several studies have reported an association between the age that toothbrushing was claimed to have commenced and caries experience (Type 4). Overall, 12% of 1.5–4.5 year olds who started to brush before the age of 1 year had some caries experience (active decay, filled teeth or teeth missing due to decay) compared with 19% who started between the ages of 1 and 2 years and 34% of those who did not start toothbrushing until after the age of 2 years.[1] Again, these data need to be treated with caution because of confounding factors.

Recommendation: Advise parents/carers to commence brushing once the primary teeth have commenced eruption.

Evidence: (Type 4,5)

The profession should advise and encourage individuals to maintain an effective level of oral hygiene

PERIODONTAL DISEASE

Although plaque is the primary aetiological agent for periodontal disease it is evident that there is considerable variation in the extent and severity of tissue destruction between individuals, teeth and tooth sites.[6] The aim is to maintain a level of plaque control which ensures that the rate of tissue destruction is reduced sufficiently to ensure that most individuals maintain a comfortable and functional natural dentition for life. However, the level of plaque control required varies from individual to individual.

The oral care industry continues to try and provide the public with toothbrushes and toothpastes that improve the effectiveness of plaque control and periodontal health. The efficacy of these different products has been evaluated in numerous clinical trials the results of which have been the subject of a number of traditional reviews.[35,37]

Frequency of brushing

The effective removal of plaque every second day has been shown to prevent gingivitis[38] and resolve experimental gingivitis;[39] the less frequent removal of plaque did not prevent or reduce gingivitis. No optimum frequency has been determined but there is a consensus that twice daily brushing is consistent with maintaining good gingival health.[35,40]

Recommendation: Brush twice daily.

Evidence: (Type 5)

Brushing duration and technique

Individuals rarely brush for the length of time they say they do[41–43] and rarely exceed 60 seconds.[44,45] Most use a simple horizontal brushing action, spend little time brushing lingual areas, and fail to remove plaque effectively from the approximal surfaces of premolars and molars.[46] Traditional reviews of the literature (Type 5) have concluded that no particular method is superior to any other and it is more realistic to modify the patient's existing method of brushing, emphasising the need to repeat the procedure on all available tooth surfaces.[35,47]

Recommendation: Modify existing method of brushing, emphasising a systematic approach to maximise plaque removal.

Evidence: (Type 5)

Manual toothbrushes

The published literature on the relative merits of different manual toothbrushes is extensive. In general (Type 5) it is accepted that toothbrushes should have the following attributes: a handle size appropriate to the user's age and dexterity, a head size appropriate to the user's mouth, a compact arrangement of soft, end rounded nylon filaments not larger than 0.009 inches in diameter and bristle patterns which enhance plaque removal in the approximal spaces and along the gum margin.[48] In an effort to improve the efficacy of plaque removal toothbrushes with filaments arranged at different heights and angles have been developed. Several randomised controlled studies (Type 2) have demonstrated that these designs were significantly more effective at removing plaque[49,50] and reducing gingivitis[52] than flat trim brushes.

Recommendation: Use a small headed brush with soft, round ended filaments, a compact, angled arrangement of long and short filaments and comfortable handle.

Evidence: (Type 2,5)

Powered toothbrushes

Most modern powered toothbrushes have a small, circular head which performs oscillating, rotating or counter-rotational movements. Timers are now being introduced into the design giving the user feedback on the duration of brushing. Numerous clinical trials have been performed comparing the efficacy of such toothbrushes with other models or manual toothbrushes. Traditional reviews[53] have generally concluded (Type 5) that powered toothbrushes are more effective in removing plaque, and in some instances reducing gingivitis, than manual toothbrushes.[3] A recent Cochrane Review[54] concluded (Type1) that powered toothbrushes with an oscillating/rotating movement were more effective in removing plaque and reducing gingivitis than a manual toothbrush. Two studies have reported that powered toothbrushes improved compliance.[55,56] Ideally dental professionals should provide advice and instruction in the use of these devices.[57]

Recommendation: For those individuals who are unable to maintain an effective level of plaque control and periodontal health powered brushes with an oscillating/rotating action may be more effective than manual brushes.

Evidence: (Type 1,5)

Toothpaste

Since most individuals are unable to maintain an effective level of plaque control by mechanical means alone, various chemical agents have

been added to toothpastes to enhance the removal of plaque and thereby improve periodontal health. The most widely used agent in toothpastes is triclosan, a broad-spectrum antibacterial agent. The effectiveness of triclosan formulations has been improved by either adding a copolymer to enhance its retention in the mouth or by adding zinc citrate to provide additional antibacterial activity. These formulations have been shown in randomised controlled trials (Type 2) to provide significant reductions in plaque and significant improvements in gingival health[58,59] when compared with a fluoride toothpaste alone. In studies of 3 years duration the triclosan/copolymer formulation was reported to reduce the onset of periodontitis in adolescents[60] and the further progression of periodontitis in at- risk adults.[61]

Recommendation: Use toothpastes which contain triclosan with either copolymer or zinc citrate to improve levels of plaque control and periodontal health.

Evidence: (Type 2)

PROFESSIONAL INVOLVEMENT

The profession has a wider responsibility for preventing and controlling dental diseases than simply providing toothbrushing advice. The effectiveness of intensive professional involvement in preventive programmes has been well documented in a number of longitudinal studies. In a 4-year trial (Type 2) children, aged 7–14 years, were allocated to test and control groups.[62] During the first 2 years those in the test group received oral hygiene instruction, a professional prophylaxis and topical application of sodium monofluorophosphate every 2 weeks. During the third year this programme was repeated once a month and in the final year every 2 months. The control group brushed their teeth with a 0.32% solution of sodium fluoride once a month throughout the 4 years. Children in the test group had virtually no plaque and gingivitis and had a very small caries increment when compared with the control group. A similar programme was evaluated in adults (Type 2) over a 6-year period.[63] During the first 2 years the test group received preventive measures every 2 months and during the subsequent 4 years every 3 months. The preventive measures comprised: instruction and practice in oral hygiene with emphasis on interdental cleaning, a professional prophylaxis and topical application of fluoride. The control group was recalled at yearly intervals and received conventional care. The preventive programme improved periodontal health and reduced the progression of periodontitis and the incidence of caries when compared with the control group. During a further 9 years the test group continued to receive the preventive programme at varying intervals depending on perceived risk.[64] Sixty-five per cent of subjects were recalled once a year, 30% twice a year and 5% at 2–4 monthly intervals. The results demonstrated that the programme effectively prevented recurrence of dental disease in all but a small number of highly susceptible individuals.

Whilst such studies clearly indicate the effectiveness of a combination of personal and professional plaque control measures in controlling dental diseases, the frequency of recall which ranged from 2 weeks to 4 months is probably unrealistic for most patients and practices.

SUMMARY

The advice that dental practitioners and hygienists give to their patients on toothbrushing should be based on the best available evidence, with due consideration being given to the individual patient's ability to achieve and maintain an acceptable level of oral health. Increasingly, systematic reviews[12,54,65] and Clinical Guidelines[66,67] are being published to support recommendations. This review indicates that much of what we advise is based on traditional reviews of the literature in which the selection of studies does not entail an appraisal of their quality. However, the number of high quality systematic reviews is increasing and will provide stronger evidence to support the advice we give and Clinical Guidelines.

Most people perceive toothbrushing as a tedious procedure which is performed primarily to provide cosmetic rather than health benefits. The increasing popularity of powered brushes and fluoride toothpastes which contain agents that also improve plaque control and periodontal health are to be welcomed. Clinician's can maximise the health benefits of this process by advising patients about frequency, choice of

Despite improvements in oral health there is still the potential for many individuals to gain greater benefit. The clinician has a clear role in providing appropriate advice to enable patients to maximise the effects of toothbrushing. Future services should recognise and support the profession in this role

Table 2 The levels of evidence for recommendations for control of periodontal disease

	Instructions	Evidence
Frequency of brushing	Twice daily	Type 5
Brushing duration and technique	Modify existing method of brushing emphasising a systematic approach.	Type 5
Manual toothbrushes	Small headed; soft, round ended filaments; compact, angled arrangement of long and short filaments; comfortable handle.	Type 2,5
Powered toothbrushes	Powered brushes may be more effective than manual brushes.	Type 1,5
Toothpaste	Toothpastes containing triclosan with either copolymer or zinc citrate provide improved levels of plaque control and periodontal health.	Type 2

toothpaste and brush, post-brush rinsing and the supervision of children.

In the UK only 62% of dentate adults recalled having been given some advice or information about toothbrushing or gum care. Patients should be given advice and encouragement to achieve and maintain an acceptable level of oral health. The advice should be tailored to the individual and reinforced at regular intervals if the desired behaviour and benefits are to be sustained.

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IN BRIEF

- A preventive strategy at the planning stage describing patient selection, surgical technique, prosthetic design and loading
- A preventive strategy for the maintenance period describing recall examination and diagnosis and therapy
- The level of evidence currently available to support these strategies

5

Prevention. Part 5: Preventive strategies for patients requiring osseointegrated oral implant treatment

VERIFIABLE CPD PAPER

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Prevention for patients requiring rehabilitation with oral implants is about preventing implant failure and biomechanical complications. This paper describes preventative strategies for the planning stage for implant treatment and the later maintenance period and indicates the level of scientific evidence supporting these strategies.

PREVENTION

1. Smoking cessation advice
2. Dietary advice
3. Prevention of tooth wear
4. Toothbrushing advice
5. **Patients requiring osseointegrated oral implant treatment**
6. Older dentate patient
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Missing teeth and supporting oral tissues have traditionally been replaced with dentures or bridges permitting the restoration of masticatory, phonetic function, and aesthetics. Dental implants now offer an alternative for tooth replacement. Inserted into the mandible or maxilla, these implants are retained because of the intimacy of bone growth onto their surface so that they can support a dental prosthesis. Osseointegration is the word used to describe the healing of bone around implants so that there is direct anchorage of the implant that is then maintained during functional loading without the growth of fibrous tissue at the bone-implant interface.[1]

Prevention for patients requiring rehabilitation with oral implants is about preventing implant failure. Biological failure occurs when osseointegration is not established or is not maintained. When not established in the first place, implant failure is described as 'early failure' and will be observed before or at abutment connection. When osseointegration does occur but then is lost, the implant failure is described as a 'late failure' as this is observed at any time after abutment connection. When an implant is not osseointegrated, a peri-implant radiolucency is observed radiographically and the implant is clinically mobile. It is obviously important to prevent implant failure through adequate planning to facilitate establishment of osseointegration and then to preserve the long-term maintenance of osseointegration. This paper describes preventive strategies for the planning stage (Table 1) for implant treatment and the later maintenance period (Table 2) and indicates the level of scientific evidence supporting these strategies.

Table 1 Factors in preventive strategy at planning stage

Patient selection
- General health
- Smoking
- Bone quality and other anatomical factors
- Oral hygiene
- History of radiotherapy

Surgical technique
- Surgical trauma
- Number of implants
- Type of implant
- Microbial contamination
- Antibiotic usage

Loading

Prosthetic design

Table 2 Factors in preventive strategy for the maintenance period

Recall examination and diagnosis
- Examination of the prosthesis
- Examination of the implants

Therapy
- Patient administered hygiene procedures
- Mechanical debridement by the professional
- Pharmacological therapy
- Surgical procedures

PREVENTIVE STRATEGY AT THE PLANNING STAGE

Patient Selection

General Health

It seems likely that systemic conditions that interfere with wound healing also interfere with implant osseointegration, although there are actually few studies looking specifically at particular medical conditions. Patients with systemic diseases such as diabetes mellitus, or those taking systemic steroid therapy or other immunosuppressive medication are known to have impaired wound healing and these patients are often thought to also have an increased rate of implant failure. Many of the published reports specifically investigating diabetes include too few patients to offer conclusive results.[2,3] A study analysing data from the Department of Veteran Affairs Dental Implant Registry in the USA observed an association between the medical history in general of a patient and implant failure.[4] This was then reported by a conference seeking consensus on variables predictive of implant failure (Perio Consensus Report 1996).[5] However, regarding diabetes, this publication reported no greater implant failure rate in patients with well-controlled diabetes mellitus than observed in the general population.

Smoking

Several observational studies have described a relationship between smoking and increased implant failure but the strength of this relationship varies between studies. One study has shown only a 0.6 mm mean difference in bone levels between smoking and non-smoking groups over a 10-year period, which is of little clinical significance.[6] More recently a study reported smokers to have a one and a half times the 6% failure rate observed in patients of the group who had never smoked.[7] Implants in the maxilla had almost two times the risk of failure in smokers than non-smokers. The authors of this study suggested that the increased failure rate was caused by the exposure of the peri-implant tissues to tobacco smoke. Other researchers have also implicated altered peri-implant tissue conditions.[8–10] Generally there is a consensus that smokers have about twice the number of failed implants compared with non-smokers, although well-designed trials are lacking.

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Bone quality and other anatomical factors

Implant success is related to the quality of the bone into which the implant is inserted and therefore this factor should be taken into account when planning the placement site of the implants. Site seems to be an important factor irrespective of whether the implants are loaded or not.[11–13] Higher failure rates have been reported for implants placed in maxillary bone compared with mandibular bone and also in the posterior segments of both jaws. Posterior sites may also restrict the bone volume available for placement of large implants because of vital structures such as the inferior alveolar nerve or maxillary sinus.[14] A reduced success rate has also been described when bone grafting is undertaken to facilitate implant placement at sites of inadequate volume.[16] Bone quality seems to relate primarily to bone density and the denser the bone, the fewer the failures, with the exception of extremely dense bone. The presence of dense bone may favour early implant stability, which is one of the prerequisites for predictable osseointegration. Interestingly, it has been shown in a laboratory model that the maximum stresses and strains are concentrated about the crestal cortical bone rather than the cancellous bone and that from a biomechanical point of view, implants may be almost completely supported by the cortical bone, when present.[15]

Oral hygiene

The patient should have demonstrated the ability to maintain proper hygiene before proceeding with implant treatment as a cause-effect relationship between bacterial plaque accumulation and the development of inflammatory changes in the soft tissues surrounding oral implants has been shown.[17] However, no relationship between previous periodontal disease and implant failure has been established yet.[18–20]

Several studies have indicated that remaining teeth might act as a reservoir for the colonization of the subgingival area around implants.[21,22] This suggested that there may be an association between susceptibility for periodontitis and susceptibility for peri-implantitis, especially in partially edentulous patients. However, a recent study has failed to find any relationship between ongoing periodontitis around teeth and bone loss around implants inserted in the same jaw. Patients were included in this study with either a history of stabilised or progressive periodontitis and patients had no more marginal bone loss than patients with a healthy periodontium when measured radiographically and clinically.[23]

Keratinised mucosa

It has been suggested that an adequate band of keratinised mucosa about an implant is necessary for its success[24,25] but it has not been possible to demonstrate this scientifically[26] and the consensus view now is that there is no correlation between the width of keratinised mucosa and implant failure.[5] However, it may be that the presence of keratinised tissue facilitates the patients' hygiene procedures but in many patients these may be adequate without keratinised tissue.[11] Similarly, an adequate sulcus is required for plaque control and to avoid tissue tension involving the peri-implant soft tissues.

Radiotherapy

Individual observational studies of implant failure rates in irradiated and non-irradiated patients have been compared. This has shown

that failure rates in the mandibles of irradiated patients are slightly higher than those of non-irradiated patients but that irradiated maxillas show a much higher failure rate than irradiated mandibles.[27] The failure rate was also shown to be dose dependent with an increased failure rate at higher radiation doses.

As fibrosis and loss of micro-vascularity begins about 6 months after irradiation and then progressively worsens,[28] implant treatment should probably be undertaken early. Whilst there is much support for the use of hyperbaric oxygen therapy for these patients from observational studies, there is a dearth of high-level evidence from randomised controlled trials (RCTs) evidence supporting or rejecting its benefits.[29]

Genetic factors
Differences in genetic makeup that reflect differences in healing or other factors may relate to implant success, but at present there is still no available information.

Surgical technique

Surgical trauma
Prevention of failure should also take into account the surgery. This should be undertaken as atraumatically as possible and implants should be placed using drills at appropriate speed and with adequate irrigation to prevent bone heating. If the temperature is permitted to rise to over 47°C for 1 minute, then this may cause a zone of necrotic bone surrounding the inserted implant and it is thought that this may be clinically significant.[30,31]

Number of implants
An adequate number of correctly positioned implants should be planned as part of the loading consideration. Excess loading may lead to biological failure, that is, loss of osseointegration, but also to mechanical failure of the implants or retained prosthesis. There is some evidence from a few studies to show that the number of implants supporting a fixed prosthesis may be important for treatment success.[6,32] Three or more implants seems to be more successful than two implants for the rehabilitation of partially dentate patients.

Implant type
Implant surface characteristics such as roughness and type of coating may influence the failure pattern and numerous surface modifications have been developed to enhance clinical performance. A recent systematic review found that there were very few studies comparing different implant types and no evidence that any of the implant systems evaluated was superior to the another.[33] Those studies included investigated Astra, Branemark, IMZ, ITI, Steri-Oss and Southern implant systems. However, these findings were based on a few RCTs all having short follow-up periods and few study patients.

Microbial contamination
A high standard of cross-infection control should be adopted for implant surgery as a correlation has been observed between increasing numbers of implants placed in a patient and increased failure rate.[34] The authors of this study suggested that this could have been due to the longer operating time and consequent larger wound contamination. A larger failure rate has also been reported in patients with high plaque scores likely as a result of bacterial contamination at the time of implant placement.[35] It is also known that biomaterial infections are extremely resistant to host defence mechanisms and antibiotic therapy.[36] Microorganisms preferentially adhere to implant surfaces and form a biofilm to protect themselves from the host.[37] The shape of the implant therefore may also have a bearing on infection rate. Hollow implants used in orthopaedic surgery (intramedullary nails) have been found to have an infection rate almost two times that of solid nails but this was from an animal study rather than a clinical trial.[38] Similarly, implants with a porous surface have been reported to have more early infections than dense implant.[39]

Antibiotic usage
It is common practice to use prophylactic antibiotics or a course of antibiotics after implant placement to increase the success although this practice remains controversial. There is some evidence from observational studies that preoperative antibiotics reduce the early failure rate [40] although no randomised controlled trial has been carried out yet. Chlorhexidine mouthrinse used pre-operatively is also associated with a reduced complication rate.[41]

Loading
Excessive loading in relation to bone quality is another cause of implant failure.[11,23] It has been suggested that implants should not be loaded during a healing phase of 3–4 months in the mandible and 6–8 months in the maxilla if osseointegration is to occur.[1] Some studies comparing immediately loaded and conventionally loaded Branemark mandibular implants showed an overall seven times higher early failure rate for those immediately loaded.[42,43] Experimental evidence has indicated that early loading causes micromovement of the implant and differentiation of cells into fibroblasts resulting in fibrous encapsulation rather than osseointegration.[44] Alternatively, other laboratory experiments have shown that daily low frequency micromotion may stimulate bone growth.[45] The precise level of micromotion that can be tolerated clinically without significantly inhibiting bone formation is unknown.

Recently, immediate and early loaded implants are being used particularly in the mandible.[46] It is likely that the bone quality is of major importance for success in this situation. Some authors are also advocating implant surface modifications as a means of facilitating the

Implant type

A recent systematic review found that there were very few studies comparing different implant types and no evidence that any of the implant systems evaluated was superior to the another

earlier loading of implants.[47] There are an inadequate number of good quality randomised controlled trials comparing immediate versus conventionally loaded implants[48] and also the related question of whether to close over soft tissues during healing (two-stage surgery) or to leave exposed (one stage surgery) to provide clear evidence for practice.[33]

Whilst there is little clinical evidence that bruxism or clenching parafunctions are associated with increased implant failure, there seems to be general consensus that excessive loading may induce bone loss. It is actually difficult to obtain good evidence as it is difficult to clinically quantify the magnitude and direction of bite forces applied by a patient in relation to the bone quality and control groups.[49]

Prosthetic design

The planned type of prosthesis, crown, fixed bridge or overdenture, has implications for maintenance by the patient. The implant plan should aim to achieve an emergence profile that enables easy cleaning. The suprastructure should be designed so that the patient can maintain proper oral hygiene. If the reconstruction is overcontoured, especially interproximally, this will prevent the achievement of optimal oral hygiene.[50]

It has been suggested that cantilever length influences stress distribution, particularly on distal implants,[51] but only a few studies have investigated this. One study reported that cantilevers longer than 15 mm had to be remade more often than shorter cantilevers.[52]

PREVENTIVE STRATEGY FOR THE MAINTENANCE PERIOD

The aim after completion of implant and restoration is to prevent implant failure by offering the patient a programme designed for his or her individual needs

Examination and diagnosis

It is generally recommended that patients should be reviewed regularly. The recall interval may be 6 months but will vary according to the patient's individual needs. There are no cost benefit analyses studies relating to this view. The examination should focus on the prosthesis, the implants and the peri-implant tissues.

Examination of the prosthesis

This should include noting the retention and stability, any abutment or screw loosening or loss of cement. The occlusion should be examined.

Examination of the implants:

• *Mobility*

Pain or sensitivity when eating or when the abutment screw is tightened may be an early indication of osseointegration failure. However, it is important to bear in mind that failed implants can be completely asymptomatic. Any indication of mobility indicates a failed implant as a result of loss of osseointegration and is occasionally present when radiographic bone changes are not distinct. For research purposes, the prosthesis may need to be removed but this would be unreasonable in normal clinical practice at review appointments and mobility testing cannot be carried out if implants are supporting a cemented prosthesis. Radiographic examination, whilst not as accurate a test for implant failure as mobility, provides a good indication and avoids having to remove a fixed prosthesis.

The Periotest electronic device provides an objective measure of mobility although it does not provide an indication of implant failure any earlier than indicated by radiographic changes.[53] Several factors have an influence on Periotest values including, the length of the implant and abutment, whether the implant is in mandibular or maxillary bone, and bone density.

It has been proposed that at abutment connection, a 10 N cm reverse torque could be applied to the implant to check for mobility but this may risk damaging a weak immature bone/implant interface and is therefore not recommended.[54] Other non-invasive evaluation methods are now available but the correlation between their measures and osseointegration are not clear.[55,56] Simply to know whether an implant is mobile or not may be more clinically relevant.

• *Radiographs*

Periapical radiographs should be taken to show the bone level about implants. These should be taken in a standardised way so that they are reproducible and avoid distortion. Dental panoramic radiographs are of less use than periapical radiographs, particularly for research, in monitoring bone stability about implants because of the inferior image resolution and the inability to modify the angulation of the x-ray beam.[57] A periapical radiograph should be first taken soon after abutment connection to provide a baseline measure of bone level for comparing subsequent follow-up radiographs taken to monitor any progressive marginal bone loss or 'saucerization'.[58] This bone loss may result from peri-implantitis or overloading of the implant. Regular radiographs at determined follow-up periods may not be necessary but rather should be taken to clarify some question prompted by the clinical examination.

The implant would not initially be mobile with this type of bone loss as there remains a large area of bone/implant interface osseointegration. Alternatively, a thin radiolucent peri-implant margin may be observed surrounding the entire implant, suggesting absence of osseointegration and a loss of stability.[59] When excessive marginal bone loss or a radiolucent peri-implant margin is observed then the implant mobility should be checked and this may require removal of a bridge.

Less than 1.5 mm of marginal bone loss during the first year of loading, and thereafter less

Radiographs

A periapical radiograph should be first taken soon after abutment connection to provide a baseline measure of bone level for comparing subsequent follow-up radiographs taken to monitor any progressive marginal bone loss or 'saucerization'

than 0.02 mm each year, has been defined as success[60] although some authors have doubted whether a firm limit for an acceptable annual bone loss can be established.[61] It is not technically possible to observe radiographic changes of 0.1 mm but threaded implants permit reference by way of the threads for serial radiographs. Another shortcoming is that only interproximal aspects of an implant can be observed.

• *Peri-implant tissues*

The attachment between an implant and the surrounding tissues is quite different from that between a tooth and the surrounding tissues, primarily because there is no periodontal ligament. Nevertheless, if an implant is biocompatible, one may expect the usual wound healing principles to establish healthy peri-implant tissues. One of the key factors for the long-term success of oral implants is the maintenance of healthy tissues around them.[62]

A cause-effect relationship between bacterial plaque accumulation and the development of inflammatory changes in the soft tissues surrounding oral implants has been shown.[17] Peri-implant mucositis is the term used to describe the reversible inflammatory changes in the tissues around an implant.[65] If this condition is left untreated, it may lead to the progressive destruction of the tissues supporting an implant (peri-implantitis) and ultimately to its failure.[63] The majority of the evidence for this association comes from microbiological observations based on observational studies. These demonstrate the presence of suspected periodontal pathogens in peri-implantitis situations or the presence of the usual microorganisms associated with health in the clinically healthy situation.[65,66] For maintaining healthy tissues around oral implants it is important to institute an effective preventive regimen and, when a pathological condition of the tissues around implants has been diagnosed, then a therapeutic intervention should be initiated as soon as possible.[67] Peri-implant inflammation is successfully treated by effective oral hygiene and plaque control as with inflammation around natural teeth. Different maintenance regimens and treatment strategies for peri-implantitis (failing implants) have been suggested, however it is unclear which are the most effective.[62,67–69]

It is not clear how reliable the various periodontal parameters are for identifying peri-implant pathology.

Bleeding on probing (BOP) is the periodontal parameter used to evaluate the presence of an inflammatory process at the base of a periodontal pocket. The presence of bleeding is noted on probing in the pocket until a slight resistance is met using gentle force. Standardised probes which produce forces of 0.25 N are available. The absence of BOP is a reliable indicator for periodontal stability[70] but the use of this measure for peri-implant tissues is not necessarily as helpful and insufficient data are currently available.

The sulcus bleeding index (SBI), is the bleeding tendency of the alveolar mucosa surrounding the implant abutment observed by running a periodontal probe along the abutment circumference 1 mm into the mucosal pocket and parallel to the margin of the soft tissues. This parameter distinguishes between healthy and inflamed tissues but may not be able to identify failing implants.[11]

Pocket probing depth (PPD), is the linear distance from the free mucosal margin to the base of the pocket. The base of the pocket is defined as the apical termination of the junctional epithelium when used for teeth but for implants there is no periodontal attachment to stop the tip of the probe. A deep pocket is a protective habitat for putative pathogens which may lead to peri-implant pathology.[71] A recent report suggested that probing measurements around osseointegrated oral implants and teeth were different. Even mild marginal inflammation was associated with deeper probe penetration around implants in comparison to teeth.[72] Pocket probing depth may not provide as accurate an indication of disease as bone level measurements on intraoral radiographs,[11] but it could still be useful in practice.

Other signs of infection such as hyperplastic tissues, suppuration, swelling, or colour change may also provide an indication that therapy is indicated. Mucosal recession exposing threads or a rough implant surface might reduce the ability of the patient to maintain the implant clean from plaque in addition to causing an aesthetic problem.

Therapy

Patient administered hygiene procedures

The patient should be instructed in brushing using soft brushes and interproximal brushes and flossing with appropriate designs of floss such as superfloss for mechanical plaque removal.[73] Adjunctive twice-daily antimicrobial mouthrinsing with an agent such as chlorhexidine has been recommended for patients with physical impairment.[73–75] Powered toothbrushes have also been recommended.[76,77] Recently a Cochrane Systematic review examined the effectivness of different maintenance therapies for patients with oral implants.[62] This review indicated that there was little available evidence for the effectiveness of interventions for maintaining healthy tissues around dental implants. However, Listerine mouthwash, 20 ml used twice a day for 30 seconds, as adjunct to routine oral hygiene was found to be effective in reducing plaque formation and improving health around implants. There was no evidence that the use of powered or sonic toothbrushes was superior to manual tooth brushing.

Mechanical debridement by the professional

Given the association between plaque and the development of pathology of the tissues about implants, it would be reasonable to arrange the following regimen, although no cost benefit

Therapy

When a pathological condition of the tissues around implants has been diagnosed, then a therapeutic intervention should be initiated as soon as possible

analyses have been carried out. An appropriately trained professional should provide intensive motivational hygiene instruction for the patient about 1 week after abutment surgery.

After restoration this should be repeated. Remotivation and patient instruction in oral hygiene should be carried out every 6 months or at an appropriate time period for the individual patient.

Professional removal of plaque and calculus from the implant-abutment surface should be undertaken when needed. Scaling with hard plastic or titanium instruments is recommended to avoid scratching and roughening the titanium implant abutment surface that may increase the chance of bacterial colonization,[78] although all of the evidence for colonisation is derived from *in vitro* studies and no clinical trials have validated this hypothesis. Plastic scalers are also recommended to avoid galvanic corrosion and contamination of metallic implants although there is no evidence to support this.[79,80] Plastic tips for ultrasonic devices are also recommended. A rubber cup and fine abrasive polishing paste (fluor of pumice, Nupro Fine, tin oxide) might be helpful.[81]

Scaling

Scaling with hard plastic or titanium instruments is recommended to avoid scratching and roughening the titanium implant abutment surface

Pharmacological therapy

Systemic antibiotics are frequently used in clinical practice as an adjunct to surgical intervention for the treatment of peri-implantitis although the evidence for their efficacy has not been clearly demonstrated.[82] Subgingival irrigation with antimicrobial agents has also been advocated for the prevention of peri-implantitis.[82] Phosphoric acid gel application has also been recommended,[81] although a recent Cochrane review on maintenance for implant patients did not find any evidence that phosphoric etching gel (monthly 35% for one minute) offered any clinical advantage over mechanical debridement.[62]

Surgical procedures

Surgical procedures have been recommended for the management of peri-implantitis.[67] In particular, open flap debridement to facilitate smoothing of the implant surface and removing unsupported implant threads that protect bacterial plaque. The implant surface may also be 'decontaminated' using various chemical agents[83] or laser energy,[84] but there is no evidence that either is necessary or effective. Once the surface has been rendered 'bacterial free', further surgery to alter the local anatomy may be necessary to enable easy plaque removal.[85]

DISCUSSION AND CONCLUSIONS

Early implant failure is most commonly attributed to excessive surgical trauma together with inadequate healing because of host compromise, premature loading and infection. The most important causes of late failure are likely to be peri-implantitis and overload together with host factors.[11,27] The common observation that failures tend to be concentrated in particular individual patients suggests that certain factors are important in determining implant success. Even though several factors have been highlighted as associated with a higher failure rate this may not preclude the patient from proceeding with implant treatment. This particularly applies to the patient selection factors. The most appropriate clinical option for tooth replacement for a patient who smokes or who has undergone radiotherapy may be implant treatment but the clinician should advise the patient as to the likely reduced success rate.

It is important to know which therapy is most effective to manage a patient and consequently the importance of evidence-based dentistry is becoming increasingly recognised. There is a general consensus that randomised controlled clinical trials (RCTs) are preferred to answer questions of therapy effectiveness, and systematic reviews can evaluate the quality of RCTs and combine their results to reach more reliable conclusions.[86] A randomised controlled trial is not however always feasible. Patients cannot be randomised to smoking, diabetes, or radiotherapy groups, for example, and so the evidence must sometimes be based on good observational studies. Systematic reviews have a clearly formulated hypothesis employing systematic methods to identify, select and critically appraise relevant research. Data from original trials are collected, analysed and if possible summarised to provide a more precise estimate of the intervention effects than available from individual trials. Unfortunately there are few RCTs as yet available investigating any management alternatives for oral implant rehabilitation.[87] Recently a Cochrane Systematic review examined the effectiveness of different maintenance therapies for patients with oral implants.[62] This review indicated that there was little available evidence for the effectiveness of interventions for maintaining healthy tissues around dental implants and the relatively few findings that were presented were based on short follow-up periods (the longest was 5 months) and there is no reliable evidence for long-term maintenance. Therefore many of the standard maintenance therapies used are not based on reliable scientific evidence. These therapies may be effective, but their efficacy needs to be demonstrated in trials and their relative cost should also be investigated.

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PRACTICE

6

IN BRIEF

- Ageing dentate patients are increasing in number.
- Caries risk assessment facilitates dental management.
- Restoration monitoring, repair or refurbishment should always be considered before a restoration is placed.
- Stabilisation splints are helpful in preventing further non-carious tooth tissue loss.
- Fluoride release from restorative materials may not have a therapeutic benefit.
- Dry mouth is not specifically age related.

Prevention. Part 6: Prevention in the older dentate patient

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Managing the ageing dentition is a frequent problem for practitioners. Prevention of further tooth loss, let alone preserving tooth tissue, whilst minimising the effects of operative intervention form the basis for successful management of older dentate patients. The purpose of this article is to consider the prevention of caries, further tooth tissue loss due to operative intervention and non-carious tooth tissue loss in the ageing dentate patient.

PREVENTION

1. Smoking cessation advice
2. Dietary advice
3. Prevention of tooth wear
4. Toothbrushing advice
5. Patients requiring osseointegrated oral implant treatment
6. **Older dentate patient**
7. Professionally applied topical fluorides for caries prevention
8. Pit and fissure sealants in preventing caries in the permanent dentition of children

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Last scene of all,
That ends this strange eventful history,
Is second childishness and mere oblivion,
Sans teeth, sans eyes, sans taste, sans everything
As You Like It, Shakespeare (c.1599)

Twenty years ago Shakespeare's vision of ageing in the UK was alarmingly accurate with people commonly surviving their natural dentition. Advances in our understanding of dental disease and dental care coupled with increasing dental awareness and motivation by patients has fortunately changed his somewhat dim view of dental ageing.

The part played by the dental profession in this public health success story is sadly somewhat underplayed. One of the consequences of our success however, which practitioners face on a day-to-day basis is managing the ageing dentition. This along with meeting the expectations of an ever increasing elderly population with quite rightly youthful expectations of both function and aesthetics is demanding. Prevention of further tooth tissue and tooth loss *per se* is paramount in the management of all patients but especially elderly dentate patients. One retained tooth, for example, can support and help retain a lower partial denture with which the patient can function whereas a complete lower denture would be unstable with poor retention, particularly if the ridge is especially atrophic.

Caries is often described as a disease of the two extremes of life assuming all risk factors remain equal. The availability of fluoride in toothpaste particularly has changed the pattern of disease seen by practitioners, with caries largely confined to pits and fissures and smooth surface caries relatively uncommon in younger patients. In contrast elderly patients are more likely to present with root caries and caries adjacent to existing restorations. Alongside this different pattern of caries experience elderly patients present with non-carious tooth tissue loss, the cumulative effects of generalized periodontitis and failing often quite advanced restorative dentistry.

The purpose of this article is to consider the prevention of caries, further tooth tissue loss due to operative intervention and non-carious tooth tissue loss in the elderly dentate patient. Prevention for the edentulous patient with or without implant-retained prostheses is covered elsewhere in the series. Many of the interventions we prescribe for our patients on a daily basis are not evidence-based and considerable research is required to provide an evidence base for our clinical practice. There are however a lack of clinical studies in this area, which makes this difficult. Given the increasing number of elderly dentate patients it is suggested that this is an area that deserves some priority when research funding is allocated. Interventions suggested for

prevention in the elderly dentate patient will however be supported by evidence where it is available. The strength of this evidence will be indicated using the following hierarchy of evidence:

Type 1 Systematic review of at least one randomized controlled trial (RCT)
Type 2 At least one RCT
Type 3 Non-randomized intervention studies
Type 4 Observational studies
Type 5 Traditional reviews, expert opinion

CARIES

Caries is a totally preventable disease irrespective of a patient's age. Assuming all risk factors remain equal it is unusual to see new lesions in any patient but particularly in older patients where susceptible pits and fissures if prone to caries will already have experienced the disease. Physiological ageing of a dentition however results in gradual exposure of root surfaces, which can be prone to caries in later life ie a new susceptible site emerges and consequently the pattern of disease experience changes with age.

Currently there is considerable debate in the literature regarding the management of dental caries with the evidence suggesting that we move to a less interventive approach. This involves concentrating our efforts on arresting established lesions, especially root and cervical caries, reversing early occlusal lesions and only intervening when lesions are cavitated. Central to this philosophy is assessing the caries risk of our patients and recognizing that this assessment can change.

Caries risk assessment

Helps the practitioner decide whether to intervene and informs the frequency of subsequent recall and radiographs

Table 1 Determination of caries risk

High	Factor	Low
Diet high in fermentable carbohydrate	**Diet** Check with diet history	Diet low in fermentable carbohydrates
Frequent consumption not confined to mealtimes	**Frequency** Check frequency of consumpton with diet history	Infrequent consumption or confined to mealtimes
High plaque score	**Plaque** Amount and nature	Low plaque score
Low flow rates High lactobacilli and streptococcus counts	**Saliva** Amount and nature	High flow rates Low lactobacilli and streptococcus counts
Not dentally motivated Deprived background Low dental aspirations High caries family	**Socio-economic Status**	Dentally motivated patients Privileged background High dental aspirations Low caries family
High number of Filled and Missing Surfaces (FMS)	**Past Disease Experience**	Low number of Filled and Missing Surfaces (FMS)
High number of Decayed surfaces (DS)	**Current Disease Experience**	Low number of Decayed surfaces (DS)
Irregular and/or pain only attenders	**Attendance Pattern**	Regular attenders
Infrequent use of rinses and toothpaste Non-fluoridated water supply	**Fluoride and Chlorhexidine**	Frequent use of rinses and toothpastes Fluoridated water supply
Xerostomia, Learning difficulties Cariogenic medication	**Medical History**	Fit and well
Partial dentures used to replace missing units	**Other**	Bridgework used to replace missing units

Patients can move from low to high risk by changing their diet, for example, older patients post radiotherapy or past smokers sucking sweets more frequently than normal to combat the effects of a dry mouth or in lieu of a cigarette.

Restricting operative intervention to high and moderate risk patients whilst opting for a preventive monitoring type approach in low risk patients is arguably a more scientific approach to the management of the dental caries rather than the purely surgical approach traditionally adopted in the UK.

ASSESSING CARIES RISK

Caries risk assessment is defined as the risk that a patient will develop new lesions of caries or existing lesions will continue to progress assuming that all aetiological factors (diet, time, susceptible surface and plaque levels) remain equal (Table 1). Individuals are assessed as being at high, medium and low risk of developing further lesions. A high-risk category would be allocated to a patient where the majority of the factors in Table 1 point to a high risk and vice versa. Moderate risk would be attributed where the factors in the table balance out.

It is an important assessment as it informs the recall period for patients in regular dental care, helps the practitioner to decide whether to intervene or instigate preventive regimes; let alone the frequency that further radiographs should be taken for monitoring purposes (Table 2). It is accepted however that the recommendations in Table 2 have no robust evidence base. A systematic review looking at the evidence base for 6-monthly check-ups is currently ongoing. Until such time as the results of this review have been reported it is suggested that the recommendations in Table 2 are a good starting point. Computer programs are available to help clinicians assess caries risk and also to plan preventive treatments but these systems are in their infancy and have yet to be fully evaluated.

CARIES PREVENTION

Having decided what the patient's caries risk assessment status is it is suggested that the following preventive regimes, which combine the application of fluoride and chlorhexidine (Type 2)[1] are appropriate:[2]

High Risk

High-risk patients require intensive prevention regimes to include:

- Baseline radiographs
- Prophylaxis with application of chlorhexidine for 1 minute followed by rinsing
- Apply sealant to pits and fissures, which must be checked for integrity at recall
- Fluoride varnish application. Patient should be advised not brush or eat hard foods for 10 hours. Three applications of fluoride varnish are recommended over a 3-month period
- Brushing twice a day with a fluoridated toothpaste

- Rinsing daily for 1 minute with a fluoride mouthwash (0.05% NaF) at bedtime (Type 2)[3]
- Rinse weekly rather than daily (Type 2)[4] with a chlorhexidine solution for 6 weeks
- After 6 months repeat baseline radiographs to monitor proximal lesions and restore any lesions, which have reached the middle third of dentine. If progression has been detected increase the application of chlorhexidine and apply fluoride varnish two to three times on a six monthly basis
- Oral hygiene instruction and dietary counseling are required to ensure success
- Monitor patient at six monthly intervals until patient's caries risk falls to moderate or low

Moderate risk

Prevention for patients in this group should include:

- Prophylaxis followed by fluoride varnish application. Patient should be advised not to brush or eat hard foods for 10 hours. Three applications of fluoride varnish are recommended over a 3-month period for every year the patient remains at moderate risk
- Brushing twice a day with a fluoridated toothpaste
- Rinsing daily for 1 minute with a fluoride mouthwash (0.05% NaF) at bedtime (Type 2)[3]
- Monitor lesion size and depth and whether new lesions arise at 6–12 monthly intervals until the caries risk moves to low. If lesions progress or new lesions arise increase applications of the fluoride varnish and give further dietary advice

Low risk

Prevention is limited to brushing twice a day with fluoridated toothpaste with reviews at 12–18 month intervals to check for white spot formation and proximal radiolucencies.

PRESERVING TOOTH TISSUE

Elderly patients if prone to caries in their youth are likely to have relatively large restorations, as a consequence of the restorative cycle or staircase, and these will be prone to eventual failure.[5] The term staircase is to be preferred as the word cycle implies a return to the start where clearly each step on the staircase is a step further to the loss of a tooth. Newer elderly cohorts will have progressively more sound teeth, as operative intervention will have been restricted to where indicated, with minimal preparations and where modern adhesive materials will have been used. These patients will require different management strategies and this will pose a challenge for practitioners in the future.

Currently on average 60% of restorations placed by practitioners are replacement restorations that are deemed to have failed in clinical service.[6] The commonest reason cited for replacing restorations is secondary caries. There is considerable debate in the literature as to what constitutes secondary caries, ie is it recurrent caries or residual caries or is it a new lesion. It has been suggested that secondary caries is in fact a new carious lesion adjacent to an existing restoration. As such it should be treated as a primary lesion and more often than not the adjacent restoration does not warrant complete replacement therapy (Type 4).[7] Marginal defects are often misdiagnosed as secondary caries and restorations replaced needlessly. Similarly restorations are frequently replaced that could have been repaired, refurbished or simply monitored.

Replacement of restorations where a more preservative approach could have been adopted pushes the tooth further down the restorative staircase which if followed to its ultimate conclusion will result in tooth loss. Practitioners are encouraged therefore to minimize the nature and effect of operative intervention wherever possible.

Table 2 Caries risk assessment

Caries Risk	Recall Interval	Intervention	Radiograph Frequency
High	Six Monthly	Yes	Six Monthly
Moderate	Six Monthly- Annually	Yes	Annually
Low	1-2 years	Monitor and attempt to arrest and reverse the lesions	1-2 years

NON-CARIOUS TOOTH TISSUE LOSS

Elderly patients frequently exhibit the effects of non-carious tooth tissue loss (NCTTL). NCTTL is often multi-factorial and is a combination of erosion (intrinsic and or extrinsic), abrasion and attrition. Extrinsic erosion due to acid present in the diet will on the whole affect the labial surface of the anterior teeth and to a lesser extent the occlusal surfaces of the lower permanent molars. Intrinsic erosion due to acid regurgitation (gastric acid) will usually affect the palatal surfaces of the upper teeth and on occasion the occlusal surfaces of the lower permanent molars. The effects of NCTTL are cumulative and irreversible but in a similar manner to periodontal disease the process has periods of disease activity and quiescence. Consequently in a patient who presents with NCTTL it cannot be assumed that the disease process is still active and some form of assessment is required. This usually involves taking study casts and comparing them with casts taken 6 months later to determine if the process is still ongoing. Dietary analysis is important to identify factors that might be responsible for the NCTTL the patient has experienced. Liaison with a medical practitioner should intrinsic erosion be diagnosed will also be necessary. Once a diagnosis is made the prime objective is to stabilize the disease process and prevent further tooth tissue loss before addressing the patient's functional, aesthetic or occlusal needs. A significant number of patients are successfully managed on preventive regimes with relatively few patients needing extensive advanced restorative therapy.

Restoration replacement

Consider restoration repair, refurbishment or monitoring in regular patients

Missing teeth

Replacement of missing units with bridgework is associated with less caries and periodontal disease than the use of removable partial dentures to replace missing units

PREVENTION OF NON-CARIOUS TOOTH TISSUE LOSS

It is very important that a correct diagnosis is made if appropriate preventive measures are to be effective, recognising that NCTTL can be multi-factorial. It would be sensible to liaise with the patient's medical practitioner, particularly if you suspect intrinsic erosion is responsible for the NCTTL the patient has experienced. It is helpful to explain to your medical colleague, in the referral letter, the association between eating disorders, reflux etc and NCTTL. It is also important to emphasise that reflux can often be asymptomatic and NCTTL can be the first sign of an underlying problem. A dietary history will be required if you suspect an extrinsic erosive cause and counselling the patient with regard to their dietary habits may be necessary.

Patients often attend with NCTTL seeking an assurance that the condition will not deteriorate and are happy if further NCTTL can be prevented. Unfortunately many patients are treated with extensive treatments, for example, a full mouth rehabilitation in a slavish attempt to restore teeth to their pre disease shape and contour. Whilst this is appropriate for a small number of patients a more preservative preventive philosophy is indicated for the majority of patients. A hard acrylic splint, in the form of a stabilisation splint, is very helpful to prevent further tooth tissue loss due to attrition and this is frequently the only treatment required. Patient compliance with splint wear can however be problematical and as teeth scarcely meet in the day, night time wear is all that is required. It may also be used as a diagnostic aid, particularly if an increase in the occlusal vertical dimension is planned subsequently. If abnormal occlusal loading is identified as an aetiological factor this will also need to be corrected, by a specialist, but only after a period of splint wear.

A stabilization splint is designed to have the following features:

- Even contact of all teeth in centric relation (retruded contact position – RCP)
- Protrusive and excursive guidance
- No non-working interferences

To produce a stabilization splint for a patient on a semi-adjustable articulator the laboratory will need the following:

- Full arch impressions
- Facebow record
- Centric and protrusive occlusal records

The splint may need to be relined with cold cure acrylic resin to improve the retention of the appliance and occlusal adjustment will typically be required. Frequently this is the only treatment required to stabilize a patient's dentition and prevent further tooth tissue loss. The evidence base for using splints in this way however needs to be tested in a properly conducted randomised controlled clinical trial.

If you have a patient who has a history of recurrent vomiting, for example, as in hiatus hernia advise the patient not to brush their teeth after vomiting. This is because tooth brushing will further abrade the eroded tooth tissue. To prevent tooth tissue loss counsel your patient to rinse with either 0.05% NaF rinse or alkaline mineral water. These will neutralise the effects of the acid and prevent further erosion and decrease subsequent sensitivity.

FURTHER REMARKS

Removing all the caries: Is this always necessary?

A randomised controlled study (Type 2)[8] has demonstrated that if dentine affected by caries but uninfected is sealed in it does not progress and lesions will arrest and burnout. With newer adhesive materials the prospect of reliably sealing affected but uninfected dentine within the centre of a preparation is achievable clinically. This will reduce the incidence of carious exposure of the pulp and could be termed preventive endodontic therapy.

Fluoride release from restorative materials: Is this useful?

Manufacturers often make claims about fluoride release from restorative materials. Whilst water fluoridation and the topical effects of fluoride in toothpaste are beyond question the therapeutic effects of fluoride release from restorative materials are questionable. A systematic review of the literature (Type 1)[9] showed no evidence of a preventive effect when fluoride-releasing restorative materials are used. Practitioners should therefore not place undue reliance on manufacturers' claims regarding fluoride release.

Replacing missing teeth: denture or bridgework?

In an elderly population who are retaining more of their natural dentition the replacement of missing units is a common clinical situation faced by practitioners. A randomised controlled trial (Type 2)[10] has clearly demonstrated that the replacement of missing units with bridgework is associated with less caries and periodontal disease than the prescription of partial dentures. The use of bridgework in suitably selected cases for the replacement of missing units is arguably therefore a more preservative approach to fixed prosthodontics in the elderly.

Dry mouth: An age-related phenomenon?

It is a myth that salivary flow reduces due to ageing.[11] Dry mouth is however common for elderly patients who are on medication, which reduces salivary flow due to autonomic effects. This can change a patient's caries risk and new lesions may develop consequently. Similarly patients who have had surgery to their salivary glands and or radiotherapy will have reduced salivary flow. These patients are best managed with a saliva substitute to ease the feeling of

dryness. There are several on the market but it is sensible to prescribe one that contains fluoride. At least one randomised controlled trial has shown that 10% chlorhexidine varnish is useful for controlling root caries in adults with a dry mouth (Type 2).[12]

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IN BRIEF

- Topical fluoride treatments are safe and effective but should be applied only to patients with decayed smooth surfaces or those at high risk of caries.
- Both APF gel and fluoride varnish are effective and can be recommended for caries prevention in permanent teeth. To maximize fluoride uptake, gels should be applied for 4 minutes.
- The frequency of fluoride application depends on individual risk, but should be at least biannual when indicated.
- Cleaning or prophylaxis is not necessary prior to the application of topical fluorides.

7

VERIFIABLE CPD PAPER

Prevention. Part 7: Professionally applied topical fluorides for caries prevention

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This paper reviews the use of professionally applied topical fluorides (PATF) in caries prevention. PATFs are indicated for children and adults with one or more decayed smooth surfaces and/or those who are at high caries risk. Frequency of administration depends on the patient's caries risk, and is usually every 6 months. The effectiveness of fluoride varnish and gel applications has been well established in caries prevention trials involving permanent teeth. Although both types are effective, varnish may be preferred because it is easier to apply, reduces the risk of fluoride over-ingestion, and has greater patient acceptance. Fluoride foams are similar products to gels, but have not been tested clinically. The use of in-office two-part rinses is not recommended because they have not been proven effective. A cleaning, or prophylaxis, is not necessary before the application of topical fluoride for caries prevention. In conclusion, when used appropriately, PATFs are a safe, effective means of reducing caries risk among high-risk populations.

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Caries prevalence among children in western countries has fallen dramatically over the past three decades.[1] Not all children, however, have experienced the same degree of caries risk reduction, and dental decay remains a significant problem for a substantial minority of high-risk children. The decline in caries prevalence has also not been uniform across tooth surfaces. On a percentage reduction basis, occlusal lesions have declined less than lesions on other tooth surfaces, and make up a higher proportion of the burden of dental caries.[2]

The use of professionally applied topical fluoride (PATF) is one means of preventing caries that is frequently used in private practice and public health settings. In terms of the relative reduction in decayed and filled surfaces, PATF is more effective against smooth surface caries than occlusal caries.[3] Given the present characteristics of dental caries, the appropriate use of PATF in developed countries must be examined.

Dental personnel have a wide choice of different PATF agents, vehicles, and regimens; and should be aware of the supporting evidence upon which to base their decisions. To gain a better understanding of the use of PATF, the following issues are reviewed: indications for use; caries prevention effectiveness and clinical application of different types of PATF; fluoride ingestion and toxicity; and whether a cleaning is necessary prior to topical fluoride application. The strength of the evidence was classified using the following typology:

Type 1: Systematic review of two or more clinical trials
Type 2: At least one randomized controlled trial
Type 3: Non-randomized intervention studies
Type 4: Observational studies
Type 5: Other designs, traditional literature reviews, expert opinion.

WHICH PATIENTS SHOULD RECEIVE PATF?

PATF should not be applied on a routine basis in dental practices. A patient's susceptibility to caries must first be determined and, based on this information an appropriate preventive care plan should be designed for each individual. The surfaces at risk for decay must also be considered because PATF is more effective against smooth surface caries than against pit and fissure caries.

Topical fluoride applications are indicated for patients with active smooth surface caries and those patients in high caries risk groups (Table 1). This includes special patient groups, such as those undergoing orthodontic treatment. In high-risk groups, evidence indicates an anti-caries effect over a 2-year period,[4] but PATF application does not make a significant difference in low-to-moderate risk children who also receive water fluoridation and dental sealants.[5,6] From a cost-effectiveness perspective, patients with low caries risk who reside in optimally fluoridated areas are unlikely to benefit from PATF therapy. The number of children that must be treated to prevent one decayed surface is esti-

Table 1 Indications for use of professionally applied topical fluorides

- Patients who are at high risk for caries on smooth tooth surfaces
- Patients who are at high risk for caries on root surfaces
- Special patient groups, such as:
  - Orthodontic patients
  - Patients undergoing head and neck irradiation
  - Patients with decreased salivary flow
- Children whose permanent molars should, but cannot, be sealed
- Not recommended for patients with low caries risk who reside in communities with optimal fluoridation

mated at 18 if caries incidence is low, but only 3 for groups with high caries incidence.[7]

A possible indication for the use of PATF is adults with exposed root surfaces. The problem of root caries is likely to increase due to population aging and the increased retention of teeth. However, no clinical studies have yet examined the potential benefits of this intervention.

FLUORIDE VARNISH

Since their introduction in the 1960s, fluoride varnishes have become the most widely used PATF in Europe.[8,9] The most common types of NaF varnish are Duraphat (2.2% F) and Fluor Protector (0.1% F). The advantage of varnish is its ability to adhere to tooth surfaces, which prolongs contact time between fluoride and enamel and improves fluoride uptake into the surface layers of enamel.

Biannual application of fluoride varnish can result in a reduction of 38% in caries increment over 2 years. Evidence available to date suggests that fluoride varnish and gel are equally effective in caries prevention

Caries prevention

For the permanent dentition, the anti-caries effect of fluoride varnish has been confirmed in a number of clinical trials. In a meta-analysis on the caries preventive effect of Duraphat varnish, eight studies were identified that were of high quality and provided Type 1 evidence.[10,11] Based on these studies, it was estimated the use of varnish resulted in a 38% reduction in caries increment (95% CI = 19–57%). In a second analysis, which included six additional studies, the estimated effect was again a 38% reduction (95% CI = 25–50%). Studies involved subjects ranging in age from 6-to-15 years; the application frequency was most often biannual; and the majority of studies were continued for at least 2 years.

Recent findings are consistent with the conclusions of the meta-analysis. In a high-risk community, children who received at least two varnish applications per year showed a 37% reduction in mean caries increment for a 4-year period compared with a control group.[12] Similarly, the effectiveness of fluoride varnish was supported in 24- and 48-month comparison studies of varnish and dental sealants.[13,14] In the 24-month report, compared with the control group, the use of fluoride varnish resulted in a 66% reduction in DMFS on non-fissured surfaces and a 38% reduction on fissured surfaces. However, in both reports, dental sealants were found to have superior performance for the prevention of decay.

The only direct comparison of the effectiveness of fluoride varnish and gel, in a developed country, showed no statistically significant differences between the treatment groups (NaF varnish and APF gel).[15] In this 3-year RCT study involving 12–13-year-olds, the mean total DMFS increments were 3.1 and 3.6 for the varnish and gel groups, respectively. The findings suggested varnish was as effective as gel for caries prevention.

For the primary dentition, the evidence is limited and only two randomized controlled trials have been conducted. Several studies of fluoride varnish have reported prevented fraction percentages of between 30-44%,[16,17] but findings have been inconsistent and most comparisons have not found significant differences. Recent studies have also found that varnish may slow the progression of early enamel caries in the primary dentition.[18,19] However, at present there is insufficient evidence with which to assess caries prevention effectiveness in primary teeth.

No definite conclusions can yet be drawn about the relative effectiveness of Duraphat and Fluor Protector varnishes.

Clinical application

PATFs must be reapplied at regular intervals to be effective and the frequency will depend on the risk level of the patient. Different application frequencies have been effective in clinical trials, but it is generally recommended that fluoride varnish be applied at least every 6 months.

The application of varnish is straightforward and can be done by a dental hygienist or a trained assistant (Table 2).[20] The entire process takes between 3–5 minutes per patient, depending upon the number of teeth present. Varnish is generally well accepted by dental personnel and patients, and has been found to be preferred to fluoride gel by both groups.[21] Dental hygienists found varnish easier and faster to apply, and allowed for better control of moisture and fluoride ingestion.

No common or serious side effects of varnish use have been reported. As a precaution, it is contraindicated in asthmatic patients due to possible allergic reactions. The temporary tooth discoloration caused by Duraphat varnish is objectionable to some patients, but is readily removed upon brushing.

Table 2 Procedure for the application of fluoride varnish

- Remove excess moisture from teeth with a cotton swab, cotton roll, or air syringe. Meticulous drying of the teeth is not necessary because the varnish will set in presence of moisture.
- Dispense 0.5–1 ml of varnish in a dappen dish. This should be enough for the entire dentition.
- Apply varnish as a thin layer using a disposable brush, or cotton pellet.
- The entire tooth surface must be treated, but do not place large amounts on tooth surfaces. Avoid applying varnish to gingival tissues because of the risk of contact allergies.
- No drying is required after application because varnish sets in a few seconds.
- The patient's mouth can be closed immediately following treatment.
- Patients can only have fluids or soft foods during the next four hours. Hard foods should be avoided.
- Patients should not brush their teeth for the rest of the day. This enhances the uptake of fluoride into the tooth structure.

Note: Varnish is contraindicated for persons with a history of allergies or asthma.

FLUORIDE GEL AND FOAM

Fluoride gel applications are more commonly used in the US and Canada. Gels are applied in Styrofoam mouth trays, and the most widely used gel is 1.23% F acidulated phosphate fluoride (APF). Fluoride foams are relatively recent products that are similar to gels, but have not been assessed in clinical trials.

Caries prevention

The effectiveness of PATF gels has been documented in numerous clinical studies. In a meta-analysis of fluoride gel trials, van Rijkom *et al*. included nine studies (ten comparisons) of professionally applied gels published between 1970 and 1992.[7] The overall average prevented fraction was 22% (95% CI = 18–25%) indicating good evidence of effectiveness in permanent teeth. All of the PATF studies used APF gel, application frequency varied from 1–2 times per year, and the ages of subjects ranged from 6–15 years.

No significant differences were found between application frequencies, but this result should be interpreted with caution because no head-to-head comparisons were included. Although two randomized trials have found no difference between annual and biannual application frequencies,[22,23] these studies could not control for the number of additional PATF applications which may have been received from private dentists not involved in the studies. Due to this possibility, there is a lack of evidence that annual applications are effective for caries prevention, and biannual applications are advisable.

A recently published Cochrane Review of fluoride gels included 25 studies, 14 involving PATF.[24] Based on these studies, the DMFS pooled prevented fraction was 28% (95% CI = 19–37%). The authors found insufficient information to evaluate application frequency, or caries prevention in the primary dentition.

Fluoride foams have not been assessed in clinical trials. Their characteristics are likely similar to gels because the same method of application is used, their fluoride concentrations are comparable, and fluoride enamel uptake is better.[25]

Clinical application

The frequency of gel application varies based on the caries risk level of the patient, and is usually provided at least every 6 months. Gel application is uncomplicated and can be performed by a dental auxiliary (Table 3).

The four-minute application of fluoride gel is recommended based on studies of enamel fluoride uptake.[26,27] When contact time is reduced to one minute, enamel fluoride uptake is significantly less. No clinical data support the 1 minute application of any product when used in the typical 6-month recall system. Nevertheless, many dental practices have reported applying fluoride gel for only 1 minute.[28]

Gel application is acceptable to most patients. However, some children find the experience to be unpleasant, and gagging may occur with young children. The most common adverse effect is over-ingestion, which can lead to nausea and vomiting. The inadvertent ingestion of gel can be prevented by the use of a suction device, seating the patient upright, not overfilling trays, and using well-fitted trays.

Table 3 Procedure for the application of fluoride gel

- Mouth trays should be tried in the patient's mouth. It may be necessary to adapt or trim trays.
- Patient should be seated upright and suction should be used during the procedure.
- Teeth should be air-dried before gel application. For caries prevention, cleaning or prophylaxis is unnecessary prior to PATF.
- Enough gel, or foam, should be used to completely cover the teeth, but should be no more than 2–2.5 grams per tray or 40% of the tray's volume.
- Upper and lower trays should be inserted separately.
- Fluoride should be applied for 4 minutes, not 1 minute.
- Patient should expectorate for 1–2 minutes after tray removal.
- Patient should not rinse, eat, or drink for at least 30 minutes after the procedure.

Note: For patients with porcelain or resin restorations, neutral sodium fluoride is recommended to prevent etching of restorations.

IN-OFFICE FLUORIDE RINSES

Two-part fluoride rinses are being used more frequently in North American practices instead of gels or foams.[28] These rinses consist of two fluorides, APF and stannous fluoride, which are mixed or used concurrently; and are different from the mouthrinses used in school-based programs or home-use.[29]

Two-part rinses are marketed as a preventive agent that is better tolerated than tray applications and reduces fluoride ingestion. However, none of these claims has been supported. First, it is unlikely these products are as effective as other agents because the fluoride concentrations are much lower compared with APF gel (1,500–3,000 ppm vs. 12,300 ppm). Caries prevention effectiveness has not been reported in any randomized clinical trials. Second, the risk of ingestion is greater because rinses can be more easily swallowed. These rinses should never be used for young children because acute fluoride toxicity could result if they were swallowed. Lastly, it is doubtful whether in-office rinses are better tolerated by patients because of their sharp, metallic taste.

In-office fluoride rinses are not recommended for caries prevention because other effective ant-caries PATF products are readily available.

FLUORIDE INGESTION AND TOXICITY

Fluoride applications must be carefully monitored because the potential for overingestion and toxicity does exist. Fluoride is rapidly absorbed in the gastrointestinal tract and young children are particularly vulnerable. Patients should not be left unattended during the application of PATF.

A considerable amount of fluoride may be retained after gel application, even if suction

Studies of enamel fluoride uptake suggest that a four-minute application is to be recommended. Reducing contact time significantly reduces enamel fluoride uptake

A cleaning or prophylaxis is not necessary prior to the application of topical fluorides

devices are used (on average 7.7 mg in children).[30] The risk of fluoride ingestion with fluoride foam is reduced, compared with gel, because a smaller amount is needed for applications. The exposure to and retention of fluoride foam by the patient may be significantly less compared with APF gel application.[25]

Fluoride varnish has a high fluoride concentration, but its safety is acceptable. Varnish is fast setting, fluoride is slowly released, and a small amount is needed for the complete dentition. Measurements of fluoride after topical treatments with varnish show levels far below those considered toxic.[31,32] Consequently, varnishes may be a better alternative to fluoride gels, especially for young children.[8]

PATF is not a risk factor for dental fluorosis when used at 6-month intervals, and if precautions are taken to minimize ingestion.[30]

IS A CLEANING NECESSARY PRIOR TO THE APPLICATION OF TOPICAL FLUORIDE?

Several clinical studies have reported that a cleaning, or prophylaxis, is not necessary before the application of topical fluorides.[23,33,34] No significant differences in caries reduction were found between patients who received a cleaning before application of PATF and those patients who did not receive a cleaning.

SUMMARY

The following is a summary of the important scientific facts and principles concerning the use of PATF:

- PATF should not be applied on a routine basis in dental practices. Fluoride applications are only indicated for patients with decayed smooth surfaces and those at high caries risk (Type 1)
- Both APF gel and fluoride varnish are effective and can be recommended for caries prevention in permanent teeth (Type 1)
- Frequency of PATF application will depend on the risk level of the patient, but should be provided at least on a biannual basis when indicated (Type 1)
- For gel applications, gel should be retained in the mouth for 4 minutes (Type 5)
- During topical fluoride application, precautions must be taken to minimize fluoride ingestion (Type 5), and
- No cleaning or prophylaxis is necessary before the application of topical fluoride for caries prevention (Type 1)

Table 4 provides a comparison of the different types of PATFs considered in this review. Evidence indicates varnish and gel applications are similar in caries prevention effectiveness in permanent teeth. Although no clinical trials support the use of fluoride foam, it is likely to be equivalent to fluoride gel use for caries prevention. For several reasons, fluoride varnishes may be a better alternative to fluoride gels, particularly for young children. These reasons include reduced risk of fluoride over-ingestion, greater patient acceptability, and faster and easier application. The use of in-office two-part rinses is not recommended. When used appropriately, professionally applied topical fluorides are a safe, effective means of reducing caries risk among high-risk populations.

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Table 4 Comparison of professionally applied topical fluorides

	Caries prevention	Clinical application	Fluoride ingestion	Cost	Acceptability
Varnish	Effective in high risk children (permanent teeth)	Easy Application time varies	Lowest risk Moisture can be better controlled than gel or foam	Most expensive	Preferred by patients and hygienists, compared with gel
Gel	Effective in high risk children (permanent teeth)	Easy Four-minute application time	% retained can be substantial Procedure must be followed to reduce risk	Low cost	Well-tolerated by most patients, but varnish is preferred
Foam	Not clinically tested Likely similar to gel	Easy Four-minute application time	Risk of over-ingestion is less compared with gel	Low cost	Not formally assessed Likely to be similar to gel
In-office two-part rinses	Not clinically tested	Most convenient	Greater risk of swallowing Not recommended for young children	Least expensive	Not formally assessed

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IN BRIEF

- Pit and fissure sealants are an effective preventive technology for children at high risk of dental decay as long as the sealant is retained.
- Autopolymerizing sealants and visible light curing sealants have high retention rates; glass ionomer cements have lower retention rates and their use is not recommended.
- Isolation of the tooth from contamination by saliva is the most important aspect of sealant placement.
- Cost-effectiveness requires that only those sites, surfaces and teeth at greatest risk should be sealed.

8

VERIFIABLE CPD PAPER

Prevention. Part 8: The use of pit and fissure sealants in preventing caries in the permanent dentition of children

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This paper reviews evidence concerning the use of pit and fissure sealants in preventing caries in the permanent dentition of children. While the evidence with respect to some sealant types and application techniques is incomplete, systematic reviews have clearly demonstrated that sealants are an effective preventive technology when used in high risk children, and that with proper application techniques long-term retention rates can be achieved. However, careful selection of patients and teeth for sealant placement is required to ensure cost-effectiveness.

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Over the past three decades there has been a substantial improvement in the oral health of children as evidenced by declines in the prevalence and severity of dental decay. Systematic exposure to fluorides, along with better nutrition, rising material standards of living and better access to dental care have reduced the susceptibility of contemporary child populations to infectious diseases affecting the oral cavity. For example, a recent study of Canadian children aged 13–14 years found that 64% were caries free.[1] However, among those with some experience of decay DMFT values ranged from 1 to 11 with a mean close to 3.0. This indicates that in this population a substantial minority remain susceptible to decay and that there is significant variation in the risk of disease among those who remain susceptible. For many of these children, effective caries preventive techniques are available which can reduce substantially their experience of this disease.

These preventive methods can be easily applied in dental practice and there is a substantial body of research evidence with respect to their effectiveness. For example, systematic reviews have been published for fluoride gel, fluoride varnish, chlorhexidine, pit-and-fissure sealants and dental health education.[2] This review summarizes the evidence for pit-and-fissure sealants when used to prevent caries in the permanent dentition of child populations. The rationale for the use of sealants as a major preventive intervention is the high prevalence of pit and fissure caries. Evidence suggests that between 90% of caries in children occurs in pits and fissures.[3]

The review considers the following questions:

- How effective are sealants in preventing dental caries in children?
- Which is the best sealant material to use?
- Does the placement technique have an influence on effectiveness?
- Which tooth and tooth surfaces should be sealed?
- How soon after tooth eruption should sealants be placed?
- Which children should receive sealants?

The strength of the evidence having a bearing on these questions can be classified using the following typology:

Type 1: Systematic review of two or more clinical trials
Type 2: At least one randomized controlled trial
Type 3: Non-randomized intervention studies
Type 4: Observational studies
Type 5: Other designs, traditional literature reviews, expert opinion

SEALANT MATERIALS

Since their inception, a number of types of sealants have been developed and tested for effectiveness. These differ according to the base material used, the method of polymerization and

Table 1 Types of sealants evaluated in effectiveness studies

- Autopolymerizing
- Visible light curing
- Fluoride containing visible light curing
- Autopolymerizing glass ionomer cements
- Resin-modified (light-cured) glass ionomer cements
- Resin-bonded amalgam

whether or not they contain fluoride.[4] The types of sealants that have been assessed are summarized in Table 1.

EFFECTIVENESS OF SEALANTS

The effectiveness of sealants has been documented in numerous clinical studies. A systematic review published in the early 1990s found that the preventive fraction (PF), that is the proportion of occlusal decay prevented, among children receiving a one-time application of autopolymerizing sealant was 71%.[5] This preventive fraction PF is given by $(I_0 - I_1)/ I_0$ where I_1 is the incidence of dental caries in the group treated with fissure sealants and I_0 is the incidence in the control group. Ultra-violet light polymerized sealant had a PF of 46%, but this 'first generation' product is no longer available. Although studies had been undertaken of visible-light cured sealants, none allowed the PF to be calculated so these were excluded from this review.

This original review was updated in 2001 by the inclusion of an additional five studies.[2] While only one of these used the split mouth design, they provide additional evidence of the effectiveness of autopolymerizing sealants and some evidence that visible-light cured resin sealants are also effective. A second review of studies also reported that there is good evidence that sealants are effective in high caries risk children as long as the sealant is retained.[3]

Since sealants are accepted as an effective preventive method, it is no longer ethically acceptable to compare the decay experience of teeth that are sealed with teeth that are not. Consequently, new sealant materials cannot be assessed in this way. Rather, since occlusal caries does not develop as long as the sealant remains adhered to the tooth, the length of time sealants are retained is now used as a surrogate measure of their effectiveness in preventing decay. Studies can be conducted on the relative caries preventive effect of two or more types of sealant since all teeth involved in the study are sealed. However, sealant longevity tends to be the most common outcome in this type of study.

Although rates of dental caries in children have declined, a substantial minority remain susceptible to the disease and there is significant variation in risk among those who remain susceptible. The majority of caries in children occurs in pits and fissures

WHICH IS THE BEST SEALANT MATERIAL TO USE?

Studies of the retention rates of different types of sealant are complicated by the fact that studies used different follow-up times. While autopolymerizing sealants have been observed for as long as 15 years, newer materials have only been subject to short-term follow-up. Since the highest rate of sealant loss occurs during the first year after application,[6] the calculation of annualized loss rates can mean that sealants observed for short periods of time can appear to be less effective. Nevertheless, currently available evidence indicates the following:[7]

- Autopolymerizing sealants have high long-term retention rates, with 60% of surfaces remaining covered after 5 to 7 years.
- Visible light curing sealants have retention rates similar to autopolymerizing sealants.
- Fluoride-containing visible light cured sealants have only been evaluated in short-term studies but have retention rates similar to autopolymerizing and conventional light cured sealants for the equivalent follow-up periods. Whether or not the incorporation of fluoride leads to further reductions in caries incidence or enhances the inhibition of incipient or inadvertently sealed hidden caries has not been determined.
- Retention rates for glass ionomer cements, both conventional and resin-reinforced, are significantly lower than that of resin based sealants and their use is not recommended.
- Since the probability of sealant failure is highest soon after placement for all types of sealant, they should be evaluated clinically for partial or total loss within 1 year of placement.

DOES THE PLACEMENT TECHNIQUE HAVE AN INFLUENCE ON EFFECTIVENESS?

A detailed description of current thinking regarding sealant application techniques is to be found in Waggoner and Siegal.[8] They describe the following steps:

Cleaning the pit and fissure surfaces

Before acid etching and sealant placement the tooth surface must be cleaned of plaque and other debris. Surfaces can be cleaned using a prophy cup or brush with or without pumice, with an explorer and forceful rinsing with water, with a toothbrush and toothpaste or by means of air abrasion. Where different cleaning methods have been compared, no differences in retention rates have been found. Although widening of fissures with rotary instruments has been recommended, current evidence does not conclusively support this practice. One disadvantage is that in most jurisdictions this means that hygienists and dental assistants cannot be given the task of sealant placement.

Isolation of the tooth

Complete isolation of the tooth from contamination by saliva is the most important aspect of sealant placement. Isolation by rubber dam or cotton rolls are equally effective and result in similar retention rates. Since teeth that are not completely erupted are difficult to isolate, sealants should not in most circumstances be placed on teeth until the occlusal surface is completely free of gingival tissue.

Etching the enamel surface

In order for the sealant to adhere the enamel surface needs to be etched, usually with an orthophosphoric acid liquid gel. Liquid and gel are equally effective in terms of surface penetration and sealant retention. Clinical studies indicate that a 15 second etch is adequate for sealant retention and no additional benefit received from longer etching times of 45 or 60 seconds. Studies

comparing acid etching with air abrasion as a method of enamel preparation are inconclusive. While bond strengths are comparable, one study found higher rates of micro-leakage for air-abraded enamel. However, a recent study[9] found no difference in retention rates on enamel surfaces prepared by the two methods.

Rinsing and drying the tooth

Rinsing and drying times are not important as long as they are sufficient to ensure the complete removal of all etching material from the tooth surface.

Applying the sealant

All pits and fissures should be sealed. The placing of a bonding agent on the surface prior to the sealant does not appear to enhance retention rates.

Polymerization

In order to reduce contamination, it is generally recommended that the polymerization of light cured sealants is undertaken immediately after placement. However, one study suggested that allowing the sealant to sit on the tooth surface for 20 seconds prior to polymerization increased sealant penetration.[10] Clinical studies of the effect of this on retention rates have not been conducted.

Evaluation of the sealant

The sealant should be inspected to ensure complete coverage of the occlusal surface and the occlusion checked for interferences. Filled sealants tend to be thicker than unfilled sealants and are more likely to require adjustment after placement.

WHICH TEETH AND TOOTH SURFACES SHOULD BE SEALED?

There have been changes in the distribution and severity of dental caries in the permanent teeth of children. The prevalence has declined, progression of carious lesions has slowed so that cavitation occurs later in the course of the disease and teeth appear to remain at risk beyond the first few years after eruption. According to Rozier[11] dental caries is now a disease that affects selected sites of selected surfaces of selected teeth. Since sealant placement is relatively expensive, this means that only those sites/surfaces/teeth at greatest risk should be sealed.

The teeth and tooth surfaces at greatest risk for caries are the pits and fissures of molars. While it was initially considered that the first molars are at greatest risk of attack, epidemiological studies indicate that first and second molars are at equal risk and have a higher probability of decay than any other tooth type. Consequently, both first and second molars are the main candidates for sealants. Premolars are much less susceptible to decay than molars and are less likely to be candidates for sealants.

There is some evidence, although incomplete, that while the greatest risk for decay in molars appears to be 2 to 4 years after eruption, the pits and fissures of first permanent molars remain susceptible to primary decay into adolescence and beyond.[12] This evidence challenges early guidelines suggesting that teeth remaining caries-free for 4 or more years after eruption do not need to be sealed. Consequently, the length of time since eruption should not be the main factor determining the placement of the sealant. Rather, the patient's overall caries risk should be the main criterion employed.

Other tooth-level factors which should be taken into account in decisions to use sealants are:

Tooth morphology

Pit and fissure morphology has a significant influence on the risk of caries. Teeth with deep pits and fissures that catch an explorer are the best candidates for sealants while teeth with wide and easily cleaned grooves do not require sealing.

Status of the proximal surfaces of the tooth to be sealed

If a proximal restoration involves the pit and fissure surfaces it should not be sealed. If proximal caries is present a non-carious occlusal surface may be a candidate for a sealant if conservative procedures for managing the interproximal decay are feasible.

Caries status of the occlusal surface

Occlusal surfaces whose caries status is uncertain or surfaces where the caries is confined to the enamel can be sealed, since early lesions will not progress but will arrest as long as the sealant remains intact. Such tooth surfaces should be assessed at regular intervals to ensure the complete retention of the sealant. Where caries has progressed to dentine the tooth should be restored. Preventive restorations involving sealant materials or composites may be indicated.[13]

Eruption status

Since adequate isolation is needed for sealant retention to be ensured, it is generally recommended that sealants not be placed until the tooth is sufficiently erupted for the risk of contamination by saliva during sealant placement to be eliminated.

Overall caries activity

If the individual's caries history indicates that they are susceptible to pit and fissure caries, any caries-free pit and fissures of the teeth at greatest risk should be sealed. Susceptibility is usually indicated by the occurrence of one or more caries lesions per year.

WHICH CHILDREN SHOULD RECEIVE SEALANTS?

Since an increasing proportion of children are caries free significant effort has been devoted to

The caries preventive potential of sealants has been demonstrated in numerous studies. Sealant retention rates are now used as surrogate measure of their effectiveness in preventing decay

Retention rates for glass ionomer cements are substantially lower than that for resin based sealants and their use is not recommended. First and second permanent molars are at equal risk of decay and more likely to decay than any other tooth type. These are the main candidates for sealant application

Cost-effectiveness requires that only those children at high risk for caries should be considered for sealant application

developing methods for identifying those individuals at highest risk of caries. Cost-effectiveness requires that only those children at high risk should be considered for sealant applications. Numerous factors have been included in caries risk prediction models. However, none are totally accurate and given the variations in caries levels, and variations in risk factors between age cohorts, socio-economic and cultural groups and the fact that risk profiles are constantly changing, it is unlikely that a universally applicable model will be developed.[14] However, the majority of models include, as significant risk predictors:

- Caries history in the primary and permanent dentition, and
- Current level of caries activity

Consequently, these should be the main factors considered when assessing whether or not a child is likely to benefit sufficiently from sealants for their use to be considered cost-effective.

SUMMARY

Although the evidence having a bearing on all aspects of sealant use is incomplete and the strength of the evidence underlying some recommendations somewhat uncertain, a recent US Workshop on Guidelines for Sealant Use[15] and a Canadian evidence based care report[7] summarized some important scientific facts and principles:

- Sealants have been shown to be safe and effective in preventing dental decay in susceptible teeth and individuals (Type 1);
- In addition to preventing caries, sealants can arrest incipient decay (Type 2);
- Cost-effective use indicates that sealants should be placed on the pits and fissures of teeth at greatest risk (predominantly first and second permanent molars) in individuals susceptible to decay (Type 4);
- Children with previous or current caries experience should be considered for sealants (Type 3); others should not.
- Pit and fissure caries begins in childhood and can continue into adolescence and adulthood (Type 4).
- Sealants should be placed as early as possible after the occlusal surface is free of gingival tissue and up to 4 years after eruption (Type 3). Placement may be indicated beyond 4 years post-eruption depending upon the caries susceptibility of the individual (Type 4).
- Resin sealants should be used: autopolymerizing (Type 1) and light-cured (Type 2/3) have satisfactory retention rates. Glass ionomer cements should not be used (Type 2/3).
- Sealant use is technique sensitive; particularly with respect to moisture control (Type 3).
- Sealants should be evaluated clinically, especially when placed over incipient decay (Type 2).

The main principle underlying the use of sealants is that prevention is better than treatment. Sound, non-diseased teeth even though sealed are more valuable than properly restored teeth. Nevertheless, the indiscriminate use of sealants is not recommended. Maximizing the cost-effectiveness of this preventive technology is an important consideration.

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